Economic Analysis of a Fuelwood Consuming Activity: Empirical Evidence for Traditional Red Sorghum Beer Producers in Ouagadougou, Burkina Faso

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Abstract

This paper aims to analyze the determinants of input demand for local red sorghum beer production in Ouagadougou, which is an activity conducted mainly by women from these areas. The descriptive analysis in the paper emphasizes on the extent of this activity in the national economy, and namely in firewood consumption. The producer theory approach through an econometrical method using a cost translog function also helps to derive conditional input demand namely for firewood. The estimated coefficients of firewood conditional demand of local beer producers, ''dolotières'', have shown weak price elasticity hampering the fuelwood price policy. However, the simulation regarding taxation of fuelwood price effect on quantity demanded consequently states an overall reduction in demand for fuelwood in Ouagadougou. This induces a decrease in the local beer producer's profit for a given level of production. In addition, the paper deals with short term analyses.

Keywords: Translog Cost Function, return to scale, dolo supply, elasticities, red sorghum beer, producer's surplus, firewood demand

1. Introduction

Most studies on the demand for wood energy in developing countries are referred to as household demand. Several authors have studied the determinants of household energy choices and the transition between wood energy and other conventional sources of energy: Hosier (1988), Ferari (1990), Hosier and Dowd (1997), Ouedraogo (2002; 2006), and Fawelinmi Oyerinde (2002), Campbell et al (2003). Some authors were also interested in describing wood energy sector and quantifying the volume and value of timber produced on certain markets (Chavin, 1981; Sow, 1990; Banks et al., 1996; Alam et al., 1998).

These studies have either emphasized the scale of the problems of urban and rural households' wood energy supply, or analyzed the relationship between the demand for wood energy and income levels of households. They have also described the difficulties to substitute other energy sources to firewood and have contributed to the evaluation of the determinants of household energy choices.

This attention to consumption of wood for domestic use obscures the usage of wood in crafts. However, it is clear that the majority of artisans in Sub Saharan Africa uses wood energy as input in their production, so that today, due to growth of certain craft activities (various foundries, forges, jewelry, traditional brewery, restaurant etc.), this demand especially in urban areas, far exceeds domestic demand. In Ouagadougou, the aggregate demand of wood energy in 2000 is shared by 59% as intermediate consumption for artisans and 41% as household consumption. The five major categories of artisans whose demand for fuelwood is very marked in this city are the bronze foundries, aluminum smelters, restaurant owners, barbecue and local red sorghum beer producers namely "dolotières".

In the foregoing contribution (of artisan usage of firewood), it is the "dolotières" who catch our attention. They produce "dolo", a traditional beer made from red sorghum. This activity is conducted by more than 1,000 of women in Ouagadougou. *Dolo* preparation requires two days of cooking and uses an average of 458.17 kg of firewood, that is, about a half ton of wood. In 2000, wood consumption for the production of *dolo* amounted to

48,269 tons, representing 28% of craftsmen's total consumption and 16.5% of wood total consumption. Note that this activity generates significant revenue for very vulnerable social strata. Since the devaluation of the CFA franc in January 1994 in West African Economic and Monetary Union (WAEMU) countries, higher prices for industrial beer resulted in increased dolo demand, which induces an increase in the production of this traditional beer and an increase in the number of production units.

As it is difficult to conduct effective policies for firewood substitution by other sources (of energy) for households mainly due to the heterogeneity in this population, public interventions on a production sector such as dolo production which is relatively homogeneous could be easier and more effective to design and implement.

The objective of this work is to bring together elements of an economic analysis in order to provide better insight into the possibilities to limit firewood consumption in a sector that heavily relies on it.

After delivering pieces of information on the processing and marketing of *dolo*, we will econometrically estimate the function of total production cost, and we analyze the properties of production technology. We will then go through an aggregate approach of supply function for the city of Ouagadougou. The results obtained will allow us to outline effective policies to reduce wood consumption in this activity.

2. Notes on *Dolo* Production and Data Set

We consider the description given by Marie-Michele Ouedraogo (1974, p. 284). "Red Sorghum purchased on the market or in the countryside, is put to germinate, [and] then dried up before being crushed. Thus, it is quenched in large jars half stuck in the ground. The mixture is stirred and bailed out, and transferred into cooking jars put on wood fireplaces. After a first cooking of about three hours, a new transfer occurs in the jars stuck in the ground, where the mixture cools for hours. A second cooking of seven or eight hours completes the preparation of *dolo*. We then have a sweet non-alcoholic juice called "Biss-Kom" or water of germinated red sorghum. From that moment, the *dolo* is drinkable, but it is never marketed at this stage. The liquid is again cooled in jars stuck in the ground and then fermented for a long time with a handful amount of sourdough incorporated by the "dolotière". In Ouagadougou, plants of all kinds can be introduced into the *dolo* at that moment to activate fermentation and spice *dolo* taste. *Dolo* must be kept the night of the second day of preparation and the morning of the third day it is ready [for consumption] …" So is summarized the process of making this traditional beer that lasts about ten hours of preparation.

Women who produce red sorghum beer are called "dolotières". *Dolo* has a very important cultural value and occurs largely in the tradition of the Burkinabe people (customary rites and festivals). It is also a highly priced drink in both urban and rural areas. The CFA franc's devaluation in January 1994 and the country's fiscal policy regarding taxation of alcoholic beverage greatly contributed to raising the price of industrial beer. As a consequence, demand for traditional beer has increased, resulting in new entry of "dolotières" in the *dolo* industry and in increasing the number of producers. "Dolotières" are present in all districts and neighborhoods of Ouagadougou, though it should be noted that their density is higher in the suburbs (newly parceled and non-parceled areas).

The data used in this study were collected in 2000 during extensive surveys on "*craftsmen woodfuel demand in Ouagadougou*". These surveys were funded by the Coordination Unit of the Regional Program of Traditional Energy Sector (UC-RPTES). A specific questionnaire was developed for "dolotières". Of 1013 dolotières located in Ouagadougou, 154 were interviewed during the survey, that is, 15% of these producers. Table 1 provides details of key economic data listed.

Table 1. Key economic variables collected on "dolotières"

Variables	Units
Production of « Dolo »	Liter « Dolo » or value in CFA Franc
Price of « Dolo »	CFA F/Liter
Cost of red sorghum (ferment)	CFA F/Kilogram
Price of red sorghum	CFA F/Kilogram
Firewood cost	CFA F/Kilogram
Firewood price	CFA F/Kilogram
Water cost	CFA F/Liter
Water price	CFA F/Kilogram
Wage / production	CFA F/Employee/production (cooking)
Firewood quantity	Kilogram

| Water quantity | Liter |
| Red sorghum ferment quantity | Kilogram |

Source: RPTES (2000).

