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Tanira T. Kingi
Tom F. Kompas

Asia Pacific School of Economics and Government
THE AUSTRALIAN NATIONAL UNIVERSITY

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Tanira T. Kingi
Institute of Natural Resources
Massey University, New Zealand

Tom F. Kompas*
Asia Pacific School of Economics and Government
Australian National University

Abstract

Communal land ownership is frequently considered a constraint on farm productivity as farmers endeavour to balance socio-cultural obligations with the demands of commercial agriculture. Recently, the Fiji Government has encouraged indigenous Fijians to take up profitable sugarcane growing using traditional practices of 'communal farming'. Using Stochastic Frontier Analysis, this study finds that under certain conditions, farm productivity and technical efficiency increased for farmers in these co-operative farming groups. It also finds that there were improvements among inexperienced farmers who resided in villages, previously the group at the highest risk of performing poorly. The realisation of these outcomes lies in the influence of a firm structure that allows the expression of cultural and traditional practices, rather than their suppression, while also consenting to the accumulation of economic wealth within a culturally acceptable framework.

*Contact author: Tom Kompas, Asia Pacific School of Economics and Government, Crawford Building (#013), Australian National University, Canberra, ACT, 0200, Australia. Email: tom.kompas@anu.edu.au, Ph: 61 2 6125 6566 Fax: 61 2 6125 5570.

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1. INTRODUCTION

Economic advancement of most developing countries is tied inextricably to the development of their agrarian industries. While the introduction of markets, infrastructure and institutional reform are essential factors in the evolution of commerical economic activity, low productivity persists in many instances. Moreover, the low productivity among peasant or village farmers is often attributed to cultural factors that inhibit individual enterprise and undermine the motivation to shift from a subsistence-based existence to one more focused on cash generating activities. In traditional agrarian societies, the transition from subsistence to a market economy often means that farmers are caught between the demands of commercial activity and the social responsibilities of custom and convention.

Increasing the capacity of indigenous Fijians to participate in the commercial agricultural sector has been a focus of Fijian economic development strategies since the Spate Report (1959) and the Burns Report (1960). A key principle behind these efforts was independence from the village and individualisation of production. Both reports recommended that the way forward for Fijian economic prosperity and development of the rural economy was to establish a "community of independent farmers" free from the "burden of obligations" (Spate, 1959:9, 22). Underpinning their argument was the assumption that traditional society was an obstacle to change and the persistence of custom hindered cash-orientated activities.

Critics of Fiji's development policies in the three decades following the Spate Report basically made three observations. First, the majority of the large-scale, state-led development projects had fallen short of their objectives of developing sustainable centres of economic growth. Second, physical separation from village activities had not created communities of individual, commercially orientated farmers; at least not on the scale envisaged by Spate and Burns. Finally, customary practices persisted, in spite of efforts to create independence that overcame the influence of culture on economic activity.

The recent emergence of Fijian[1] 'group farming' collectives or 'management groups' made up of new entrants to the sugar industry has generated much interest among Government policy makers and the sugar industry. The number of formal groups that have formed themselves into a legal entity is relatively low. Nonetheless, they join a much larger number of informal groups spread throughout the cane growing districts: some established recently and others that are now in the second generation of farmers.

For Fiji's ailing sugar industry, this development may provide one solution to a complex array of problems associated with the restructuring of its producer base. It also has a historical foundation. Recent promotion of these structures as the 'way forward' for Fijian farming has received widespread publicity[2]. Formal groups are characterised by: (1) amalgamating lands into a single production unit; (2) centralising management decision-making; (3) co-ordinating and controlling farm inputs and labour; (4) pooling capital; and (5) incorporating traditional or cultural values/concepts such as *solesolevaki* (communal work).

It is within this historical background and socio-cultural context that this paper examines the issue of communal land and economic development. In particular, this research poses the following question: Can farm structures overcome the socio-cultural constraints and improve the technical efficiency of communally owned farms? The remainder of the paper is as follows: Section 2 provides a brief description of Fiji's sugar industry. Section 3 outlines the theoretical framework and the basic properties of stochastic frontier analysis. Data sources and the empirical model are given in Section 4. Section 5 discusses the results and Section 6 concludes with policy recommendations.

