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**Malaria, Production and Income of the Producers of Coffee and Cocoa:
an Analysis from Survey Data in Côte d'Ivoire¹**

Malaria, coffee and cocoa production and income

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Abstract:

The sectors of coffee and cocoa represented in Côte d'Ivoire, before the political crisis, approximately 15% of the GDP and 40% of exports. The zones of production of these two cultures are in the forest area which is infected with malaria. The culture of these products is less constraining than that of the food crops such as rice or yam (one does not need to replant each year for example). However, the maintenance of the ground and of the trees and pest management contribute to obtain high yields. In addition, these products allow the producers to obtain monetary income. However, output is not the sole determinant of the level of income: precocity and speed of gathering, by permitting early sale, contribute to get higher income. In addition, food crops such as rice growing, are produced in the area. The objective of this paper is twofold, first, to evaluate the role of malaria on coffee and cocoa productions, second, to assess if the behaviour of rural households facing a liberalisation of the coffee and cocoa chains has an impact on their income. Three functions are thus estimated: production of coffee, production of cocoa and income. Data are taken from a survey carried out on 800 households (21 villages) in 1999 in the forest area of Danané. The main results are the absence of malaria impact on productions and the dominance of individual over collective sale strategies.

Topic: Health in developing countries

Keywords: cocoa, coffee, lowland rice, malaria, sharecropping, Côte d'Ivoire

JEL classification: I12, O13

Introduction

The coffee and the cocoa are the main crop cultures in Côte d'Ivoire and ensure the major part of income for rural households. Even if the share of these sectors in exports has decreased for two decades,² Côte d'Ivoire, in spite of the economic crisis, remained the first world cocoa producer and provides 40% of the world production (www.Afrik.com, 2005). Coffee production represented in 2004 7 to 8% of the world market for Robusta and 3% of the world market for Arabica (Marchés Tropicaux, 2004).

The liberalization of commodity chains in 1999 (removal of a guaranteed price to the producers and emergence of private operators), should have had two effects:

- to increase competition between purchasers;
- to increase producer's income after a rise in the world price of raw commodities.

This policy had not the expected effects. For instance, a fall in world price did not encourage the producer to store a part of their production, and sale later at higher price. Moreover, price fluctuation, rain deficit, degradation of rural tracks and political instability contributed to make unsteady the income of the producers (Afrique Agriculture, February 2005; www.marches-tropicaux.com).

Confronted with constraints or modifications of their environment, rural households develop strategies of production in order to cope with negative effects. This capacity of adaptation varies according to the characteristics of the households.

I Behaviour of agricultural households facing external constraints

The producers of coffee and cocoa in Côte d'Ivoire have to deal with two kinds of constraints, one related to the liberalization of the commodity chains, the other related to malaria. The objective is to observe which strategies rural households implement to cope with:

- a shift in agricultural policy and the emergence of a competitive internal market for coffee and cocoa;
- eventual negative effects of malaria.

Strategy of production and marketing

De Janvry and Sadoulet (2001) highlight the strategies developed by Mexican farmers who, in order to compensate for lower income, are seeking jobs in non-agricultural activities. Pender *et al.* (2004) show that small farms in Uganda compensate for their smallness by obtaining a higher production per hectare. This result is confirmed by Coelli and Fleming (2004) for food crops in New-Guinea. Mochebelele and Winter-Nelson (2000) observe that in Lesotho members of small farms compensate for the loss of labour due to migration (in the mining sector in South Africa) by being more efficient owing to a better management financed by worker remittances. These papers show that rural households are able to implement strategies to cope with the internal constraints they are facing. This capacity of reaction is also expressed when external constraints occur (change in agricultural policies, Dalton 2004). The liberalization of coffee and cocoa chains in Côte d'Ivoire is an example of an external constraint. On one hand, liberalization implies the suppression of a guaranteed price. On the other hand, producers can benefit from competition by choosing the best selling period, or by creating a co-operative able to impose its conditions to the purchasers.

Strategy of compensation induced by parasitical diseases

The production and the consumption of households can be modified by exogenous shocks, such as a change in the health of household members. The theory of human capital (Becker 1965) assumes that a deterioration of the health has a negative effect on the productivity of the working population. The empirical studies fail to show such a negative effect. In Paraguay, rural households adopted strategies to reallocate labour between family and hired labour to compensate for the loss of

productivity due to malaria (Conly 1975). Sauerborn *et al.* (1996), in Burkina-Faso, Audibert and Etard (2003) in Mali and Audibert *et al.* (2003) in Côte d'Ivoire observe the same strategy.