It should be noted that this information relates mainly variable costs. This leads us to confine ourselves to a short term approach, without direct consideration of fixed costs. These data will be used to develop a total restricted variable cost function. We will use a flexible functional form: the translog.

3. A Translog Model of Total *Dolo* Production Costs

The non-homothetic translog function is a second order Taylor series of the logarithm of the cost with respect to the logarithm of the explanatory variables. It gives an approximation of an unknown function *a priori* and imposes relatively few restrictions on production technology. We can add that cost shared equations derived are linear in parameters. Unlike homothetic functions, conditional demands for input are function of production level. Given its properties, it is the most common functional form used to specify cost functions (Note 1) nowadays.

3.1 Model Functional Specification

The non-homothetic Translog Cost Function is written as follows:

$$\ln C = \ln \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln P_i + \frac{1}{2} \cdot \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln P_i \ln P_j + \alpha_y \ln Y + \frac{1}{2} \gamma_{yy} (\ln Y)^2 + \sum_{i=1}^{n} \gamma_{iy} \ln P_i \ln Y \qquad (1)$$

where $\gamma_{ij} = \gamma_{ji}$,

i, j = firewood (B), germinated red sorghum (M), labor (L) and water (E); C is the total cost of production, Pi the price of the ith input, Y the quantity of *dolo* produced.

Factor prices and production levels are exogenous variables. α and γ are parameters to be estimated (Note 2).

In order to adequately describe producer's behavior, cost function must be, among other things, homogeneous of degree 1 with respect to prices of inputs used, for a given level of production. This implies the following restrictions:

$$\sum_{i=1}^{n} \alpha_i = 1, \quad \sum_{i=1}^{n} \gamma_{ij} = \sum_{i=1}^{n} \gamma_{ji} = \sum_{i=1}^{n} \gamma_{iY} = 0 \qquad (2)$$

Other restrictions inherent to Translog Cost Function could be added:

- For this cost function to be homothetic, it is necessary and sufficient that the parameters $\gamma_{iY} = 0 \ \forall \ i = 1,....,n.$ Homogeneity of constant degree with production function takes place if in addition to the foregoing restrictions on homotheticity, we set: $\gamma_{YY} = 0$; in which case the degree of homogeneity is equal to $1/\alpha_Y$.

- The constant returns to scale of dual production function will appear if, in addition to the restrictions of homotheticity and homogeneity, $\alpha_Y = 1.$ Finally, translog function reduces to Cobb-Douglas function with constant returns to scale if, besides all the above-mentioned limitations, we require that each of $\gamma_{ij} = 0, i, j = 1,....,n.$

3.2 Estimation Procedure

The Translog Cost Function can be directly estimated from equation (1), but for more efficient estimators, it can be achieved by estimating the optimum demand equations of factors resulting from cost minimization, transformed here into cost shares of factors equations (E. R. Berndt, 1991). Thus, by deriving the equation (1) and using Shephard's lemma, we obtain the following cost shares of factors equations:

$$\frac{\partial \ln C}{\partial \ln P_i} = \frac{P_i}{C}\frac{\partial C}{\partial P_i} = \frac{P_i X_i}{C} = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln P_j + \gamma_{iY} \ln Y \tag{3}$$

where $\sum_{i=1}^{1} P_i X_i = C,$ total cost of factors.

The cost shares of factors S_i, are defined as follows:

$$S_i \equiv P_i X_i / C, \text{ et } \sum_{i=1}^{n} S_i = 1.$$

For this study, "dolotières" use four factors of production. So, factor demand equations or cost shares of factor equations will be as follows in the system of equations (4):

$$S_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln P_j + \gamma_{iY} \ln Y \quad , \quad i = 1, 2, .., 4 \tag{4}$$

Note that without symmetry restrictions there are 24 parameters to be estimated, six in each of four cost shares equations. If the constraints of symmetry between the four equations are imposed $(\gamma_{12} = \gamma_{21}, \gamma_{13} = \gamma_{31}, \gamma_{14} = \gamma_{41}, \gamma_{23} = \gamma_{32}, \gamma_{24} = \gamma_{42}, \text{ and } \gamma_{34} = \gamma_{43})$, the number of parameters to be estimated is reduced to 18. As previously posed in equation (2), economic theory requires that the Translog Cost Function be homogeneous of degree 1 with respect to factor prices: the inclusion of this constraint results in the following restrictions in the group of equations (5):

$$\sum_{i=1}^{4} \alpha_i = 1 \quad , \quad \sum_{i=1}^{4} \gamma_{iY} = 0, \quad \sum_{j=1}^{4} \gamma_{ij} = 0 \quad , \quad i = \{1, 2, 3, 4\ \} \tag{5}$$

These six restrictions will further reduce the number of parameters to estimate from 18 to 12. The system of equations of factors' demand has the special property that for each observation, the sum of the dependent variables (the share of cost) of all equations is always equal to one. Indeed, if there are n units of factor cost (or factor demand equations), only n-1 are linearly independent. This property of factor demand equations has several econometric implications on which we will focus our attention.

First, since the sum of cost shares is always equal to unity and only n-1 of factor demand equations are linearly independent, then system (5) relations imply that the sum of Ordinary Least Squares (OLS) residuals u_i across all factor demand equations is always equal to 0 for each observation:

$\sum_{i=1}^{4} u_i = 0$, and errors matrix A* is singular and non-diagonal.

Second, because of the unit amount of cost shares of factors for each observation, when symmetry restrictions are not imposed, estimation equation by equation using least squares (OLS) method gives parameters that always obey property of homogeneity in the system of equations (5). Berndt and Wood (1975.1979) have empirically shown that the parameters estimated by OLS, when the constraint of symmetry among the demand for factors equations is not imposed, still obey the restrictions of the system (5). However, the cross product of OLS residues matrix is not singular. Thus, OLS method produces good estimators.