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[1] This paper follows the common practice of using the term 'Fijian' to describe the ethnicity of Fijians who are members of the indigenous, Melanesian ethnic group and 'Indo-Fijian' for those of Indian descent.
[2] Fiji Development Bank (FDB, 2003:17-18) and the Native Land Trust Board (NLTB, 2003:5) profiled the Naleiwavuwavu Cane Development Scheme recently formed by the *yavsa* Naleiwavuwavu of Betoraurau , Sabeto. The success of the organisation has been attributed to the establishment of a 'management group' to administer funds received under the Farming Assistance Scheme and members working collectively under the traditional concept of *solesolevaki.*

2. FIJI'S SUGAR INDUSTRY

Indigenous Fijian sugar cane growers have been minor players in Fiji's sugar industry, making up 26 per cent of the total number of growers in 2003. While land ownership lies almost exclusively with indigenous Fijians, the majority of sugar production has come from Indo-Fijian tenant growers that have 30-year agricultural leases administered by the Native Land Trust Board (NLTB). The total number of leases to indigenous growers registered with the NLTB as of 2003 was 3,416. Between 1997 and 2015, 4971 leases will expire, the majority of which are held by Indo-Fijian tenants. As leases expire, an increasing number of Fijian landowners are choosing to allocate the leases to members of their own land-owning *mataqali* unit.

Fiji's sugar industry is under immense strain as industry and political leaders attempt to formulate restructuring strategies to improve the efficiency of its 21,000 small-farm sugar suppliers and its ageing processing mills and transport system before the reduction of the preferential prices received from the European Union (EU) and their removal in 2008. Under the 1975 Lome Convention (an agreement between the EU and African, Caribbean and Pacific countries) Fiji and other African, Caribbean and Pacific (ACP) sugar producers have received preferential prices for a defined amount of sugar exported to the EU. By 2007 the preferential prices under the former Lome Convention (now the Cotonou Agreement) will be removed, placing significant pressure on the restructuring of the production, processing and transport sectors. Recommendations for the reform of the production sector include a major reduction in the number of producers along with an increase in the average farm size.

Loans from financial institutions to sugarcane farmers have decreased significantly in recent years because of the uncertainty about the future of industry and the large number of bad debts written-off because farmers were unable to service their loans (FDB, 2003). Funds borrowed from outside the industry have been steadily declining since 1994 (Rao, 2003). Given the uncertainty about the future of the industry, credit criteria of financial institutions have become more stringent. The criteria include the requirement for agricultural leases to be registered under ALTA or NLTA, which are administered by the NLTB[3]. As well, *vakavanua* or informal leases (i.e., leases not approved by the NLTB) on reserve land were made ineligible as security to access these sources of capital for indigenous farmers. Not surprisingly, the number of lease conversions has increased.

The tightening of financial criteria for debt financing has also seen preference by financial institutions and government funding ministries in granting loans to those indigenous farmers who are members of formal management groups[4]. The rationale for this lending policy is that membership of a group will improve farm management decision-making and the pooling of resources (capital items) will increase the likelihood of key farm management activities being carried out. Informal groups sharing tractors and pooling labour have been in existence for many years. On the other hand, formal groups (Trusts, Limited Liability Companies and other legal entities) have only emerged within the last five years. The total number of such entities is uncertain but may be as low as ten.

3. TECHNICAL EFFICIENCY AND STOCHASTIC FRONTIER ANALYSIS

Stochastic frontier analysis of technical efficiency was independently proposed by Aigner et al. (1977), Battese and Corra (1977) and Meeusen and van den Broeck (1977). Underpinning the stochastic frontier approach was the idea that deviations from the frontier might not be entirely under the control of the agent. The stochastic frontier model specification for cross-sectional data can be expressed as follows:

[3] Agricultural and Landlord Tenants Act (ALTA), 1976, and Native Lands Trust Act (NLTA), which has been in place since the establishment of the Native Lands Trust Board (NLTB) in 1940. Under ALTA, tenants held 30-year leases with the NLTB and lease rent was fixed at 6 per cent of the unimproved capital value (UCV). Since the expiry of the ALTA leases in 1997, all land transactions are now administered by the NLTB under NLTA. Under NLTA, tenants have no right of renewal but all new leases will be for a 'rolling' 5 to 10 year term (up to a maximum of 50 years) and can be offered on a sharecropping basis. Rent will be established by the NLTB to reflect the 'market price' (Lal et al., 2001:16).