Gertler and Gruber (2002) evaluate the ability of Indonesian households to maintain their consumption in the event of a health shock. They test the assumption that a significant shock decreases income as a result of a drop in labour supply and of an increase in health spending. Wagstaff (2005) observes in Vietnam an effect on income and on health spending.

As in the sample, rural households grow either lowland rice or rainy rice growing, we check whether those suffering from malaria compensate for the debilitating effects by hiring labour.

II. Perennial crops and rice production systems

Characteristics of the coffee and the cocoa

The coffee requires maintenance and the production system is well-known. The weeding (two to three times per year), the soil nutrient management (NPK fertiliser, urea, potash, nitrogen...) and the maintenance of the trees contribute to increase yields. Pruning is an essential element of cocoa management. Pruning involves thinning and removal of old or dead stems. Trees must be trimmed every four to five years. Under these conditions, one can expect a yield of 2t/ha. In Côte d'Ivoire, the average output turned, at the beginning of the years 2000, around 300-400 kg/ha (Marchés Tropicaux 2004).

The cocoa-tree has a lifespan from 25 to 30 years and reaches its full development towards the age of 10. The age of the cocoa-tree is thus a significant determinant of output. The cocoa-tree must be treated and just like for the coffee-tree, the soil must be regularly weeded and the tree trimmed. The average output in Côte d'Ivoire oscillated between 400-500 kg/ha at the end of the nineties (CIRAD, 1996).

The main feature of coffee and cocoa crops is that trees are the property of the farmers and are passed down from generation to generation.

The coffee and the cocoa harvests are done in August and September. Although the marketing campaign starts at the beginning of October, one observes for the cocoa two periods of sale, called main sale (October to January) and small sale (March to June) whereas the sale of the coffee is done in general in once (October to December). With the liberalization of the chain, farmers can use competition at their advantage by selling to the best bidder: the trackers,³ the village co-operatives, the traders.

Exploitation of the plantations

In Sub-Saharan Africa, the land, managed by a “head of land”, belongs to the village and is managed by its natives. The production system of coffee and cocoa, contrary to food crops, depends on the type of contracts between the owner of the trees and the hired workers.

Let Q be the agricultural production, then the income (I) of the owner is (Cudeville 2005; Ghatak 2003):

$$I = \alpha Q + \beta$$

where:

α is the share of the production Q being allocated to the owner and β is a fixed transfer. The types of contract are defined according to the values of α and β :

- $\alpha = 1$ and $\beta = 0$, the cultivator is the owner of the trees;
- $0 < \alpha < 1$ and $\beta < 0$ or $= 0$, contract of sharecropping, with or without, division of the cost of inputs between the owner (of the trees) and the sharecropper;
- $\alpha = 1$ and $\beta < 0$, leasing agreement;
- $\alpha = 0$ and $\beta > 0$, wage contract.

The effect of these various types of contract, and in particular of sharecropping, on the production and on efficiency, has interested the economists since Adam Smith. For Marshall, the sharecropping was a source of inefficiency for two reasons. First, the marginal income of the sharecropper is lower than its marginal productivity. Second, getting only one fraction of the harvest, the sharecropper has

no incentive to maximise his effort. This Marshallian approach was long time accepted and confirmed by empirical work (Bell 1977; Sadoulet *et al.* 1994; Laffont and Matoussi 1995). This view was questioned by Johnson (1950), then by Cheung (1969) who advanced the idea that sharecropping cannot be studied without taking into account the behaviour of the owner, insofar as he has the ability to check the effort provided by the sharecropper. Consequently, the issue of the interest of sharecropping for the owner, such as risk sharing, arose (Pender and Fafchamps 2001; Ghatak 2003; Cudeville 2005; Arcand, Ai and Ethier 2006). Those authors show that this question cannot be studied without referral to transaction costs, market imperfections and adverse selection. The evidence of a lower efficiency or productivity for the exploitations under sharecropping contract is not so obvious and several studies show that these exploitations can be as efficient as the ones directly exploited (see the review of literature by Otsuka and Hayami, 1988). Changes in the environment of the farmers due to a better access to credit and the development of new marketing policies, can explain the disappearance of the Marshallian inefficiency (Benin and Al 2005). We intend to check this assumption.