Third, the fact that the covariance and errors cross-product matrices must both be singular, the estimation by the method of maximum likelihood, which minimizes the cross product of errors, is not feasible. Also, the procedure most commonly used to solve matrix singularity problem is to eliminate arbitrary one of the n demand equations and proceed to the estimation of the n-1 remaining equations by the ML method. In this case, we will eliminate the fourth equation and directly estimate, equation by equation, the 12 parameters of the three equations shown in system (6):

$$S_1 = \alpha_1 + \gamma_{11} \ln(P_1 / P_4) + \gamma_{12} \ln(P_2 / P_4) + \gamma_{13} \ln(P_3 / P_4) + \gamma_{1Y} \ln Y$$
$$S_2 = \alpha_2 + \gamma_{21} \ln(P_1 / P_4) + \gamma_{22} \ln(P_2 / P_4) + \gamma_{23} \ln(P_3 / P_4) + \gamma_{2Y} \ln Y \tag{6}$$
$$S_3 = \alpha_3 + \gamma_{31} \ln(P_1 / P_4) + \gamma_{32} \ln(P_2 / P_4) + \gamma_{33} \ln(P_3 / P_4) + \gamma_{3Y} \ln Y$$

Eliminated equation parameters are deduced indirectly from restrictions tied to the property of homogeneity in system (5), which allows them to be written in terms of estimated parameters of the first three equations. These

parameters are expressed as follows:

$$\alpha_4 = 1 \ -(\alpha_1 + \alpha_2 + \alpha_3)$$
$$\gamma_{14} = \ -(\gamma_{11} + \gamma_{12} + \gamma_{13})$$
$$\gamma_{24} = \ -(\gamma_{12} + \gamma_{22} + \gamma_{23})$$
$$\gamma_{34} = \ -(\gamma_{13} + \gamma_{23} + \gamma_{33})$$
$$\gamma_{4Y} = \ -(\gamma_{1Y} + \gamma_{2Y} + \gamma_{3Y})$$
$$\gamma_{44} = \ -(\gamma_{14} + \gamma_{24} + \gamma_{34}) \ \Rightarrow \ \gamma_{44} = \gamma_{11} + \gamma_{22} + \gamma_{33} + 2(\gamma_{12} + \gamma_{13} + \gamma_{23})$$

(7)

Note that the parameters indirectly estimated are linear combinations of parameters estimated directly from the three equations selected. Likewise, variances of these parameters are linear combinations of those of the first equations, which facilitate their computation.

4. Results and Economic Analysis of Dolo Production

The sample used includes 149 "dolotières" of the 154 respondents. For the estimation, several methods are used (OLS, 2SLS, 3SLS and ML). We will favor the method of Maximum Likelihood, since it not only gives invariant parameters, but also provides statistics that directly help test our hypotheses.

4.1 Variable Total Cost Function of Folo Production

We have simultaneously estimated the demand functions for input and the cost function under the constraints of symmetry, of homothety and of homogeneity.

Table 2. Estimation results by the method IZEF / LM (SUR) of cost shares equations and of the Translog Cost Function. 149 sample observations. T-statistics are in parentheses

Translog Cost Function			
Variables	Parameters	Variables	Parameters
$\alpha(0)$	10,942 (616,9)***	$\gamma(LY)$	-0,027 (-2,5)**
$\alpha(B)$	0,312 (45,0)***	$\alpha(B)$	0,312 (45,0)***
$\alpha(M)$	0,583 (89,6)***	$\gamma(BB)$	0,134 (5,0)***
$\alpha(E)$	0,053 (23,5)***	$\gamma(BM)$	-0,128 (-5,5)***
$\alpha(L)$	0,052 (0,1)	$\gamma(BE)$	0,0003 (0,0)
$\gamma(BB)$	0,134 (5,0)***	$\gamma(BL)$	-0,006 (-0,2)
$\gamma(MM)$	0,204 (8,5)***	$\gamma(BY)$	-0,039 (-5,2)***
$\gamma(EE)$	0,035 (12,4)***	$\alpha(M)$	0,583 (89,6)***
$\gamma(LL)$	0,053 (1,1)	$\gamma(MM)$	0,204 (8,5)***
$\gamma(BM)$	-0,128 (-5,5)***	$\gamma(ME)$	-0,032 (-5,6)***
$\gamma(BE)$	0,0003 (0,0)	$\gamma(ML)$	-0,044 (-1,3)
$\gamma(BL)$	-0,006 (-0,2)	$\gamma(MY)$	0,072 (10,2)***
$\gamma(ME)$	-0,032 (-5,6)***	$\alpha(E)$	0,053 (23,5)***
$\gamma(ML)$	-0,044 (-1,3)	$\gamma(EE)$	0,035 (12,4)***
$\gamma(EL)$	-0,003 (-0,3)	$\gamma(EL)$	-0,003 (-0,3)
$\alpha(Y)$	0,801 (39,7)***	$\gamma(EY)$	-0,006 (-2,7)***
$\gamma(YY)$	-0,064 (-2,4)**	$\alpha(L)$	0,052 (0,1)
$\gamma(BY)$	-0,039 (-5,2)***	$\gamma(LL)$	0,053 (1,1)
$\gamma(MY)$	0,072 (10,2)***	$\gamma(LY)$	-0,027 (-2,5)***
$\gamma(EY)$	-0,006 (-2,7)**		

Statistics	Functions				
	Firewood	Red Sorghum	Water	Labor	Log (Variable Cost)
R^2	0,20	0,48	0,52	0,40	0,95
Ajusted-R^2	0,18	0,46	0,51	0,38	0,94
Durbin-Watson	1,87	1,86	2,06	1,58	1,80
Mean dependent var.	0,33	0,57	0,05	0,06	10,61

B = Firewood, M =Germinated Red Sorghum (ferment), L = Labor, E = Water.

*** implies that the coefficient is statistically significant at 1%,

** implies that the coefficient is statistically significant at 5%

* implies that the coefficient is statistically significant at 10%.

IZEF/LM = Iterative Seemingly Unrelated Regression

Parameters estimated by IZEF/LM method are consistent with symmetry constraint, and are linearly homogeny to prices.

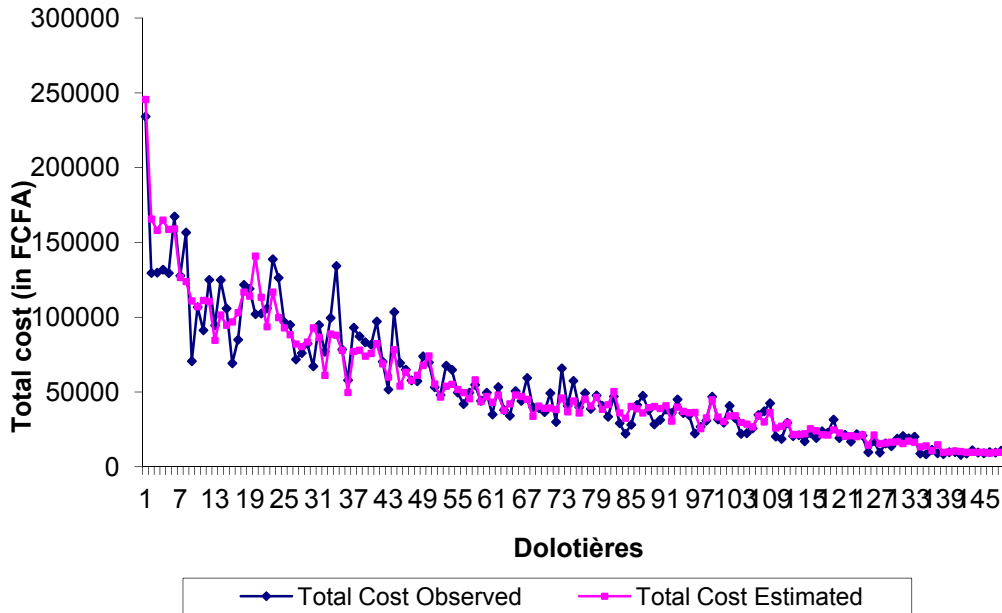Graph n°1 shows adjustment of cost function to data.