(1) $Y_i = f(X_i, \beta)e^{v_i - u_i}$

Where Y_i is the output of the i-th firm; X_i is a vector of inputs and β a vector of parameters to be estimated. This specification allows for a non-negative random component in the error term, u_i, to generate a measure of technical efficiency. The random error, v_i, accounts for measurement error and captures random variation in output due to factors beyond the control of firms, measurement error and statistical noise. The error term v_i is assumed to be independently and identically distributed (iid) normal random variables $N(0, \sigma_v^2)$ with mean zero and constant variance. The error term u_i captures firm-specific technical inefficiency in production[5] specified by:

(2) $u_i = z_i\delta + w_i$

where z_i is a (1 × m) vector of explanatory variables that may influence the efficiency of a firm; δ is (m × 1) vector of unknown coefficients, and w_i a random variable such that u_i is obtained by a non-negative truncation of $N(z_i\delta, \sigma_u^2)$. Input variables can be included in Equations (1) and (2) as long as the technical efficiency effects are stochastic (Battese and Coelli, 1995). The technical efficiency of production of the ith farmer in the data set, given the level of inputs, is defined by:

(3) $TE_i = \dfrac{E(Y_i \mid u_i, X_i)}{E(Y_i \mid u_i = 0, X_i)} = e^{-u_i} = \exp(-z_i\delta - w_i)$

The measure of technical efficiency is based on the conditional expectation given by Equation (3), evaluated at the maximum likelihood estimates of the parameters in the

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[4] While not all groups are referred to as 'management groups', this is the term being used to describe groups that have an informal arrangement to share equipment and formal groups that have adopted a centralised management system.

[5] Forsund, Lovell and Schmidt (1980:23) argue that inefficiency is typically determined by factors that are associated with farm management practice, and therefore socio-economic factors are not necessary to include in efficiency analyses. In spite of this claim, many studies in the past decade have incorporated social factors (age, gender and education): see Battese, Malik and Gill (1996); (labour) see Battese and Tessema (1993); (extension) see Hasnah, Fleming and Coelli (2004); (family and social cohesion) see Audibert (1997); (management, organisational form, property rights) see Wilson, Hadley and Asby (2001), Mathijs and Vranken (2001) and Gavian and Ehui (1999); (environmental conditions) see Sherlund, Barrett and Adesina (2002); and farmers' attitude toward technology (Amara *et al.* 1999).

model, where the expected maximum value of *Yi* is conditional on $u_i = 0$ (Battese and Coelli, 1988). The measure of *TEi* must have a value between zero and one. *Yi* denotes the value of production in original units. The technical efficiency of the firm is the ratio of its mean production, given its realised firm effect, to the corresponding mean production if the firm effect was zero. The corresponding mean technical efficiency of firms in the industry is defined by:

(4) $$TE = \left\{ \frac{1 - \Phi[\sigma_u - (\mu / \sigma_u)]}{1 - \Phi(\mu / \sigma_u)} \right\} e^{-\mu + \frac{1}{2}\sigma_u^2}$$

Given the specifications of the stochastic frontier model expressed in Equations (1) and (2), the stochastic frontier output for the *i*th farmer is the observed output divided by the technical efficiency, *TEI,* expressed as:

(5) $$Y_i^* = \frac{Y_i}{TE_i} = \frac{E(X_i \beta + v_i - u_i)}{E(-u_i)}$$

(6) $$Y_i^* = \frac{Y_i}{TE_i} = \frac{\exp(X_i \beta + v_i - u_i)}{\exp(-u_i)} = \exp(X_i \beta + v_i)$$

where *Xi* represents the vector of values of the functions of input variables in Equation(1). The condition that $u_i \geq 0$ in Equation (1) guarantees that all observations lie on or beneath the stochastic frontier. The parametisation from Battese and Corra (1977) and following Battese and Coelli (1995) replaces σ_v^2 and σ_u^2 with $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2 / (\sigma_v^2 + \sigma_u^2)$ where γ must lie between zero and one: γ of 0 indicates that deviations from the frontier are due entirely to noise, while γ of 1 indicates that all deviations are due to technical inefficiencies. Maximum-likelihood estimates for all parameters of the stochastic frontier and inefficiency model, defined by Equations (1) and (2), simultaneously obtained by using the programme, FRONTIER 4.1 (Coelli,1996). This parametisation allows a search across this range to obtain a good starting value for γ, for use in an iterative maximisation process involving the Davidon-Fletcher-Powell (DFP) algorithm (Coelli, 1996). The relative contribution of the inefficiency effects to the total variance terms as defined by Coelli et al. (1998:188):

(7) $$\gamma^{*} = \frac{\gamma}{\{\gamma + [(1-\gamma)\pi / \pi - 2]\}}$$

The technical efficiency measure depends on the conditional expectations shown in Equation (3) where $v_i - u_i$ values are assessed at the maximum likelihood estimates of all parameters in this model and the expected maximum value of output depends on the error term, $u_i = 0$ (Coelli et al., 1998).