III Methodological Framework

Data

A survey was carried out in 1999 in 21 villages of the area of Danane (west of Côte d'Ivoire), including the "sous préfectures" of Danane, Zouan-Hounien, Bin-Houye, Bolequin and Guiglo. If the coffee and the cocoa are the most important cash crops, rice and manioc are the main food crops. The cultural methods for rice differ according to villages. Lowland rice may ease the transmission of malaria.

A sample of nearly 750 farmers was randomly selected using a two-stage sampling process. In the first stage, villages were selected on the basis of criteria related to the size of the population and the proximity of lowlands, and classified into three agroecosystems:

- R0, villages located in the northern zone, without lowland rice;

- R1, villages located in the southern zone, with one annual harvest of lowland rice during the rainy season;
- R2, villages located in the southern zone, with full water management and two annual harvests of lowland rice.

In the second stage, households were randomly selected in the 21 villages (7 per agro ecosystem).⁴

The data concerning the characteristics of the households and the agricultural activity (incomes, production system, sharecropping, inputs, etc.) were collected by questionnaire. Prevalence of malaria is measured by the proportion of the household members with number of parasites higher than 99/ μ l of blood. Blood samples were taken at 6-week intervals during one year.

Characteristics of the villages and the families

The villages differ by size, demographic composition, geographical area and by their infrastructures. These infrastructures reflect the fact that people are broad-minded (church and mosque). They also reflect the degree of modernism (school, electricity), of social cohesion (co-operatives).

The average size of the families is of 7.3 people and varies somewhat between the three agro ecosystems. It is higher in R2 and R1 where one counts on average 8.6 people (standard deviation, sd = 5.4) and 7.2 people (sd = 4.9) respectively, while in R0 one counts 6.4 people on average (sd = 3.8). The structure of the population is somewhat different since it is older in R0 (12% of more than 59 years; 40% less than 15 years) than in R1 and R2 (less than 6% of more than 59 years and 45% less than 15 years). The natives form the majority of the population of the villages.⁵ There are two main groups, Guéré, living in R0 and Yacouba, living in R1 and R2. The population is mostly animist however in R2 Christians represent 26% of households. Islam concerns only 3.5% of households in R0 and R1, and 9% in R2.

Rice is cultivated like rain rice in the three zones, and its importance decreases with the development of lowlands rice. In R1, lowland rice represents 35% of rice plots and 49% in R2.

For cash crops, sharecropping leads to negotiations between owners and sharecroppers who control the access to labour (CIRAD, 1990). Sharecropping concerns 20-25% of the plantations. The negotiations concern the distribution of the harvest and of the costs of exploitation. The only contract used in the villages is: 2/3 of the harvest to the owner (who made the advance for inputs), 1/3 to the sharecropper.⁶ The owners can in addition appeal to hired labour (piece worker, daily worker, monthly worker).

In the sample, the average acreage of the plantations, in particular for the cocoa, is greater when the exploitation is in sharecropping.

Strategy of production

- the respect of practices, the age of the seedlings, are the technical determinants of yields;
- the demographic structure and the health of household members influence the use of extra-family labour whose productivity is lower (Ruf 1995);
- the production is higher when the exploitation is in sharecropping as it is the only financial resource for the sharecropper;
- the production of rice, in particular when it is irrigated (more work demanding), may have a negative effect on the production of coffee and cocoa by diverting family labour from the latter activities;
- the prices influence the decision for harvesting;
- malaria, which impinges unequally the households, reduces the productivity;
- the exploitations confronted to malaria compensate for its invalidating effects by hiring extra family labour.

Strategy of marketing: assumptions regarding the determinants of gross incomes

- income resulting from cash crops does not depend only on yields and on output, but also on the decision to harvest as soon as possible in order to sell quickly (to guarantee a higher price);
- sharecropping contributes to higher incomes insofar as it induces a higher production;
- co-operatives, by imposing the selling prices, should increase the incomes of the owners;
- price, and thus income, also differ with the purchasers: trackers pay the lower price;
- coffee yields smaller income than cocoa;

Strategy of investment in health: assumptions regarding the determinants of health

- households which invest in health are less infected by malaria;
- standard of living can be considered as an investment in health and then it reduces the risk of being infected by malaria;
- lowland rice increases the risk of malaria;
- insecticide spreading increases the risk of malaria (higher resistance of the vectors);
- the environment (geographical location) is a determinant of malaria.