Figure 1. Total cost of dolo production

If one focuses on the relationship between quantity produced and total production costs, by setting the variables to their average price, we obtain the line represented by the graph n° 2

Figure 2. Links between quantities produced of dolo and total cost (setting prices to the sample average)

4.2 Economic Analysis of Dolo Production Technology

4.2.1 Cost Shares

Estimation procedure of total cost bases upon the computation of cost shares. These are obtained par the formula (4 bis):

$$S_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln P_j + \gamma_{iY} \ln Y, \quad i,j = B, M, L, E. \quad (4\,bis)$$

The leading share is from millet, and then wood with respectively on average, 57% and 32%. The other two factors weigh very little since water is 5% and wages 1% of the variable total cost.

Since our focus is on wood consumption, it is interesting to examine the relationship between the share of costs devoted to wood and the level of *dolo* production. Table 2 shows that the coefficient γ_{BY} is negative. This effect is clearly illustrated on graph 3 which connects the cost shares of wood to production level.

Figure 3. Trend of wood cost share with respect to dolo production

Production is characterized by a decrease of costshare devoted to the factor of production, wood, when the quantities produced increase. This assumes the existence of production technology of increasing returns to scale as indicating an improvement in inputs (firewood) productivity when stepping dolo production.

4.2.2 Return to Scale

The whole process seems to present returns to scale. As Giora Hanoch (1975) showed it, returns to scale (presented here by μ) are computed as the inverse of elasticities of cost function with regard to production (Note 3) (εCY):

μ=1/εCY, where   εCY=∂lnC/∂lnY =αY+γBYlnPB+γMYlnPM+γLYlnPL+γEYlnPE+γYYlnY   (8)

εCY is computed using average prices of factors or by approximating this quantity relative to the average marginal cost and the mean of average costs observed.

Calculation gives the value: εcy = 0,801 and a return to scale: μ=1/εcy = 1,25. So, technology shows an increasing return to scale.

4.2.3 Marginal Cost of Production

We scrutinize production marginal cost taking into account input prices set to the sample average. To the extent that variable total cost has been estimated by normalizing the variables, terms linked to prices cancel out, and average variable total cost (CTVM) becomes:

$$CTVM = \frac{e^{\alpha_0}}{\bar{Y}^{\alpha_Y}} Y^{\alpha_Y} e^{\gamma_{YY} \left[\ln(Y) - \ln(\bar{Y})\right]^2} \qquad (9)$$

Thus, marginal cost gives:

$$CmVM = \frac{\partial CTVM}{\partial Y} = -\frac{e^{\alpha_0}}{\overline{Y}^{\alpha_Y}} \Big[2\gamma_{YY} \ln(\overline{Y}) - \alpha_Y - 2\gamma_{YY} \ln(Y) \Big] Y^{(\alpha_Y - 1)} e^{\gamma_{YY} \big[\ln(\overline{Y}) - \ln(Y) \big]^2} \tag{10}$$
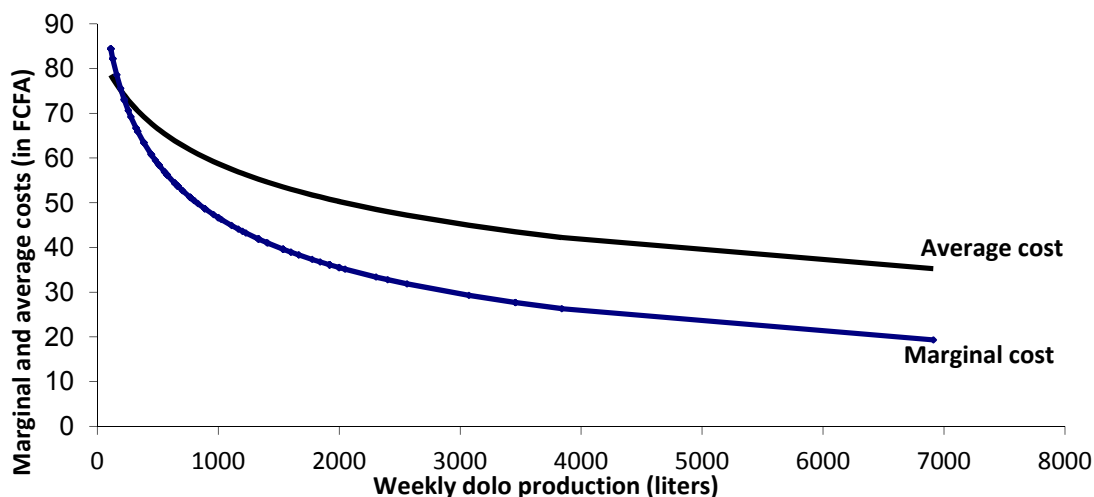
The following graph 4 shows marginal and average costs curves.

Figure 4. Marginal and mean costs of dolo production (setting inputs prices to sample average)

Marginal cost is a decreasing function of the production. This does confirm the existence of the previously identified increasing return to scale.

We have computed marginal costs relating to each "dolotière" k considering input prices that each of them faces. The formula used is then:

$$CmVM_k = \frac{\partial CTVM_k}{\partial Y_k} = -\frac{e^{b_k}}{\overline{Y}^{c_k}} \Big[2\gamma_{YY} \ln(\overline{Y}) - c_k - 2\gamma_{YY} \ln(Y_k) \Big] Y_k^{(c_k - 1)} e^{\gamma_{YY} \big[\ln(\overline{Y}) - \ln(Y_k) \big]^2} \text{, avec}$$

$$b_k = \alpha_y + \sum_i \gamma_{iY} \ln\left(\frac{P_{ik}}{\overline{P}_i} \right) \text{ et } c_k = \ln \alpha_0 + \sum_{i=1}^n \alpha_i \ln\left(\frac{P_{ik}}{\overline{P}_i} \right) \tag{11}$$

