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Technical Efficiency of Traditional and Non-Traditional Crop Production: A Case Study from Haiti

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Abstract: Limited resource farms in Haiti encounter difficulties maintaining sustainable yields for alternative crops as their dependency on external sources of inputs escalates. This paper employs a stochastic production frontier function to examine the factors socioeconomic and demographic that influence technical efficiency of a traditional crop (bean) and a non-traditional crop (potato) in Haiti. Data from 243 limited resource farmers were used in the empirical analysis. Results indicate that technical efficiency for bean and potato was related to credit access and education level. Though potato was technically more efficient and generated higher net returns per hectare, bean production required less external inputs and less foreign exchange for input purchase. Policies designed to improve technical efficiency of non-traditional crops should consider costs to limited resource farmers and the drain of foreign currency to resource poor economies.

Key words: Production cost · Capital · Cash outflow · Farm household · Multiple regression analysis · Stochastic production frontier · Alternative crops

INTRODUCTION

Agriculture has always been an important component of the Haitian Republic's economy. The agricultural sector accounts for 30% of the gross domestic product (GDP), 70% of overall employment and over 24% of exports in 2004 [1]. Crop production accounts for 93% of current agricultural land use, while pastures occupy less than 5% of available agricultural lands. In spite of its major contribution to the Haitian economy, the agricultural sector performance has remained largely unsatisfactory. Increasingly, many traditional crop farmers are incapable of producing sufficient food to satisfy household consumption. Even with the introduction of alternative crops, the yields per ha are still low. Very little is known about the factors influencing technical efficiency of traditional crops and how this knowledge can be used to introduce alternative crops with potentially higher yields into the production systems of limited resource Haitian farmers.

Haitian farmers have historically relied on income from traditional crops to buy items not produced on the farm. Traditional crops (beans (*Phaseolus vulgaris* L), maize (*Zea mays* L.), cassava (*Manihot esculenta*) and sweet potatoes (*Ipomoea batatas*)) make up 80% of the value of the agricultural production. Bean production is one of the most important traditional cash crops, having doubled in area over the past 25 years to around 300,000 ha. Despite the expansion in cultivated area, the rate of increase in bean crop output has failed to keep pace with the population growth rate and farm income share from bean production has been at a decline.

In the past thirty years, decline of agricultural productivity led the Haitian government to encourage the production of potato (*Solanum tuberosum*), cabbage (*Brassica oleracea*) and onion (*Allium cepa*) as non-traditional crops in order that farmers diversify their agricultural production system and increase farm income and foreign exchange. Evidence from other countries shows that processes of agricultural intensification and productivity growth are often driven by non-traditional crops with reliable markets and predictable returns [2].

There are different contradictory points of view regarding whether agricultural development in the developing world should follow traditional or non-traditional crop promotion. One school of thought suggests possibilities to increase agricultural production with existing resources and technology [3] using traditional crops that have higher resistance to diseases and pests than non-traditional crops and which require less modern inputs. It is also believed that any production of nontraditional crops displaces traditional food crop

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production [4] and carries large amount of outflow of capital. Another view argues that agricultural firms trade-off traditional crop and non-traditional crop outputs along a concave production possibilities frontier, implying a strictly competitive relationship between the two types of crops [5].

In contrast, others show that there are few or no possibilities for increasing agricultural production with traditional resources other than expanding the production possibility frontier through non-traditional crops production [6]. They also point out that certain complementarities may exist in a dynamic sense between the two types of crops. Dioné [7] argues that non-traditional crops have financed the adoption of animal draft technology, used in turn to increase food-crop output in Mali. Traditional crops have low response to modern inputs and stagnate in yields.

Given the small areas cultivated by limited resource farmers, it is difficult to determine how they are able to maintain their families from such low-productivity farms. Farmers survival from production and consumption units, are ultimately dependent on the efficient use of inputs on these farms. However, use of inputs is restricted to inputs that are measurable such as farm size, fertilizers, pesticides and labor. When other factors influence the level of output, the effectiveness of these inputs in reaching target output levels may be limited. Differences in farmer features along with other potentially unmeasurable inputs are likely to contribute to the overall technical efficiency of the farm household. In this context, knowledge of the relative contributions of total factor productivity should provide a comprehensive view of the structure of the agricultural sector and could help farm managers and policy makers establish appropriate and efficient policy instruments for the introduction of alternative crops to enhance farm cash income and food production.