Estimates

Four equations are estimated. The first two relate to the production of cocoa (375 observations) and coffee (304 observations). The third is the equation of income (690 observations) and the last is the health equation.

Some explanatory variables of the production equations can be endogenous (the instrumentation equations appear in Table 1a and Table 1b):

- The acreage of lowland rice, which competes with the cash crops for the families heavily affected by malaria (see above). The instrumentation equation does not highlight the effect

of malaria on the acreages of rice lowlands. Moreover, a Hausman test does not reject the assumption of exogeneity of this variable.

- The pest management can be correlated with the level of education of the farmer. A Hausman test rejects the assumption of exogeneity. The instruments used for this variable are: the acreage of food crops, house, modern house and income in 1997 for coffee and, house, sheet metal roof and elder persons for cocoa (Table 1b).
- A Hausman test rejects the assumption of exogeneity of the variable use of daily worker. The instruments used for this variable are: house, family size and the acreage of food crops for coffee and, house, adult education and the acreage of food crops for cocoa.

The equations for production are estimated, while controlling for village heterogeneity, by two-stage least squares and by ordinary or generalised least squares for the income equation. An Hausman test and presence of fixed effects were carried out.

As the households are not equally affected by malaria (in 239 households, all members are lowly or not infected, thus the variable *prev99* takes the value zero), the equation for health is estimated using a Tobit approach, controlling for village heterogeneity.

The severity of malaria can lead households to use extra family labour in the cocoa and coffee plantations. This assumption of a coping process is checked by comparing the cost of labour across differently infected households, having controlled for acreage (scatter plot).

Insert Tables 1a and 1b

IV Results

Strategy of production: determinants of the culture of the coffee and the cocoa

For a clear presentation of the results, we first present the common determinants of coffee and cocoa production. Then the specific determinants of each culture are commented.

The technical determinants of these two crops are significant and have the expected sign: pruning and pest management (at the right time) improve the production.

Controlling for the acreage of the plantations, the assumption of a larger effort when the exploitation is under sharecropping is not rejected: this type of exploitation leads to a greater production (the coefficient for the sharecropping variable is positive and significant). This result is in line with recent studies (Pender and Fafchamps 2001; Pender *et al.* 2004; Benin *et al.* 2005). For the owners, sharecropping allows to exploit more plantations (due to a constraint in labour force) and thus to earn greater income. For the sharecroppers (migrants), the strategy is to gain enough money to return and to invest in their region or country. As they receive a small share, it is beneficial to work as much as they can to get a very high production.

The assumption of a trade-off between lowland rice and cash crops is rejected: the coefficient for acreage of lowland rice is positive and significant. The assumption concerning malaria is rejected: prevalence of malaria does not have any economic effect, neither directly through the production, nor indirectly, through a coping process such as the resort of extra family workers. This result is not so surprising as several studies failed in identifying malaria impacts on output (see review in Jamison *et al.* 2006), except one. In this study, the prevalence of parasitemia above a cutoff density had a major impact on labor efficiency in the cotton production in Côte d'Ivoire (Audibert, Mathonnat and Henry 2003). One possibility is that malaria economic impact is more likely observable on crops that require intensive cultivation such as cotton.

Specific determinants

Two significant factors are specific to the culture of the cocoa. First, labour force (children and day labourers) affect positively the production. Second, the ethnic group, Guéré, has a positive effect on the production. This variable reflects rather the location of the plantation indicating the ecological characteristics of the soil.

One factor is specific to the culture of coffee: the religion.

Strategy of marketing

Determinants of the income

The relative youth of the head of exploitation lead to higher income. Young growers seem to adopt strategies of marketing more effective than the older growers. The strategies are: to sell early and not to sell to the trackers (Table 2).

Selling to the village co-operatives does not influence the level of income. The co-operatives do not play the role they should have played after the liberalization of the chain. The lack of village cohesion and too individualistic behaviour of the growers may explain the failure of the co-operatives.

More previously observed by Deaton and Dwayne (1988) also in Côte d'Ivoire, coffee gives a lower income than cocoa.