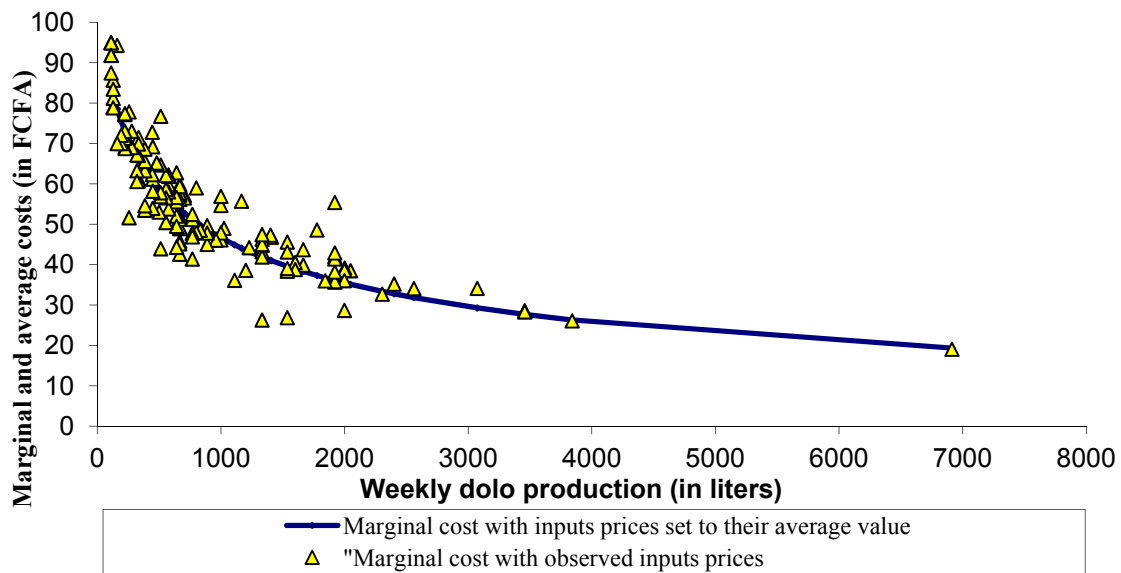Graph 5 shows marginal costs distribution according to production level.

Figure 5. Estimated and trend of marginal costs of dolo production (setting prices to sample average)

4.2.4 Technical Substitution Elasticities

Allen's partial substitution elasticities allow to measure technical substitution between factors of production. These crossed between one another indicate which ones are substitutable or complementary. A positive (negative) value of σ_{ij} implies that factors i and j are substitutable (complementary); if $\sigma_{ij} = 0$, then the two factors are independent (Field and Berndt, 1981, p. 55). These elasticities are computed through the following formula:

$$\sigma_{ij} = \frac{\gamma_{ij} + S_i S_j}{S_i S_j}, \qquad i,j = 1,....,n, \quad mais \quad i \neq j$$

$$\sigma_{ii} = \frac{\gamma_{ii} + S_i^2 - S_i}{S_i^2}, \quad i = 1,....,n \quad avec \quad i = j$$

(12)

γ_{ij}, γ_{ii}, S_i, S_j are respectively coefficients of factors prices, and cost shares of different factors in the production.

Table 3. Allen's partial technical substitution elasticities

	Firewood	Red Sorghum	Water	Labor
Fuelwood	**-0,8021**			
Red Sorghum	0,1004	**-0,1277**		
Labor	0,0023	-0,0004	**-4,8037**	
Water	0,0021	-0,0012	0,0000	**-0,1506**

Germinated millet, water and labor appear weakly substitutable to firewood. We observe a complementarity between germinated millet and water, and between germinated millet and labor.

4.2.5 Input Price-Elasticities

Direct and cross price-elasticities of input conditional demand are given by the following formula:

$$\varepsilon_{ij} = \frac{\gamma_{ij} + S_i S_j}{S_i}, \quad i = 1, \ldots, n, \quad avec \quad i \neq j$$

$$\varepsilon_{ii} = \frac{\gamma_{ii} + S_i^2 - S_i}{S_i}, \quad i = 1, \ldots, n, \quad avec \quad i = j$$

(13)

A given factor demand sensitivity to changes occurring in its own price is measured thanks to direct price-elasticities. Existing economic relation between factors is quantified by cross price-elasticities.

Table 4. Input demands price-elasticities

	Firewood	Red Sorghum	Water	Labor
Firewood	**-0.26241**			
Red Sorghum	0.17672	**-0.07257**		
Labor	0.04845	-0.00864	**-0.22905**	
Water	0.03723	-0.02054	-0.00047	**-0.00857**

From all factors, firewood is the most responsive to its own price. A 1% increase of its price induces a 0.26% decrease in its demand. We find that geminated millet of which the cost share is prevailing is found to have a relatively low own price elasticity (0.07%). Cross-price elasticities with firewood are positive, the highest being the one between firewood and germinated millet. A price increase of these factors leads to an increased demand for firewood. As for sprouted millet, its technical substitutability with firewood, observed above, is legitimated. For the other two factors, we keep commenting the figures due to their very low coefficients.

4.3 Results for Dolo Production Industry in Ouagadougou

4.3.1 Supply Function of Dolo

Total production per week of the surveyed sample is 142,021 liters for the 149 "dolotières". The sampling procedure allows us to assume these samples as representative. We can then estimate the total production of dolo for the city of Ouagadougou provided by the 1013 "dolotières" to: 142021 × (1013/149) = 965 550 liters. To establish the supply curve, we aggregate the productions according to the level of marginal cost by assigning each sample production the multiplicative coefficient of that one (1013/149). Graph No. 6 restores the supply curve.
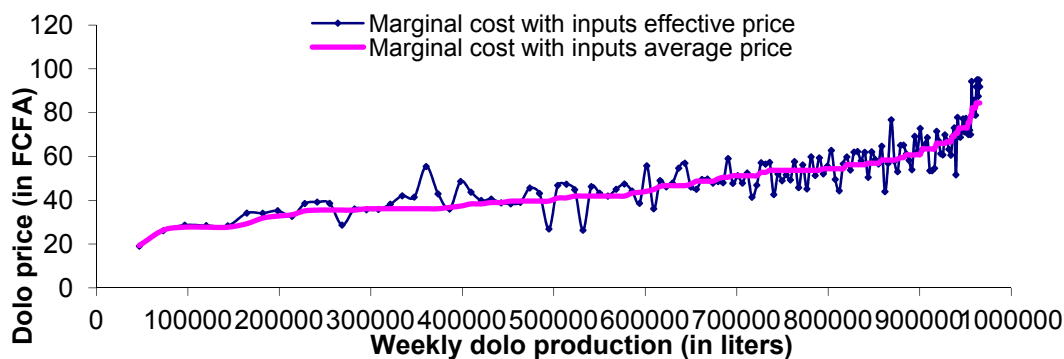