4. DATA SOURCES AND EMPIRICAL MODEL SPECIFICATION

Data collection for this study utilised a mixture of focus groups and surveys. A total of 22 focus group meetings were carried out across randomly selected locations in the eight sugar mill districts of Fiji between May and September, 2003. Of the 235 people who attended these group meetings, 178 were registered sugarcane farmers. A survey was carried out with these registered growers to collect information from on the main decision-maker and family plus details on farm management practices, use of labour and farm inputs. A series of follow-up interviews with another 33 individuals were carried out with farmers who fell into specific groups of interest. A random, stratified sample was taken from the 3,600 registered indigenous Fijian growers across the eight Fiji Sugar Corporation (FSC) districts. The total number of effective respondents was 169.

This study applies the single-stage estimation model proposed by Battese and Coelli (1995). This model is expressed in Equations (1) and (2). Kumbhakar and Lovell (2000) state that the analysis of productive efficiency should have at least two components, with both incorporated into a single-stage estimation process. The first component of the process estimates the efficiency with which producers allocate their inputs and output(s). The second component concerns the exploration of exogenous variables, which are neither inputs to the production process nor outputs. For the initial estimation process to select variables that have a significant influence on sugar output, both the Cobb-Douglas and translog forms were used.

These can be expressed in logarithmic form as Equation (8) and Equation (9), respectively:

(8) $$\ln Y_i = \beta_0 + \sum_{j=1}^{4} \beta_j \ln X_{ji} + v_i - u_i$$

(9) $$\ln Y_i = \beta_0 + \sum_{j=1}^{4} \beta_j \ln X_{ji} + \sum_{j=1}^{4}\sum_{k=1}^{4} \beta_{jk} \ln X_{ji} \ln X_{ki} + v_i - u_i$$

where the subscripts i refer to the i-th farmer; ln denotes logarithms to base e; Y represents the quantity of sugar harvested (tonnes); X_1 is the area harvested in sugarcane (hectares) in 2003; X_2 is a dummy variable for land quality (1=greater than 50 percent of farm is classified as flat, 0=otherwise); X_3 is the total number of labour hours, including family, group and hired, per year for crop maintenance and cultivation; X_4 represents capital in kilowatts (kW); and X_5 is the amount of fertiliser applied (kilograms). The value of each v_i is as defined above.

The model for the technical efficiency effects in the stochastic frontier is defined by:

(10) $$u_i = \delta_0 + \delta_1 \ln \mathrm{FC}_{1i} + \delta_2 D_{2i} + \delta_3 D_{3i} + \delta_4 D_{4i} + \delta_5 D_{5i}$$

where $\ln \mathrm{FC}_{1i}$ is the proportion of the farm in planted to cane; D_{2i} is a dummy variable equal to one if the farmer lives on the farm, zero otherwise; D_{3i} is a dummy variable equal to one if the farmer owns a tractor, zero otherwise; D_{4i} is a dummy variable equal to one if the farmer leases reserve land (including *vakavanua*), zero otherwise; and D_{5i} is a dummy variable equal to one if the farmer is a member of a management group (formal and informal), zero otherwise.

Functional Form

The choice between the Cobb-Douglas or translog functional forms was made using a likelihood ratio (LR) test. Griffiths et al. (1993:455) defined the LR test as:

(11) $$\lambda_{LR} = 2\left[L(H_1) - L(H_0)\right]$$

where $L(H_1)$ and $L(H_0)$ are the maximised values of the log-likelihood functions under H_1 and H_0 respectively. Given that the null hypothesis is true, λ_{LR} has an approximate $\chi^2_{(J)}$-distribution, where J is the number of restrictions under H_0. H_0 is rejected when $\lambda_{LR} > \chi^2_c$, where χ^2_c is a chosen critical value from the $\chi^2_{(J)}$-distribution.