Previous attempts at investigating efficiency differences of traditional and non-traditional farms have been focused on the adoption of new technologies [3,8,9]. Empirical studies have often found that adoption of new technology is highly correlated with farm productivity and income [10]. Also, farm size, equipment and labor have also been found to be important factors in explaining farm efficiency [11]. However, physical variables of the farmers (differences in farmer skills, credit access and technical assistance) do not take into account for all of the differences in crop production between farmers.

Several studies have suggested that skills of the farmer may be the key factor explaining farm production. Dey *et al*. [12] found that experience (years of managerial experience) was the most important contributor to farm productivity. Amara *et al.*[11] found that excellent farmers could consistently get more yield than an average farmer given the same farm characteristics. Parikh *et al.*[13], Liu and Zhuang [14] and Cinemre *et al.*[15] found that farm households who used credit were more efficient.

Given the inherent stochastic nature of crop production, the stochastic frontier production function approach suggested by Aigner *et al.* [16] and Meeusen and Van Den Broeck [17] appears to be an appropriate method for estimating technical efficiency in traditional agriculture. Several studies have used the stochastic production frontier method to estimate farm technical efficiency [18-24]. In general, these studies provide some evidence of agricultural efficiency and show heterogeneity among farm households in terms of their access to the best available technology.

In most studies of the technical efficiency, characteristics of the farm have been used to estimate the determinants of efficiency and inefficiency. Few attempts have been made to determine the contribution to the efficiency of the farm of immeasurable characteristics such as farmer experience, credit access, off-farm income, technical assistance, age and education. In crop production, Abdulai and Eberlin [22] attempted to include farmer characteristics through measures of experience and education. Testing a model for technical inefficiency effects on small scale farmers in Nigeria, Amos *et al.* [23] showed that age contributed negatively to efficiency. Abdulai and Eberlin [22] found that education played an important role in the level of efficiency of Nicaraguan farm households. Tilapia growout operators in the Philippines who had more years of managerial experience had higher levels of efficiency [12]. Onyenweaku and Effiong [25] found a significant positive relationship between off-farm income and efficiency.

Although the importance of these farmer characteristics has often been included in crop productivity debates on Haitian agriculture, little empirical evidence is available on the validity of such arguments. Since potato production depends on external farm inputs, it is important to examine the amount of capital outflow due to the encouragement of non-traditional crops and the efficiency of this crop in enhancing farm output. The purpose of this paper is to conduct a comparative analysis of farm level technical efficiency of bean (as a traditional crop) and potato farmers in Forêt des Pins Reserve and to determine the socioeconomic and institutional factors that influence the bean and potato

farm level efficiency. We hypothesize that the non-traditional crops are likely to be more efficient than the traditional crops. The larger technical efficiency of the non-traditional crops may translate into a use of funds to purchase imported inputs. Furthermore, the hypothesized efficiency determinants of both crops beans and potatoes are likely to be affected by the same demographic and socio-economic variables.

Stochastic production frontier and technical efficiency: Following Farell [26] suggestion's (1957), the efficiency of a farm can be defined and measured as the ratio of observed output to maximum feasible output from a frontier. If the frontier is the production function, i.e. the maximum potential output for a given set of inputs, the ratio will measure technical efficiency. Suppose that the observed input-output values from a sample of traditional and non-traditional crop producing farms are below the production frontier; then these farms are considered inefficient. This implies that the farms did not reach the maximum output possible for the inputs used, given the level of technology. Traditional crop farmers may be using traditional technologies either due to lack of access to modern inputs related to new technologies, lack of knowledge, or higher costs of adopting the new technologies. A measure of technical efficiency for non-traditional crop producing farms is given by y^{nt}/y^* and for traditional crops by y^t/y^*, where y^* is the frontier output associated with the level of inputs x and $y^{nt}/y^* > y^t/y^*$. Given the level of input x, non-traditional farms are more technically efficient than traditional crop producing farms.

A general stochastic production frontier can be given by:

$$\ln y_i = \alpha + \beta \ln x_i + v_i - u_i \quad \text{I} = 1,\ldots\ldots\ldots, \text{n} \tag{1}$$

where *ln* represents the natural logarithm, y_i is the output produced by farm i, x is a vector of factor inputs, β is a vector of unknown parameters, v_i is the stochastic error term. The error term is assumed to be independently and identically distributed ($N(0,\sigma^2_v)$). u_i is a one-sided non-negative random variable associated with the technical inefficiency in production. This one-sided term can follow such distribution as half-normal, exponential, truncated and gamma [27]. In this study, it is assumed that u_i to be independently distributed and follows a truncated normal distribution with mean μ_i(i.e. $u_i \approx N(\mu_i, \sigma^2 u)$), given by:

$$\mu_i = \delta S + w_i \tag{2}$$

where S is the vector of farm-specific variables which may influence the farm efficiency, δ is the associated matrix of coefficients and w_i is an independently and identically distributed random error term [28].