Insert Table 2*Strategy of investment in health*

The issue of the factors of malaria transmission concerns the role of lowland rice. The results of a Tobit estimation (Table 3) show that lowland rice has no effect on malaria. This confirms the epidemiologic results which concluded that lowland rice in the savannah (Henry *et al.* 2003) and forest areas (Henry, personal communication) was not a factor of increased exposure to malaria. Those areas are classified as respectively hyper and holo-endemic which implies consequently a very stable transmission (Henry *et al.* 2003; Henry *et al.* 2005).

If malaria has no consequences on production and on income, one observes a relationship between the standard of living and the severity of malaria (Table 3). Thus, the families whose standard of living, measured by the value of the goods of comfort (assets), is high, are less affected by malaria than the others. Households with higher income (as a proceed of the sale of cocoa and coffee) are more infected by malaria. This last result does not contradict the former one as cocoa and coffee

income is quickly spent on goods other than improving housing. The weak correlation between cocoa and/or coffee income and standard of living reinforces this last interpretation.

Contrary to what can be expected, the families which invest in protection against mosquitoes (measured here by the monthly expenditure in serpentines, bends insecticidal etc.)⁷ and thus indirectly in their health, are the most infected by malaria. This apparently surprising result is explained by some previous results. First, entomological survey (unpublished results) showed that lowland rice promotes growth of mosquitoes (*Culex* and *Anopheles*) and that transmission is highly intensive. As a consequence, more families in R1 and R2 (40%) than in R0 (30%)⁸ invest in protection against mosquitoes (Audibert *et al.* 2001) as they are more exposed to mosquito bites (*Anopheles* and thus to malaria). Secondly, parasites resistance to drugs was found (Henry, Niangue and Kone 2002) and that would be explained by an intensive antimalarial drug consumption and the instability of population who frequently comes and goes between Liberia and Cote d'Ivoire (Henry *et al.* 2005) .

Lowland rice, but also exploitation of cash crops, may play a role in the transmission of malaria. Results show that malaria is more severe within farmers who treated trees. Or, if treating trees allows to increase yields and thus cash income, it requires more time spent in fields and thus greater exposition to mosquitoes⁹ (Nyezimana *et al.* 2002) and then to malaria (Table 3). And, it was also been observed that cash crops are more often cultivated upon families in R1 and R2 (between 77% and 80% of them) than in R0 (less than 53%) (Audibert *et al.* 2001).

Insert Table 3

V Discussion and conclusion

The coffee and the cocoa were for the Côte d'Ivoire during decades a significant source of income. These cultures are located in the forest zone. Households also cultivate rice, either in rain culture or in lowlands. The objectives of the study were to determine the effect of malaria on the cash crop

production, and the effect of rice production system on the severity of malaria. Five points can be highlighted:

i) the rationality of the sharecroppers who maximize their production;

ii) the role of non hired labour

- the village mutual aid has no effect on the coffee and the cocoa productions
- the family labour force (children) seems more mobilized for the cocoa which has a higher impact on gross income than coffee

iii) strategies developed by the producers after the liberalization of the chain.

- they did not develop "community or collective" strategies: the village co-operatives do not obtain higher prices
- individual strategies: the timing of sales and the choice of the purchaser are significant determinants of the profit

iv) no malaria effect

- malaria does not have a direct effect on the production of coffee and cocoa
- coping process, which would consist to use hired labour in case of malaria was not observed. This can be explained partly by the cash crops production which is less labour consuming than rice or cotton.

v) factors of risk and determinants of malaria

- the wealthier households can more protect themselves against malaria than the poor households
- coffee and cocoa farming increases the risk of malaria.

Table 1a: Instrumentation of the variable Daily worker

	Production of coffee		Production of cocoa	
	Fixed effects OLS		Fixed effects OLS	
	coefficient	P-Value	coefficient	P-Value
<i>Constant</i>	1.256	0,413	2.741	0.389
Surface (log) (ha)	1,177	0,066	2.191	0.018
% of surface with young seedlings	0.540	0.295	-1.129	0.652
Sharecropper (binary)	-1.123	0.007	-0.871	0.106
Lowland rice	-1.586	0.007	-1.417	0.008
Prevalence of malaria	0.015	0.524	-0.068	0.218
Pruning	-0.431	0.421	-0.545	0.580
Family labour: adults			1.099	0.009
Family labour: children			-0.357	0.343
Mutual aid	-0.044	0.302	0.035	0.195
Guéré	5.340	0.051	5.254	0.356
Religion	1.591	0.138		
<i>Instruments</i>				
Age head of exploitation	-0,01	0,59	-0.078	0.076
Acreage of food crops			1.410	0.008
House	-0.584	0,042	-0.604	0.089
Adult education			0.048	0.010
Family size	0.218	0.013		
<i>Quality of the adjustment</i>				
R ²	0,31		0,23	
Number of observations		378		304