Testing the null hypothesis of the Cobb-Douglas production function against the general translog specification was done by setting the relevant parameters for squared and interactive terms in the translog form equal to zero. The resulting test statistic of $\chi^2_3 = 3.06$ compared to a critical value of 7.04 indicated that we were unable to reject the null hypothesis of the Cobb-Douglas at a 5% level of significance. A Cobb-Douglas functional form was thus selected. Estimates of the stochastic frontier in this paper were also confirmed using a 'random coefficients approach', following Kalirajan and Obwona (1994), allowing for the possibility of non-neutral shifts in the production frontier. Estimated results varied little and all technical efficiency rankings remain unchanged.

Hypothesis Tests

The following hypotheses are tested with generalised likelihood-ratio tests:

1. H_0: $\mu = 0$, where the null hypothesis specifies that a simpler half-normal distribution is an adequate representation of the data, given the specifications of the generalised truncated-normal model. The inefficiency factor error term, u_i, in the truncated-normal distribution is obtained by truncating (at zero) the normal distribution with mean μ, and variance σ^2_u. If u is pre-assigned to be zero, the distribution is semi-normal.

2. H_0: $\gamma = \delta_0 = \delta_1 = \ldots = \delta_5 = 0$, where the null hypothesis specifies that technical inefficiency effects are absent. That is, there is no inefficiency in the industry.

3. H_0: $\gamma = \sigma^2_u / (\sigma^2_v + \sigma^2_u) = 0$, where the null hypothesis specifies that the inefficiency effects are not stochastic.

4. H_0: $\delta_1 = \ldots = \delta_5 = 0$, where the null hypothesis specifies that farm-specific effects do not influence technical inefficiencies[6].

5. H_0: $\delta_0 = \delta_1 = \ldots = \delta_5 = 0$, where the intercept and all coefficients are zero[7]

Stochastic Production Function Variables

Definitions for the five input variables and four dummy district variations in Table are the following. Sugarcane (1) is the total volume (metric tonnes) of sugarcane as recorded by FSC for 2003. This is not a measure of total yield, as a proportion of farms have 'standing cane' or non-harvested cane at the end of the season. However, this information was not available to be included in the analysis. Land (2) is the area harvested and includes plant crop area (in hectares) and ratoon area, normally classified into years 1, 2 and 3 plus years, recorded by FSC for 2003. This figure does not include non-productive land or land used for other crops. Land quality (6) is a binary variable indicating 1 for farms with greater than 50 percent of the total land area in flat land, zero otherwise[8].

Total labour (3) includes the total number of hours of family, hired and group labour applied to cultivation, planting, fertilising, manual or hand weeding, herbicide spraying and cleaning or dressing the crop prior to harvesting. Harvesting was not included in the labour calculation as the majority of farmers indicated that they hired substitute cane harvesters. The value of 1 shown as a minimum number of hours indicates the small number of farmers who did not carry out any crop maintenance or cultivation during the 2003 season, yet were able to harvest a crop.

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[6] Setting u to non-zero and z to zero in the technical efficiency model reduces the specification to the model proposed by Aigner et al. (1977).

[7] Restricting μ to zero and z to zero in the technical efficiency model reduces the specification to the model proposed by Stevenson (1980).

[8] At the time of the survey, information on land use categories and soil information was in the process of being digitised by the Land Resources section of MASLR. Without the precise location of the farms for each of the surveyed farmers it was difficult to utilise the available information held by MASLR to give a more detailed description of the land and soil classifications for each farmer.

Capital (4) includes a common value (kilowatts -kW) of the two most valuable capital items of most farmers: bullocks and tractors[9]. Conversion from horsepower (hp) to kilowatts (kW) for tractors is 1:0.745 and bullock draught power for ploughing is estimated at 0.52 kW per bullock. For example, one 30hp tractor equals 22.37 kW and two bullocks of approximately 250 kilograms in weight equals 2.08 kW (Singh and Partap, 1999).