The technical efficiency (*TEFF*) of the *i*th farm in the context of the stochastic production frontier is defined as

$$TEFF_i = \exp(-u_i) \tag{3}$$

Following Battese and Coelli [18], the influence of the inefficiency component can be measured by $\gamma = \sigma_u^2 / \sigma^2$, where $\sigma^2 = \sigma_v^2 + \sigma_u^2$. The inefficiency effects in the production function ($\gamma = \delta_0 = \delta_1 = ... = \delta_{11} = 0$) and the effects of the variables included in the inefficiency effects model ($\delta_0 = \delta_1 = \delta_2 = ...\delta_{11} = 0$) can be tested using the likelihood ratio.

There are several functional forms used to develop the production frontier. The most common are the Cobb-Douglas and the translog production functions. The Cobb-Douglas functional form is used to specify the stochastic production frontier function chosen to perform the efficiency analysis. The parameters of the stochastic production frontier defined by (1) and (3) are estimated by maximum likelihood techniques, using the computer program FRONTIER Version 4.1 as described by Coelli [29]. The estimation of the maximum value of the logged likelihood function is based on a joint density function for u_i and v_i [30]. Technical efficiency of each farm can be obtained from

$$TEFF_i = E(\exp\{-u_i\}|\varepsilon_i) = \frac{1-\Phi[\sigma_* - (\tilde{\mu}_i/\sigma_*)]}{1-\Phi(-\tilde{\mu}_i/\sigma_*)} \times \exp\{-\tilde{\mu}_i + \sigma_*^2/2\} \tag{4}$$

where $\sigma_*^2 = \sigma_u^2\sigma_v^2/\sigma^2$, $\tilde{\mu}_i = (-\sigma_u^2\varepsilon_i + \mu\sigma_v^2)/\sigma^2$

and $\Phi(.)$ is the standard normal distribution function.

MATERIALS AND METHODS

Description of the Study Area: The Forêt des Pins Reserve, a state-owned natural forest, lies in southeastern Haiti between latitudes 18° 16 and 18° 26 north and longitudes 71° 42 and 72° 07 west in the Massif de la Selle Mountain Range. The Reserve covers 30,000 hectares and has 3,150 households distributed in 51 villages. The Forêt des Pins Reserve is a humid moist forest with altitudes ranging from 1,500 to 2,630 m and an annual

rainfall ranging form 1600 to 2000 mm. The mean annual temperature in the Reserve is approximately 14°C (57°F). In search of fertile land and work, migrant farm families have been moving to the area within and around the Reserve for the past one hundred years from every region in Haiti.

Rainfed agriculture is the main economic activity of people in the study area. The principal crops by economic importance are: potatoes, onions, cabbage, beans and maize. The main non-agricultural activities in the sampled villages are: construction, tailoring, carpentry, voodoo priesthood, midwifery and the operation of small stores and restaurants. Potato production depends more on non-farm inputs (fertilizers, fungicides and other pesticides) than the other crops. Potatoes, cabbage, onions and beans are almost exclusively commercial crops and maize is reserved for family and livestock consumption.

There are two main bean and potato cropping seasons in the Forêt des Pins Reserve. The first bean season starts in March and ends in July whereas the second season starts in August and ends in November. The first potato season starts in February and ends in July whereas the second season starts in August and ends in December. Family labor is the principal source of labor, even though some hired labor may also be employed. For households that apply fertilizers and pesticides, the quantity used may vary with their financial situation and their understanding of modern technology. Seven non-governmental organizations and the Ministry of Agriculture operate in the area and provide subsidies and technical assistance in the fields of agriculture, health and regional development.

Sixty-five percent of the farmers reported growing potatoes because they need cash income and that their land is suited to this crop. About 25% of farmers said that the main reason for growing potatoes was simply the ready market access provided by Dominican Republic consumers.