Table 1b: Instrumentation of the variable Pest management

	Production of coffee		Production of cocoa	
	Fixed effects OLS		Fixed effects OLS	
	coefficient	P-Value	coefficient	P-Value
<i>Constant</i>	-0.127	0.000	-0.009	0.878
Surface (log) (ha)	0.021	0.095	0.042	0.110
% of surface with young seedlings	0.043	0.000	0.037	0.378
Sharecropper (binary)	0.006	0.644	0.001	0.957
Lowland rice	-0.029	0.001	-0.001	0.237
Prevalence of malaria	-2.89E-07	0.999	-0.001	0.873
Pruning	-0.431	0.421	0.005	0.775
Family labour: adults			0.009	0.238
Family labour: children			0.004	0.658
Mutual aid	-0.001	0.472	-0.001	0.319
Guéré	0.269	0.000	0.024	0.912
Religion	0.049	0.011		
<i>Instruments</i>				
Acreage of food crops	0,015	0,018		
House	0.015	0.001	0.194	0.056
Modern house	-0.031	0.055		
Income in 1997	5.40E-08	0.074		
Religion			0.121	0.001
Elder persons			-0.027	0.082
Sheet metal roof			0.032	0.110
<i>Quality of the adjustment</i>				
R ²	0.35		0,56	
Number of observations		378		304

Table 2: Determinants of the production, the income of the owners of coffee and cocoa in Côte d'Ivoire (in 1999)

	Production of coffee		Production of cocoa		Income coffee & cocoa	
	fixed effects		Fixed effects		Fixed effects	
	TOLS		TOLS		OLS	
	coefficient	P-value	coefficient	P-value	coefficient	P-value
<i>Constant</i>	4.716	0.000	4.430	0.000	11.641	0.000
<i>Factor ground</i>						
Surface (log) (ha)	0.484	0.000	0.513	0.000	0.713	0.000
% of surface with young seedlings	-0.192	0.005	-0.182	0.250		
<i>Technical factor</i>						
Pest management	2.084	0.081	2.732	0.010		
Pruning (binary)	0.183	0.003	0.157	0.087		
<i>Factor work</i>						
Total family labour					0.035	0.029
Family labour: adults			-0.039	0.391		
Family labour: children			0.080	0.003		
Mutual aid	-0.004	0.342	-0.005	0.292		
Sharecropper (binary)	0.140	0.013	0.218	0.006	0.360	0.001
Cost of the extra-family labour *	0.003	0.897	0.050	0.003	4.87E-06	0.000
Lowland rice	0.098	0.045	0.018	0.001		
Surface food crops					0.023	0.010
Coffee					-0.336	0.000
<i>Characteristics</i>						
Age head of exploitation					-0.005	0.029
Religion of the head of family	-0.201	0.072				
Guéré	-0.631	0.283	1.313	0.000	1.060	0.010
Prevalence of malaria	0.001	0.580	0.005	0.208		
<i>Investment in health (prevention)</i>						
Expenditure of prevention malaria (Fcfa)						
<i>Factor of decision-making</i>						
Early sale (binary)					-0.161	0.137
Sale with delay (binary)					-0.279	0.012
Sale with the trackers (binary)					-0.359	0.001
<i>Quality of the adjustment</i>						
R ²	0.341		0.283		0.400	
Fixed effects, F test	3.410	0.0000		0.0007	3.070	0.000
Hausman test	40.31	0.0000	21.30	0.046	20.70	0.060
Over identification test	10.15	ns	5.02	ns	--	--
Number of observations	378		304		690	

Table 3: Determinants of the health (malaria)

Variables	Determinants of health (prevalence of malaria)	
	Tobit model: Prev99	
	coefficient	P-Value
Constant	16,174	0,000
Age head of exploitation	-0,145	0,0007
Expenditure protection (Fcfa)	0,001	0,098
Goods of comfort (Fcfa)	- 1, 16E-05	0,026
Income (Fcfa)	5,88E-06	0,060
Rice surface of hollows	- 0,056	0,344
Treatment in the plantations (Fcfa)	0,0001	0,002
<i>Quality of the adjustment</i>		
Log likelihood	-2162	
A number of observations	689	
Adjusted for villages heterogeneity		

References

Afrique Agriculture, février 2005.