Figure 6. Dolo weekly supply curve

A review of producers' staff according to their production capacity shows that a relatively small number of "dolotières" provides a very significant share of production. Graph No. 7 describes this situation.
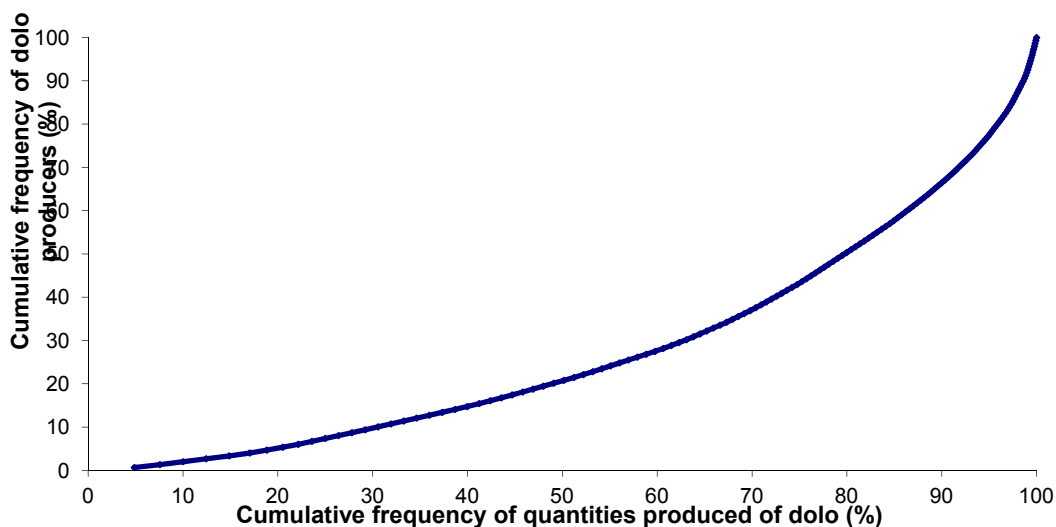
Figure 7. Concentration of dolo production's activity

We remark that 50% of production is provided by 20% of "dolotières", and that 50% of "dolotières" supply 80% of the market. This relative concentration is to be taken into account in any policy designed to promote a reduced use of firewood.

4.3.2 Dolo Producers' Total Surplus

The price per liter of *dolo* is uniform over the city of Ouagadougou. It is 100 CFA Franc (Note 4). Examination of the supply curve and the level of price 100 CFA F show the producer surplus. To the extent that we do not have individualized information on fixed costs, we will not calculate the profit, but producer surplus which is the difference between their turnover and their variable total cost.

Here, the total surplus per week establishes at 42.09 million of CFA Franc. That is, 2,188.72 million of CFA F per year. It is found that this activity is highly profitable.

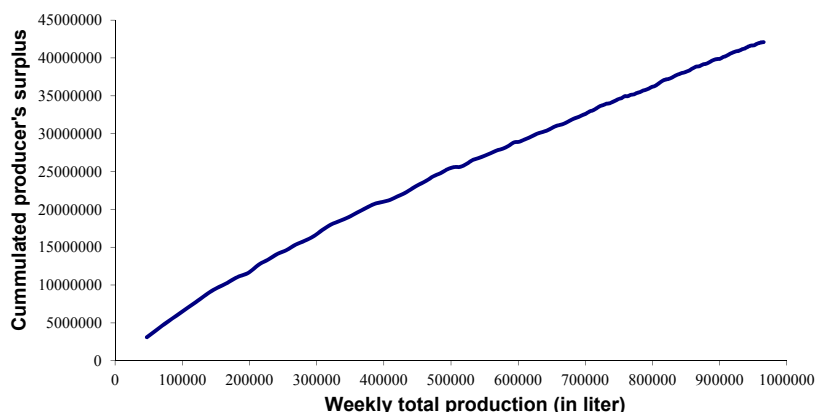Graph 8 shows the evolution of total producer's surplus as a function of total production.

Figure 8. Trend of cumulated producers's surplus as a function of dolo total production

Production concentration, as above observed, add to the existence of economy returns of scale contribute to magnify concentration in producers' surplus mobilization.
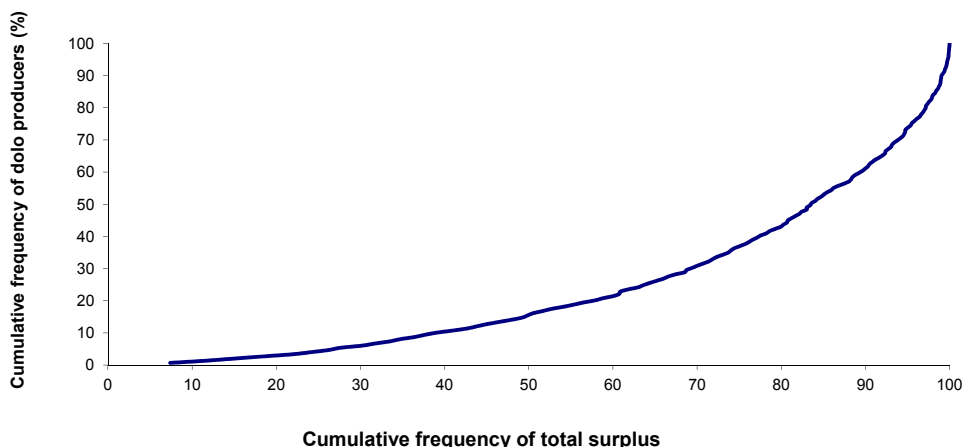
11

Figure 9. Concentration of total surplus between dolo producers

Graph N° 9 reveals that almost 60% of the total surplus is mobilized by 20% of producers.

4.3.3 Firewood Demand for Dolo Production

Shepard's lemma allows getting directly conditional demand functions from cost function. As for firewood, we get:

$$Q_B(P_B, P_M, P_E, P_L, Y) = \frac{\partial CTV(P_B, P_M, P_E, P_L, Y)}{\partial P_B} \tag{14}$$

Fixing values, excepted wood price to sample average, induces variable total cost to become:

$$\ln(CTV) = \ln(\alpha_0) + \alpha_B \ln(\frac{P_B}{\overline{P_B}}) + 1/2\alpha_{BB}\left[\ln(\frac{P_B}{\overline{P_B}})\right]^2 \tag{15}$$

Or:

$$CTV = e^{\alpha_0}\left(\frac{P_B}{\overline{P_B}}\right)^{\alpha_B} e^{\left[1/2\alpha_{BB}\left(\ln(\frac{P_B}{\overline{P_B}})\right)^2\right]} \tag{16}$$

$$\frac{\partial CTV}{\partial P_B} = \left(\frac{e^{\alpha_0}}{\overline{P_B}^{\alpha_B}}\right)\left(\alpha_B - \alpha_{BB}\ln(\frac{P_B}{\overline{P_B}})\right) P_B^{(\alpha_B-1)} e^{1/2\alpha_{BB}\left(\ln(\frac{P_B}{\overline{P_B}})\right)^2} \tag{17}$$