Sampling Selection: This study was based on different samples of farmers in 15 villages of Forêt des Pins Reserve. The interviewees were selected randomly from the list of the households provided by the Forest Resource Service of the Ministry of Agriculture. We collected data from 243 heads of households living in different villages in the summer of 2003 through formal and informal survey techniques.

The purpose of this survey was to collect data on the socio-economic and demographic aspects of the household. Detailed crop input-output data were collected for the households for the 2002-2003 crop year. The input was measured as hectares of land per farm household employed in potato or bean production in the year of the survey. Labor is the total number of man-days of head of household/family labor. Female and child labor are converted into man equivalents by treating one adolescent male as a quarter of a man, one woman as two-thirds of a man and one adolescent female as one-eights of a man [31]. Fertilizer input is the total amount of fertilizer (in kg) used for potato production in the year of the survey. Seeds represent the quantity of potato or bean seed in kg sown. Training and advisory services are provided to farmers with respect to fertilizer application and seed quality. The mean bean and potato yield over the sampled farms is 600 kg/ha and 20.4 tons/ha respectively.

Empirical estimation: The Cobb-Douglas functional form of the stochastic production frontier model is defined as

$$\ln y_i = \beta_0 + \beta_1 \ln(Area) + \beta_2 \ln(Flabor) + \beta_3 \ln(Hlabor) + \beta_4 \ln(Fert) + \beta_5 \ln(Pest) + \beta_6 \ln(Capital) + \beta_7 \ln(Seeds) + v_i - u_i \quad (5)$$

Where y_i is the total output of the *ith* farm of bean or potato in kg; *Area* represents the size of bean or potato operation in hectares, *Flabor* the family labor in man-days, *Hlabor* the quantity of labor hired by the farmer in man-days, *Fert* the quantity of fertilizers in kilogram used, *Pest* the quantity of pesticides in kilogram used, *Capital* the cash beginning used and *Seeds* the quantity of seeds in kilogram used; u_i and v_i are as defined in the previous section.

The technical efficiency of the *i*th farm, defined as the ratio of the observed output level to the corresponding stochastic production frontier function, is given by

$$TEFF_i = \delta_0 + \delta_1 Age + \delta_2 Illiterate + \delta_3 F\exp erience + \delta_4 TechAssist + \delta_5 Hsize + \delta_6 Gender + \delta_7 Perception + \delta_8 Mlocgroup + \delta_9 OffarmInc + \delta_{10} Fsize + \delta_{11} CredAccess \quad (6)$$

Description of the explanatory variables is summarized in Table 1. In order to measure farmers' perceptions of environmental degradation as a problem to farming operation, the respondents were asked a set of statements, which addressed environmental-related crop damage. Using a six-point scale with "0" indicating *I do not know* and "5" indicating *very important*, respondents

Table 1: Variable definition for bean or potato farm technical efficiency in Forêt des Pins Reserve

Variable	Variable definition
$TEFF_i$	Bean or potato farm technical efficiency level
Age	Respondent's age in years; 1 if age is less than or equal to 30 years (younger farmers), 0 otherwise
Illiterate	Respondent's years of schooling; 1 if illiterate, 0 otherwise
Fexperience	Respondent's years in bean or potato production; 1 if more than 5 years, 0 otherwise
TechAssist	A dummy variable showing whether or not that farmer had received technical assistance; 1 if received, 0 otherwise
Hsize	Number of people in the household
Gender	Respondent's gender; 1 if female, otherwise 0
Perception	Respondent's perception of environmental degradation as a problem for bean or potato yield
Mlocgroup	Respondent's member of local group; 1 if member of local group, 0 otherwise
OffarmInc	Respondent's labor status; 1 if earned income only from farm labor, 0 otherwise
Fsize	Total farm land of the household
CredAccess	A dummy variable showing whether or not that farmer had access to credit; 1 if farmer has access, 0 otherwise

indicated the importance of each environmental statement in respect to their farming operation. The value of the variable *Perception* is obtained by dividing the total perception weight for each household by the sum of perception statements.

RESULTS

A comparison between the non-traditional and traditional crop farms show that potato farmers use more inputs than bean farmers (Table 2). Large difference exists in production costs between potatoes and beans. Potato production is also more capital and labor intensive than bean production. Potato farmers use imported inputs (fertilizers and pesticides) whereas bean farmers do not. As a consequence, costs per hectare of growing potatoes are eight times greater than the costs of producing beans. About 40% of the potato cost of production was used to purchase imported inputs. Foreign exchange needed to cover the potato production costs for the 1500 ha was US$ 2,604,750. Gross output and gross revenue for potato production are greater than the ones for bean production. Potato farmers also have a net return advantage over bean farmers.