Table 1: Variables for Stochastic Frontier Production Function

Variable	Sample Min	Sample Max	Sample Mean	Sample Std.dev
1. Sugarcane (tonnes)	3.23	477.72	117.24	89.21
2. Land (hectares)	.20	12.00	2.92	1.88
3. Labour (hrs per year)	1.00	2,701.08	542.25	443.34
4. Capital (kilo watts)	2.08	41.01	16.52	12.52
5. Fertiliser (kilograms)	0	7200	882.36	961.88
6. Land quality (binary)	0	1	.473	.500
7. District 1	0	1	.159	.367
8. District 2	0	1	.289	.455
9. District 3	0	1	.242	.429
10. District 4	0	1	.278	.449
Efficiency model variables				
11.Farm in cane (per cent)	.0316	1	.474	.294
12.Reside on farm (binary)	0	1	.520	.501
13.Tractor ownership (binary)	0	1	.215	.412
14.Reserve land (binary)	0	1	.496	.501
15.Mgmt group member (binary)	0	1	.271	.445

The value for fertiliser (5) is derived from the number of bags that the farmer indicated was applied per hectare[10]. Although FSC has a record of the number of bags sold to each farmer, this data was not used. Selling bags of fertiliser to raise cash is not an uncommon practice and therefore farmers were asked about the amount that was actually applied.

[9] The lack of accurate data on the monetary value of farmers' assets (e.g. houses, vehicles, bullocks, tractor(s) and other farm implements) meant that a capital value could only be estimated from a common power factor between bullocks and tractors.
[10] Farmers usually answered in terms of bags per acre. This was recalculated to bags per hectare.

Variables 7 to 10 relate to the Mill districts. Each District 1 (7): Lautoka Mill; District 2 (8): Rarawai Mill; District 3 (9): Labasa Mill; and District 4 (10): Penang Mill. This variable is a proxy for regional differences associated with climatic differences across the two main islands of Fiji and also the industry infrastructure systems support for the growers. Each of the mill districts is made up sectors. To avoid the 'dummy variable trap' not all of the sectors in the Mill districts included in the sample, were included in the analysis.

Inefficiency Model Variables

The proportion of farm land under cane (11) is calculated using the lease area registered with FSC for sugarcane production and the total area harvested. Residence of farmer (12) is a binary variable indicating 1= farmer lives on the farm and 0=otherwise. "Otherwise" includes farmers who live in the village and village settlements. Tractor ownership (13) is a binary variable indicating 1=farmer owns tractor and 0=otherwise. Ownership includes outright ownership by an owner operator or part ownership as a member of a formal or informal group arrangement. Reserve land (14) is a binary variable indicating 1=whether the farmer leases reserve land or has a *vakavanua* arrangement or 0=otherwise. Information for this variable was derived from NLTB and FSC sources. Farmer responses were inconsistent and showed that the farmers' knowledge of their lease arrangements was not always accurate. Management group (15) is a binary variable indicating 1=management group owns tractor and 0=otherwise. "Management group" included a formal trust or other entity as well as informal arrangements between farmers.

5. RESULTS AND DISCUSSION

Maximum likelihood estimates of the model (Equation 8and 10) were obtained using FRONTIER 4.1 (Coelli, 1996). The programme follows a three-step procedure. OLS estimates of the function are first obtained, followed by a two-phase grid search for values of γ between zero and one with β parameters (except β_0) set to the OLS values and adjustments made to the β_0 and σ^2 parameters. Finally, the best likelihood values selected in the grid search are used as starting values in an iterative procedure using the David-Fletcher-Powell 'Quasi-Newton' method to form maximum likelihood estimates at a point where the likelihood function obtains its global maximum.

Hypothesis Tests

The first null hypothesis (H_0: $\mu = 0$) specifies that a simpler half-normal distribution is an adequate representation of the data, given the specifications of the generalised truncated-normal model (Table 2). The test statistic of 9.48 leads to rejection of the H_0. The second and third tests that technical inefficiency effects are absent (H_0: $\gamma = \delta_0 = \ldots = \delta_5 = 0$) and that the inefficiency effects are not stochastic (H_0: $\gamma = \sigma_u^2/(\sigma_v^2 + \sigma_u^2) = 0$) are both rejected. The traditional average response function is thus not an adequate representation of the agricultural production of Fijian indigenous sugarcane farmers. Test four (H_0: $\delta_1 = \delta_2 \ldots = \delta_p = 0$) that farm-specific effects do not influence technical inefficiencies is rejected along with the final null hypothesis where the intercept and all coefficients are zero. From the specifications of the stochastic frontier model (Equations 8 and 10), the LR test results show that the technical inefficiency effects are significant in defining the variation in productivity among Fiji's indigenous sugarcane farmers.