Relying on firewood prices paid by "dolotières" in the sample, we can plot demand function derived from millet beer production wood as in graph no. 10.
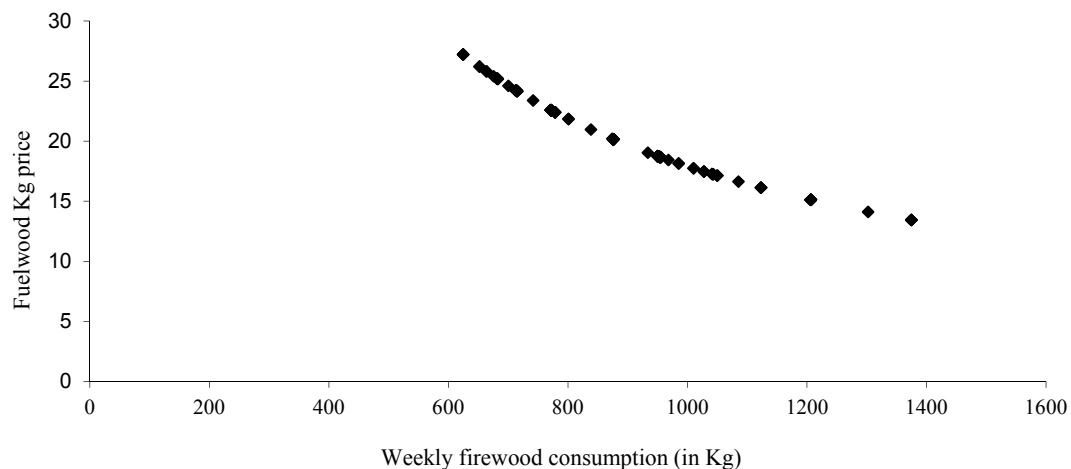
Figure 10. Firewood demand for dolo production

Examination of direct-price elasticity for firewood ε_{BB}= -0,262 confirms that firewood demand is not rigid, even though this value is quite low.

4.4 Simulations for a Lower Usage of Firewood in Dolo Production

We will develop only analyses with regard to actions regarding variable factors. This should be supplemented by a combined action on the fixed factors.

4.4.1 Effects of an Environmental Levy on Firewood Demand

To restore a proper pricing of the resource and to get virtuous results in saving resource, in alternating source of energy and in incentivizing an increase of supply, it is often advised to build on taxation through the re-adjustment of existing taxes or charges, or by creating new taxes.

It is known that the price of the standing resource is on average very low and often below the cost of rebuilding the resource. A study of firewood price structure sold at retail shows that the share of taxes related to the resource itself (environmental taxes and charges related to the regulation of uses) represents 20.4% of the price. The effectiveness of this tax is problematic, particularly with regard to environmental taxes. Arguably, 1,167,610 cubic meters get beyond environmental taxes. That is, a loss of 1.051 billion CFA francs. This represents a percentage of 85% of tax avoidance. Since the industry supplying "dolotières" uses large motorized transport (trucks with a capacity of 12 to 35 cubic meter of wood) sourcing generally in arranged and controlled timber yards, it is assumed that the degree of avoidance is lower than the observed one throughout firewood sector in Ouagadougou, and this rate of avoidance is at an average level of about 50% for the sector affecting "dolotières".

Hypothesis:

Tax avoidance = 50%

Eco tax = 20.4%.

If there is more evasion, the average price is × 2.

p the price of firewood

H the percentage increase

H × 0.204 × 2p = 1.25 p, equally h = 1.25 / 0.204 × 2 = 3

A multiplier coefficient of 3, associated with a general implementation led to an increase in retail prices of wood by 25%.

We will show what effects of such an increase are on firewood consumption for *dolo* production, on *dolo* production itself and on producers.

Conditional demand for timber factor will be modified by the reassessed price of wood. Starting from demand function derived from equation 17, we can draw the new profile.

The movement of wood demand curve resulting from changing of wood supply conditions (charging the price at 25%) is given by graph 11.
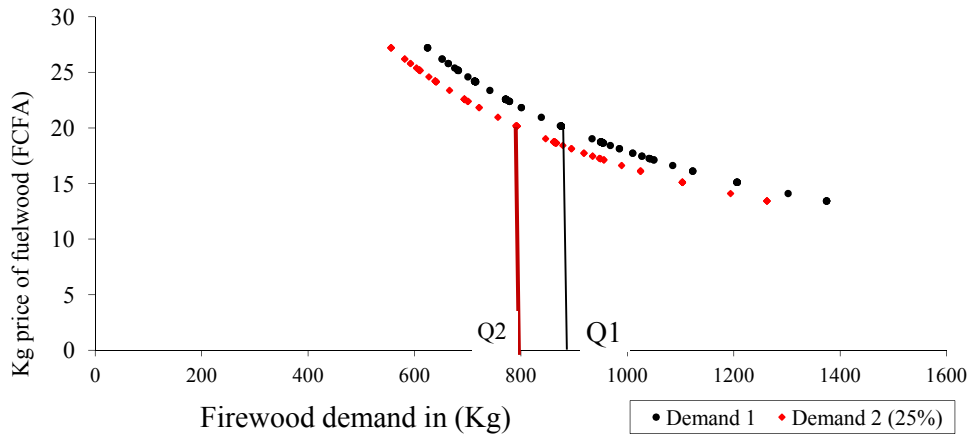

Figure 11. Effects of firewood demand of an environmental levy of 25% on firewood prices

This is achieved by assuming that the prices of all other factors are fixed at their average. We clearly observe a downward shift of the derived demand for wood, meaning that for the same price level the quantity demanded of firewood is always less on disturbed demand than on the initial one. For the same price level, the quantity required from the disturbed demand curve is always less than that of the original demand curve (Q2 <Q1).

We will more accurately calculate the change in quantity consumed, considering the factor price for each producer. The introduction of a 25% tax on timber prices will generate on average and by "dolotière" a weekly decline in quantity demanded of firewood of 85 kg, representing *dolotière*'s weekly saving of wood generated. On a global scale of all "dolotières" of this town, an annual saving of firewood resulting from this tax will be around a volume of 4,915 tons of firewood.