When production of non-traditional crops requires a large amount of capital investment to purchase farm inputs such as expensive equipment, this may work against limited resource farms who lack of capital or have little access to credit market [32]. Existing literature points out some cases in which limited resource farms are disadvantaged vis-à-vis large growers in the production of non-traditional crops [33]. One such case is the high capital intensity of production. Another case is the availability of specialized inputs. Specialized seeds, fertilizers and pesticides necessary for the production of certain crops are often unavailable in local markets. In other case, large producers can react by getting back their land parcels that were traditionally rented out under the sharecropping system. These results support the prediction that the adoption of a positive policy instrument will hurt the limited resource farmers who relied on sharecropped system as additional source of income [34].

In contrast to large-scale producers who plant up to 100 % of their land with non-traditional crops [35],

Table 2: Income, production costs and foreign exchanges for beans and potatoes in Forêt des Pins Reserve

	Crops (US$/ha)		Cash Outflow (US$/ha)		Cash Outflow (US$/year)	
	Beans	Potatoes	Beans	Potatoes	Beans	Potatoes
Labor	431.0		2,013.50			
Seed	139.0	937.50				
Fertilizers	-	1,369.70	-	1,369.7	-	2,054,550
Pesticides	-	366.80	-	366.8	-	550,200
Total Cost	570.0	4,687.50			-	2,604,750
Income						
Crop yield (kg/ha)	600.0	20,400.00				
Crop price ($/ha)	1.8	0.27				
Total ($/ha)	1080.0	5508.00				
Net Return	510.0	820.50				
Return difference	310.5					

Table 3: Maximum Likelihood parameter estimates for bean and potato farmers in Forêt des Pins Reserve

		Bean		Potato	
Variable	Parameter	Coefficient	t-ratio	Coefficient	t-ratio
Constant	β_0	3.66	4.76**	6.78	12.06***
ln(*Area*)	β_4	-0.48	-1.69*	0.08	1.13
ln(*Flabor*)	β_5	0.56	0.97	0.29	0.02
ln(*Hlabor*)	β_6	-0.58	-8.56***	-0.93	-1.52*
ln(*Fert*)	β_2			0.02	1.68*
ln(*Pest*)	β_3			-1.07	-23.61***
ln(*Capital*)	β_7	1.42	3.81**	0.94	12.96***
ln(*Seeds*)	β_1	0.21	2.47**	1.76	5.02***
Function coefficient		1.13		1.09	
	σ^2	1.65	6.92***	0.82	7.44***
	γ	0.86	15.32***	0.492	49.36***
Log-likelihood		-303.25		-177.73	

* Significant at the 0.10 level ** Significant at the 0.05 level *** Significant at the 0.01 level

Table 4: Likelihood ratio tests of hypotheses involving parameters of the technical inefficiency models for beans and potatoes in Forêt des Pins Reserve

	λ			
Null hypothesis	Beans	Potatoes	Critical X^2 value[a]	Decision
$H_0 : \gamma = \delta_0 = \delta_1 = ... = \delta_{11} = 0$	21.7	28.96	21.03	Reject H_0
$H_0 : \delta_1 = \delta_2 = ... = \delta_{11} = 0$	20.94	26.12	19.68	Reject H_0

[a] the critical values correspond to 5% level of significance

$$\lambda = -2\left\{\ln\left[L(H_0)/L(_1)\right]\right\} = -2\left\{\ln\left[L(H_0)\right] - \ln\left[L(H_1)\right]\right\}$$

farmers with less than 1 ha are likely to plant only around one-third hectare with these crops. Such small-scale producers are constrained by the lack of production credit and the need to self-insure against stochastic shocks such as labor shortage and price drops. They do this by diversifying their crop mix to include less-remunerative crops destined for domestic markets and by growing basic foodstuffs.

Stochastic frontier: The maximum likelihood estimates of the parameters of the stochastic frontier model are presented in Table 3. The estimated value of the γ-parameter in the stochastic frontier production is significant for both traditional and nontraditional crops, which means that the technical inefficiency effects are significant in determining the level and variability of traditional and nontraditional output of farmers in the study area. This result is consistent with observations made by several scientists [21, 22]. The null hypothesis that technical inefficient effects are not present in bean and potato production is rejected (Table 4).