Table 2: Generalised likelihood ratio tests for parameter restrictions in the stochastic production frontier and technical efficiency models (Equations 8 and 10)

Test	Null Hypothesis	λ	$\chi^2_{0.05}$ *	Decision
1	H_0: $\mu = 0$	9.48	5.14	Reject H_0
2	H_0: $\gamma = \delta_0 = \delta_1 = \ldots = \delta_5 = 0$	100.96	10.37	Reject H_0
3	H_0: $\gamma = \sigma_u^2/(\sigma_v^2 + \sigma_u^2) = 0$	26.97	2.71	Reject H_0
4	H_0: $\delta_1 = \ldots = \delta_5 = 0$	18.43	5.14	Reject H_0
5	H_0: $\delta_0 = \delta_1 = \ldots = \delta_5 = 0$	27.01	2.71	Reject H_0

* $\chi^2_{0.05}$ is obtained from Kodde and Palm (1986:1246)

Results for the stochastic frontier model are shown in Table 3. All estimated input variables are significant at the 5 percent level, except for District 4. Input share coefficients sum to 0.371, with land quality and regional variation contributing 0.598.

Table 3: Maximum-likelihood estimates for parameters of stochastic frontier and technical inefficiency models (Equations 8 and 10)

Variable	Parameter	MLE Coefficient	MLE T-ratio	OLS Coefficient	OLS T-ratio
Stochastic frontier					
Constant	β_0	1.468(0.082)***	17.837	1.209(0.125)	9.706
LnLand	β_1	0.301(0.024)***	12.638	0.349(0.039)	8.863
Land quality	β_2	0.096(0.026)***	3.663	0.137(0.043)	3.173
LnLabour	β_3	0.018(0.009)**	1.998	0.007(0.020)	0.344
LnCapital	β_4	0.038(0.011)***	3.561	0.019(0.018)	1.069
LnFertiliser	β_5	0.013(0.004)***	2.835	-0.001(0.008)	-0.124
District 1	β_6	0.164(0.080)**	2.056	0.333(0.143)	2.334
District 2	β_7	0.132(0.073)**	1.818	0.292(0.134)	2.173
District 3	β_8	0.143(0.077)**	1.855	0.271(0.138)	1.965
District 4	β_9	0.063(0.070)	0.899	0.269(0.137)	1.963
Constant	δ_0	-1.244(0.783)*	-1.589		
LnFarm in cane	δ_1	-0.139(0.063)**	-2.215		
Residence	δ_2	-1.366(0.519)***	-2.630		
Tractor ownership	δ_3	-0.687(0.355)**	-1.936		
Reserve land	δ_4	0.193(0.123)*	1.579		
Management	δ_5	-2.813(1.242)***	-2.265		
	σ^2	0.680(0.244)***	2.780	0.064	
	γ	0.991(0.004)***	233.203		
Ln(likelihood)			48.179		-2.274
Mean efficiency	0.828				
Number of observations	169				

Notes: Numbers in parentheses are asymptotic standard errors. ***,**, and * indicate statistical significance at the 0.01, 0.05 and 0.10 level respectively and t-ratio is asymptotic.

The most significant factors are land (β_1) land quality (β_2) and capital (β_4)[11]. Land or area harvested is a highly significant factor in the production function. Land quality is

[11] Chemical use (herbicides) was excluded from the production function because of its low significance in the inefficiency model. This result was somewhat surprising given the gains in yields that can be achieved with the proper application of herbicides.

also highly significant but this variable is an indication only of the slope of the land (i.e. farms with 50 percent of the planted area in flat land).

Data on soil fertility or land use capability was not available. The results however are indicative of the influence that flat land has on productivity. Cultivation costs are reduced and the response rates from fertiliser applications are higher than for cane grown on steep or very steep farms. Capital is highly significant and this indicates that higher kilowatt (kW) capital reserves are a significant factor in farm production.

Farms with higher reserves are those that have access to or own tractors. The output of sugarcane is highly dependent on weather patterns (temperature and rainfall distribution). These differences are captured in the four districts dummy variables in the production model. Regional variation in farmer support infrastructure is also captured in the district dummy variables. These include: the level of government assistance (e.g. agricultural ministry extension services); industry advisory services (e.g. sugar industry farm advisors) and financial assistance (FDB loans and other financial services that may have regional differences).