4.4.2 Effects of an Environmental Levy on Dolo Production

Chart No. 12 shows the movement direction of the aggregate supply curve by dolotières following a rise in firewood price 25%.
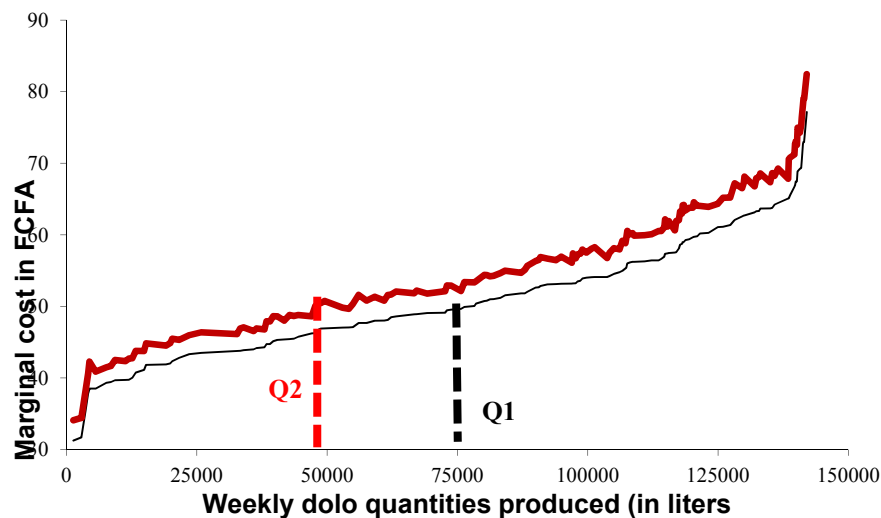

Figure 12. Effects of an environmental levy on dolo total supply in Ouagadougou

Rising timber prices will lead to a change in *dolo* supply conditions. The rising of firewood price will cause an upward movement of the supply curve to reflect naturally the increase in marginal cost due to this price increase. This upward shift of the aggregate supply curve represents a drop in *dolotière*'s profit, since for a given level of output, marginal cost is higher for supply curve 2 (*Offer* 2). This decrease in the *dolotière*'s profit reflects a loss of *dolotière*'s production surplus due to firewood high price.

The annual loss of production surplus resulting from this 25% price increase for all *dolotières* is given by the following formula:

$\Delta SP = \Sigma$ Initial production surplus - Σ Production surplus with rising prices

$\Delta SP = (6,191,047 \text{ CFA F} - 5570\ 158.5 \text{ CFA F}) \times (1013/149) \times 52$

$= 620\ 888.5 \text{ CFA F} \times (1013/149) \times 52 = 219\ 502\ 836 \text{ CFA Franc}.$

An annual loss of production surplus of about CFA F 219 502 836 will be due to this price increase, for an annual production level of 50,208,713 liters of *dolo* produced by the whole industry in this city. This decline of surplus will result in a medium and long term decrease in *dolo* production and therefore, a lower demand for firewood. For the same level of marginal cost, production level of the sector will always fall behind the initial one after the price increase (Q2<Q1). This increase could also result for *dolotières* in coping behaviors through saving attitudes and efficiency in energy usage, or through increases in *dolo* cost to offset the loss of surplus. In the latter case, it is the consumer who will pay the firewood higher price.

5. Conclusion

This work estimated the cost function and derived the conditional inputs' demands of the local red sorghum beer production in Ouagadougou. The calculation of inputs' technical substitution elasticities helped to highlight the technical characteristics of this activity. These elasticities show a low substitutability of other inputs to firewood. Thus, they highlight complementary links between water and firewood on the one hand, so for labor and firewood on the other.

The analysis of the relationship between the dolo production share costs and quantity produced shows a decline in firewood share cost when the quantities produced increase. The results predict increasing returns to scale for this activity. The formula Giora Hanoch (1975) has highlighted a dolo production technology with increasing returns to scale with a coefficient equal to 1.25 performance.

Studying the concentration of dolo production and producers' surplus among *dolotières* reveals a pronounced inequality in the distribution of production and surplus. While 50% of production is provided by 20% of dolotières, 60% of the total surplus amounts to 20% of producers. There exists a few large dolotières who produce only for wholesalers account for the largest share of the surplus. This concentration of dolo production and its surplus among producers is a major asset for any policy to reduce the consumption of firewood.

This paper also stated the economy of wood energy and the loss of dolo producers' surplus induced by an environmental levy on wood energy. This results in an annual saving of 4,915 tons of workable wood energy on this activity with an annual decline of *dolotières* total surplus of about 219,502,836 FCFA.

Craft industry, user of firewood as input, represents 59% of total demand in Ouagadougou and includes a limited number of operators (about 10,000), and as such, should be a prime target for policy regarding demand for firewood management. Given the price inelastic craft demand for firewood observed and the lack of real alternatives, a pure tax policy would not be effective. On the other hand, support for suitable equipment (Note 5) establishment might be effective. One could imagine a system like the one adopted by water agencies in France. It collects charges on craftsmen, and it uses the amount of these fees to subsidize the acquisition of better equipment and / or training craftsmen on techniques or processes of production more efficient in terms of wood consumption. This could be implemented by a specialized agency that would manage a fund from fees and redistribute according to the development of projects that would get real savings on firewood. Such a specialized agency could be the Applied Sciences and Technology Research Institute (Note 6) (IRSAT). The I.R.S.A.T., indeed, is the best suited institute for such an operation since it has available skills at its disposal in this area to propose or evaluate technically and economically feasible projects thereto. It might require some financial contribution to the beneficiaries. "Dolotières" should be a pilot class of artisans for testing such an operation or policy with regard to the importance of their consumption coefficient.

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Notes

Note 1. Many studies related to water and telecommunication manufacture industries demand for energy in the United States, have used translog as functional form [Hudson and Jorgenson (1974), Berndt and Wood (1975), Christensen and Green (1975), Berndt and Khaled (1979), Berndt and Morrison (1979), C. R. Grebenstein and B. C. Field (1979), Anderson (1980), Berndt et al. (1981), Evans and Heckman (1984), R. Teeples and D. Glyer

(1987), Berndt (1991) and Garcia S. (2002)].

Note 2. Equation (1) is the most general and flexible cost function specification which can be used to test diverse restrictions on production structure such as homotheticity, homogeneity, substitution possibilities, etc.

Note 3. Recall that the term YY =0 and that as such YY.lnY=0 in the elasticity expression.

Note 4. In reality, dolo is consumed per calabash.

Note 5. Nonetheless, one should note that reducing cooking time and / or achieving savings on fuelwood could come from artisans' production processes. Our thought is directed toward the specific case of "dolotières" where research has revealed the possibility of reducing quite considerably the cooking time or preparation time while obtaining the best beer.

Note 6. Applied Sciences and Technology Research Institute (IRSAT) is the former "Burkinabé Institute of Energy" which has already experienced the adaptation of gas fireplaces and studied yields on improved stoves with firewood.

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