Thus, it can be concluded that the explanatory variables in the technical inefficiency model do contribute significantly to the explanation of the technical inefficiency for both traditional and non-traditional crop farmers. The hypothesis of the absence of effects of the variables included in the inefficiency effects on the level of technical inefficiency is also rejected for both beans and potatoes. This implies that the joint effects of these variables on technical inefficiency are statistically significant.

The estimates show that quantity of seed planted, capital and fertilizers are important inputs determining yields in potato farms. The coefficient of capital is 0.94, indicating that 10% increase in beginning cash would result in a 9.4% increase in potato yield, ceteris paribus. The coefficient of pesticide is negative and significant, which indicates that any increase in pesticide application would result in a decrease in potato yield, other factors remaining constant. For bean, the estimates show that quantity of seed planted and capital are the most important inputs determining yield of bean.

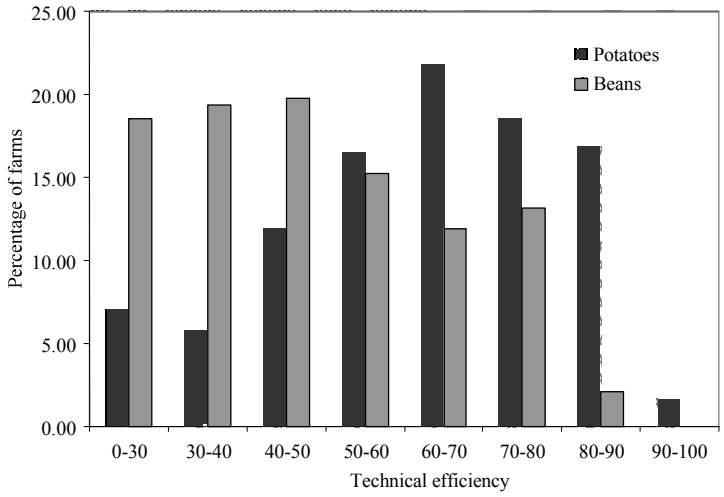

Fig. 1: Distribution of technical efficiency scores of potato and bean farms in Forêt des Pins Reserve

Distribution of technical efficiency: The level of technical efficiency, the ratio actual to potential output, is calculated for each of the farmers surveyed and presented in Fig. 1. Using the paired-difference t-test of the technical efficiency measures, the technical efficiency for bean was found to be significantly lower (t-ratio= 7.78) than the technical efficiency for potato.

For beans, the technical efficiency indices range from 2 to 85% with an average of 48%. The level of technical efficiency observed in this study appears to be lower than the 58-59% efficiency reported by Bravo-Ureta and Evenson [36] for farmers in eastern Peru. The results are also in conformity with the results of other studies that have shown the existence of substantial technical inefficiencies in developing agricultural economies. For example, high technical inefficiency has been found to exist among cereal growers in Ethiopia [37]. The results also show that there is significant technical efficiency variation among bean producers. This is also consistent with the descriptive data showing the higher variance of traditional bean yield, with a coefficient of variation of 37%, than the potato yield, with a coefficient of variation of 12%.

For potato production, the predicted farm specific technical efficiency ranged between 5.6% and 91.8% with an average of 61%. This level of efficiency is less than that found by Audibert [19] among paddy farmers in Mali (70%), Wadud and White [21] for rice farmers in Bangladesh (75%) and Bravo-Ureta and Pinheiro [20] for crops in the Dominican Republic (70%). This implies that, on the average, potato growers in Forêt des Pins Reserve are producing potato at 61% of their potential production level, given the present state of technology and input levels. It is, however, higher than the 58-59% efficiency of cotton and cassava farmers reported by Bravo-Ureta and Evenson [36] and the 60% efficiency of grain farmers in Nigeria reported by Amos *et al.*[23]. About 25% of potato farmers fall below the 50% efficiency level compared to 50% for bean farmers. About 20% of farmers use production inputs at an efficiency level over 80% compared to 2% for beans. About 57% of potato farmers have a level of technical efficiency between 50% and 80% compared to 37% for bean farmers.

Sources of technical efficiency: Multiple regression results are presented in Table 5. The computed F values are highly significant for both bean and potato crop production ($p<0.001$) and thus we conclude that there is interaction between the level of bean and potato farm efficiency and socioeconomic variables. Interpretation of Table 5 yields a number of additional insights into the process of factors affecting technical efficiency among bean and potato growers in Forêt des Pins Reserve.