Asfaw A, von Braun J, 2004. “Is Consumption Insured Against Illness ? Evidence on vulnerability of households to health shocks in rural Ethiopia.” *Economic Development and Cultural Change*: 115-129.

Arcand J.L, Ai C, Ethier F, 2006. “Moral Hazard and Marshallian Inefficiency: Evidence from Tunisia.” *Journal of Development Economics* Available online 26 July 2006.

Audibert M, and J.F Etard, 2003. “Productive Benefits after Investment in Health in Mali”, *Economic Development and Cultural Change* 51; 3: 769-782.

Audibert M, Mathonnat J and MC Henry MC, 2003. “Social and Health Determinants of the Technical Efficiency of Cotton Farmers in Northern Côte d'Ivoire.” *Social Science and Medicine* 56: 1705-1717.

Audibert M, Mathonnat J, M.J Bokossa and A. Diabagate, 2001. “Systèmes de Production Rizicole et Maladies Parasitaires dans l’Afrique de l’Ouest : caractéristiques socio-économiques des ménages agricoles en zone de forêt ivoirienne”, Working Paper, E2001.07, Université d’Auvergne, CERDI.

Beegle K, 2003. “Labor Effects of Adult Mortality in Tanzanian Households.” Policy Research Working Paper 3062. The World Bank Development Research Group.

Benin S, Ahmed M, Pender J, Ehui S, 2005. “Development of Land Rental Markets and Agricultural Productivity Growth: the Case of Northern Ethiopia.” *Journal of African*.

Cheung S, 1969. “Transaction Costs, Risk Aversion and the Choice of Contractual Arrangements;” *Journal of Law Economics* 12: 23-43.

CIRAD, 1990. “Compétitivité du Cacao, Analyse du Marché Mondial et des Principaux Producteurs”, Working Paper, CIRAD.

Coelli T, Fleming E, 2004. "Diversification Economies and Specialisation Efficiencies in a Mixed Food and Coffee Smallholder Farming System in Papua New Guinea." *Agricultural Economics* 31, 2-3: 229-239.

Conly, G.N., 1975. *The impact of Malaria on Economic Development, a Case Study*. Scientific Publication, 297, PAHO, Washington DC.

Cudeville E, 2005. "L'Agriculture dans le Développement." Course on line, TEAM.

Dalton T.J, 2004. "A household Hedonic Model of Rice Traits: Economic Values from Farmers in West Africa." *Agricultural Economics* 31, 2-3: 149-159.

Deaton A, 1998. *The Analysis of Household Surveys, a Microeconomic Approach to Development Policy*. The John Hopkins University Press, Maryland.

Deaton A., Dwayne B., 1988. "The living Standards Survey and Price Policy Reform, A study of Cocoa and Coffee production in Côte d'Ivoire." LSMS Working Paper n°44, World Bank, Washington, D.C.

Dey Abbas J, 1997. "Gender Asymmetries in Intrahousehold Resource Allocation in Sub-Saharan Africa : Some Policy Implications for Land and Labor Productivity." In the *Intrahousehold Resource Allocation in Developing Countries*, ed. L. Haddad, J. Hoddinott and H. Alderman, The John Hopkins Press: 249-262.

Gertler P., Gruber J, 2002. "Insuring Consumption against Illness. " *American Economic Review* 92, 1: 51-70.

Ghatak M, 2003. "Agricultural Organization and Economic Efficiency in Developing Countries" London School of Economics, Ec428, Lent.

Grossman M, 1972. *The Demand for Health: a Theoretical and Empirical Investigation*. New-York, NBER.

Henry MC, Assi SB, Rogier C, Dossou-Yovo J, Chandre F, Guillet P and Carnevale P, 2005. "Protective Efficacy of Lambda-cyhalothrin Treated Nets in *Anopheles gambiae* Pyrethroid

Resistance Areas of Côte d'Ivoire." *American Journal of Tropical Medicine and Hygiene* 73: 859-864.

Henry MC, Niangue J and Kone M. 2002. "Quel Médicament pour Traiter le Paludisme Simple quand la Chloroquine Devient Inefficace dans l'Ouest de la Côte d'Ivoire?" *Médecine Tropicale*, 62 : 55-57.