Age had a negative impact in explaining the technical efficiency level for both bean and potato growers. This result is consistent with the findings of Bravo-Ureta and Evenson [36] and Abdulai and Eberlin [22]. Although farmers become more skillful as they get older, the know-how is attenuated as they approach their middle age, as their physical strength begins to decline [14]. Also, according to Hussain [38], older farmers are less likely to have contacts with extension agents and are less willing to adopt new practices and modern inputs. For potato production, the number of people in the household was found to have a positive and significant correlation with technical efficiency. This result suggests that larger

Table 5: Parameter estimates and t-values of the efficiency determinants for beans and potato farmers in Forêt des Pins Reserve

	Beans		Potatoes	
Variable	Coefficients	t-values	Coefficients	t-values
Intercept	6.200	5.89	0.395	3.65***
Age (younger farmers)	0.225	1.41*	0.002	1.92**
Illiterate	-1.283	-6.28***	-0.129	-1.53*
Fexperience	1.020	9.48***	-0.087	-1.03
TechAssist	0.061	1.21	-0.114	-1.33*
Hsize	-0.018	-0.05	0.023	5.38***
Gender(Female)	5.470	1.82**	0.080	2.39**
Perception	-0.621	-1.37*	-0.022	-0.82
Mlocgroup	0.147	1.19	0.046	1.90**
OffarmInc	-0.040	-0.93	-0.024	-1.61*
Fsize	-0.040	-2.09**	-0.016	-1.86**
CredAccess	0.046	1.83**	0.078	3.24***

*, ** and***denote significance at 10, 5 and 1%, respectively

families appear to be more efficient potato producers than smaller families. Although large families put additional pressure on farm income for clothing, education, food and health, they do ensure availability of enough family labor for farm operations to be performed in time.

The *Gender* variable is significantly positive for both bean and potato growers indicating that female-headed households have higher efficiency levels than males. This is consistent with the finding of several previous studies [25]. This result can be explained by the phenomenon that women tend to be members of local groups and therefore, more knowledgeable than men in terms of new cultivation techniques, credit procedures and pest management.

The variable *Illiterate*, used as proxy variable for managerial input, has negative impacts on the technical efficiency level for bean and potato farmers. This implies that farmers with better education are technically more efficient. This finding is similar to Dey *et al.* [12] and Liu and Zhuang [14] who found that farm efficiency increases with level of education. Increased level of educational achievement may lead to a better evaluation of the importance of solid farming decision making, including the efficient use of inputs. A good level of education enhances a farmer's ability to seek, interpret and make good use of information and production inputs.

The positive and significant relationship between access to credit and efficiency suggests that bean and potato growers who have access to credit for the purchase of inputs experience higher technical efficiency. This finding is similar to that of Parikh *et al.* [13] who found that farm households who used credit were more efficient. The efficiency impact of the recent effort by the Coopérative de Solidarité pour le Développement (COSODEV), with the support of the Fonds d'Assistance Economique et Sociale as part of the Forest and Parks Protection Technical Assistance project (jointly financed by the Haitian government and World Bank) to improve farmers' access to credit would be positive, if implemented successfully. The positively significant coefficient of affiliation to local group implies that members of farmers' groups tend to be more efficient than non-members. This result is similar to Amos *et al.* [23] who found that group membership contributed to technical efficiency. This finding clearly underscores the role of organizational membership in farm productivity.

Technical assistance from organizations involved in the development inside the Reserve has a surprisingly negative effect on potato farm technical efficiency. The estimated coefficient for technical assistance indicate that more frequent contacts with extension services led to a decrease in efficiency of potato growers. While this finding may seem perverse there may be a number of explanations. Farmers may become dependent on technical assistance and receive conflicting advice from extension agents. Another reason for this outcome is that technical assistance may be concentrated towards helping the more marginal farms. Also, although there is nothing erroneous about technical assistance efforts to improve farmers' knowledge of new technology, fertilizer application and pest management, such programs have often been failing in their results. Improving the flow of information to a decision maker does not necessarily increase his/her capacity to act on it. A poor farmer may know about improved seeds, fertilizers and pesticides

without being able to obtain access to them and to employ these factors in practicing sustainable farming methods. Rural extension services often have little influence on farmers' decision making because they tend to address themselves to the problem of supplying information without providing farmers the necessary resources.

The coefficient of off-farm income was negative and indicated that increased off-farm income decreases efficiency of potato farms. Similar results were suggested by Abdulai and Eberlin [22] in Nicaragua. The negative relationship suggests that increases in non-farm work are accompanied by a relocation of time away from farm-related activities, such as adoption of new technologies and gathering technical information that is essential for enhancing production efficiency. Farm size was statistically significant and negatively affected bean and potato farm efficiency. This finding is similar to Audibert [19] in Mali who found that there is an inverse relationship between farm size and efficiency. This finding suggests that increased farm size diminishes the timeliness of input use and large farmers may encounter more problems in applying farm inputs at the right time; hence an inefficient use of farm inputs.

CONCLUSION

The purpose of this study is to evaluate farm level efficiency for bean (a traditional crop) and potato (a non-traditional crop) and the factors influencing technical efficiency level of those farms in Haiti. A stochastic production frontier function was used to perform the efficiency analysis. Estimated production efficiency, measured by the production efficiency index, ranged from 2 to 85% for bean and from 5.6 to 91.8% for potato farms. The analysis reveals that average levels of technical efficiency were 48 and 61% for bean and potato farms, respectively. The tested model proposed that the non-traditional crops are more likely to be more efficient than the traditional crops. The analysis supported this hypothesis. The findings suggest that mean technical efficiency for bean was found to be significantly lower than technical efficiency for potatoes. However, potato production is more labor and capital intensive than bean production. Also, imported inputs are needed for increased potato yields. As a consequence, foreign exchange for input purchase is required by a resource poor country and thus an outflow of capital is precipitated due to the encouragement of non-traditional crops. This finding supports our second hypothesis regarding the use of foreign exchange to purchase imported inputs to produce non-traditional crops. Hence there may be conflicts between policy makers and farmers. While farmers operate on the margin and use marginal analysis to make decisions to adopt potato as a non-traditional crop, policy makers facing tight foreign currency reserves may be evaluating the difference between efficiency gains and outflow of foreign reserves.

The results show that farm production involves inefficiency under both traditional and non-traditional crop production, suggesting that improvements in technical efficiency represent a greater opportunity for promoting bean and potato production. This could be done through promotion of local innovative crop in bean production and better use of available resources given existing technology for potato production. Also, the presence of performance variation among traditional crop farmers indicates that local knowledge of producing crops is not uniformly distributed among farmers. Promoting local innovative practices may offer an opportunity to help farmers increase production through adoption of these practices.

A third hypothesis of the model is that efficiency determinants of both crops beans and potatoes are likely to be affected by the same demographic and socioeconomic variables. The evidence also supported this hypothesis. The results of the multiple regression analysis indicate strong evidence that age, credit access and gender are important factors for improving technical efficiency level for both bean and crop production. Contrary to the expectations, off-farm income negatively influences potato farm technical efficiency.

Access to credit appears to have great influence on bean and potato farm efficiency. Our result is supportive of the view that credit encourages technological innovation by acting as an insurance mechanism in agrarian economies [14]. We demonstrate a positive linkage between education and farm productivity. This finding supports by Mellor [39] view that investment in education in rural areas should be considered as a central ingredient in a strategy designed to improve agricultural productivity. Therefore, actions aimed at improving access to credit and education are recommended. The results thus point to the need for an integrated extension credit program to enhance bean and potato production.

The results confirm age effects on technical efficiency. These results show that younger, more educated farmers exhibited higher levels of technical efficiency. This finding is similar to that observed in Dominican Republic by Bravo-Ureta. and Pinheiro [20]

who found positive effects of age and education on farm productivity. Potato farmers who indicated that they were members of local groups were more efficient. More informed individuals apparently were better able to assess the potential impacts of new technology on their farming operations [40]. Farmers who are not members of a local group and not well informed about technological innovation may overvalue the costs and underestimate the benefits.

Policies designed to improve technical assistance systems are essential policies to enhance bean and potato farmers' efficiency level. As the above findings show, technical assistance from organizations involved in the development inside the Reserve decreases technical efficiency of potato farmers. The combination of supplying information and the availability of means of production may encourage bean and potato farmers to adopt new technology. The results suggest that introducing more incentives to bean and potato farmers are essential for farm productivity.

This study provides evidence that family size is a significant variable for improving technical efficiency among potato farmers. This is consistent with the findings of Parikh *et al.* [13], that family size has a positive and significant relationship with technical efficiency. Future research that examines labor cost sharing policies on potato farm households in Forêt des Pins Reserve should be conducted.

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