Henry MC, Rogier C, Nzeyimana I, Assy S B, Audibert M, Dossou-Yovo J, Mathonnat J, 2003. Malaria Infection and Disease in the Savannah of Côte d'Ivoire." *Tropical Medicine and International Health* 8, 5: 449-458.

Jamison et al. (eds), 2006. *Disease Control Priorities in Developing Countries*. 2nd ed. World Bank, WHO, Oxford University Press.

Janvry (de) A, Sadoulet E, 2001. "Income Strategies Among Rural Households in Mexico : the Role of off-Farm Activities." *World Development* 29, 3: 467-480.

Marchés Tropicaux, 2004. 3042, February, on <http://www.marches-tropicaux.com>

Motchebelele M.T, Winter-Nelson A, 2000. "Migrant Labor and Farm Technical Efficiency in Lesotho." *World Development* 28, 1: 143-153.

Nzeyimana I, Henry MC, Dossou-Yovo J, Doannio JMC and Carnevale P, 2002. "Epidémiologie du Paludisme dans le Sud-Ouest Forestier de la Côte d'Ivoire." *Bulletin de la Société de Pathologie Exotique* 95, 2: 89-94.

Otsuka K and Hayami Y, 1988. "Theories of Share Tenancy: a Critical Survey." *Economic Development and Cultural Change* 37: 31-68.

Pender J, Nkonya E, Jagger P, Sserunkuum D and Ssali H, 2004. "Strategies to increase agricultural productivity and reduce land degradation: evidence from Uganda." *Agriculture Economics* 31, 2-3: 181-195.

Pender J, Fafchamps M, 2001. "Land Lease Markets and Agricultural Efficiency : Theory and Evidence from Ethiopia, Environment and Production Technology Division." Discussion Paper n° 81, Washington DC: International Food Policy Research Institute.

Ruf F, 1995. *Booms et Crises du Cacao, les Vertiges de l'Or Brun*. CIRAD, Khartala: Ministère de la Coopération.

Sauerborn R, Adams A, Hien M, 1996. "Household Strategies to Cope with the Economic Costs of Illness." *Social science and Medicine* 43, 3: 291-301.

Sen A, 1993. "Capability and Well-Being." In *The Quality of Life*, ed. M. Nussbaum and A. Sen, Oxford: Clarendon.

Schultz TP, Tansel A, 1997. "Wage and Labor Supply Effects of Illness in Côte d'Ivoire and Ghana: Instrumental Variable Estimates for Days Disabled." *Journal of Development Economics* 53: 251-286.

Singh N, 1980. "Theories of Sharecropping." In *the Readings in Development Microeconomics (T1: micro-theory)*, ed. P. Bardhan and C. Udry, The MIT Press, Cambridge: Massachussets.

Thomas D, 1997. Incomes, expenditures and health outcomes: evidence on intrahousehold resource allocation, In : *Intrahousehold Resource Allocation in Developing Countries*, L. Haddad, J. Hoddinott et H. Alderman (Eds), The John Hopkins Press, 142-164.

Yao S, 1996. The determinants of cereal crop productivity of the peasant farm sector in Ethiopia, 1981-1987, *Journal of International Development* 8, 1, 69-82.

Wagstaff A, 2005. The economic consequences of health shocks, Policy Research Working Paper 3644.

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² *This sector accounted for 60% of exports at the end of the eighties (Deaton, 1988) and 40% at the end of the nineties (Marchés Tropicaux, 2000).*

³ *The tracker strides over rural tracks in order to negotiate the purchase price directly with the farmer with the objective to buy the production. He can work for his own, for a trader who will then resell to exporters or to manufacturers such as Nestle.*

⁴ *The second degree concerns the random selection of the population (245 inhabitants per village) applying a Poisson regression. Then, approximately, 42 families per village were selected.*

⁵ *The sharecroppers, who are migrants, live close to the plantations.*

⁶ *This distribution comes from the fact that the owner recovers the cost of the inputs which represents a third of the production. These contracts differ from the ones observed elsewhere. For instance, in Ethiopia, the owner receives 1/3, 1/4 or 1/5 of the harvest as he does not support the costs of the inputs (Benin et al, 2005).*

⁷ *Antimalarial drugs consumption has not been observed as household members did not correctly answer to this question.*

⁸ *The difference is significant.*

⁹ *Mosquitoes are numerous in the fields.*