Other district factors include the distance from the farms to the mills. District 4 (β_9) is the Penang mill district and produced the lowest t-ratio (less than 0.9). A high proportion of the farms included in the survey were from two sectors within the Penang district (Ellington I and Ellington II). A high proportion of the growers in these sectors have *vakavanua* titles or leases to reserve lands and therefore do not have the degree of security over their land that allow them to borrow funds commercially. Growers in Ellington II sector are a considerable distance from the mill and therefore are more reliant on hired transport. These factors contribute to a moderate level of technical efficiency among the indigenous growers in the Penang mill sectors with around 84 percent of all of Penang's surveyed farmers falling into the low to medium category (see following section).

The results of the technical inefficiency model based on the asymptotic t-ratios show that residence (δ_2) and membership of a management group (δ_5) have a highly significant positive effect on technical efficiency (or a highly significant negative effect on technical inefficiency). The percentage of farm under cane (δ_1) and tractor ownership (δ_3) are also significant at the 5% level. Reserve land (δ_4) has a positive sign, which indicates a positive effect on technical inefficiency (that is an increase in technical inefficiency). Gamma ($\gamma = 0.99$) is highly significant and the mean efficiency of indigenous Fijian farmers is 82.8%.

Taking each of these technical inefficiency variables in turn we find that residence is highly significant (t-ratio =–2.63), showing that farmers who live on the farm are more efficient than those who live in villages or settlements. Membership of a management group (either formal or informal) is also highly significant (t-ratio = -2.26). Group membership appears to provide a mechanism to overcome problems that an individual farmer may face. These include the pooling of resources to purchase expensive capital items such as tractors and the centralising of management decisions to improve the coordination and management of labour.

The proportion of the farm planted to cane is significant (t-ratio = -2.215), supporting the argument that farmers with greater investment in sugarcane are more likely to be better producers. Tractor ownership is less significant (t-ratio = -1.936) than the other variables but it does indicate that greater capital investment in machinery improves technical efficiency. Farmers with bullocks may well be able to farm profitably and sustainably on small blocks but the physical demands of manual ploughing is an issue for farmers who are, on average, close to 50 years old. Additionally, farmers with bullocks are more likely to be subjected to requests from family to donate their bullocks to village ceremonies.

Reserve land is significant (at the 10 percent level, t-ratio=1.56) and its positive sign indicates that farmers with formal leases on reserve land (Class J) or informal arrangements on reserve land are less technically efficient. These lease arrangements can be problematic for farmers, particularly with the restrictions imposed when applying for financial loans. Lack of credit security (collateral) on *vakavanua* and Class J leases has caused increasing pressure from financial institutions and the Government for landowners to convert to agricultural leases (Class A) that are under the administrative control of the NLTB.

Farm Profiles by Efficiency Rankings

The farm level efficiency measures from the frontier estimates, combined with the farm characteristics from the survey data, provides a profile of indigenous Fijian sugarcane farmers by efficiency ranking (Table 4). Following Kompas and Che (2004) these rankings are arbitrarily divided into 'low' (25 to 82 percent), 'medium' (82 to 92 percent) and 'high' (93 percent and higher).

Table 4: Summary characteristics of efficiency groups

Average value of farm features	Unit	Efficiency of farm group		
Low		Low	Medium	High
<25% to 81%		<25% to 81%	82% to 92%	>93%
Total output		60.3	114.1	199.7
Land area	*ha*	2.7	2.7	3.5
Yield – tonnes of sugarcane per hectare	*tsc/ha*	24.5	43.2	61.6
Area of farm planted in sugarcane	%	42.4	49.1	50.8
Area of ratoon cane replanted	%	5.6	17.5	24.9
Land quality (1=flat; 2=rolling; 3=steep)		1.5	1.4	1.7
Total annual labour hours per hectare	*hrs/ha*	170.0	203.7	198.4
Chemical (herbicide) used by farmers	%	36.4	55.1	54.8
Fertiliser (kilograms) per hectare	*kg/ha*	312.2	259.2	318.4
Reserve or *vakavanua* lease	%	53.7	47.1	48.8
Tractor used (hired or borrowed)	%	77.8	51.6	75.7
Tractor owned by farmer or group	%	14.3	21.7	31.0
Age of farmer	*yrs*	50.1	47.2	51.0
Farming experience	*yrs*	13.7	15.9	17.3
Contract with FSC	*yrs*	14.2	13.9	15.1
School years	*yrs*	8.3	8.0	7.2
Cash crops	%	27.3	35.8	23.8
Reside on farm	%	42.9	53.6	61.9
Tertiary qualifications	%	10.5	2.9	2.4
Trade or technical skills	%	29.8	17.1	21.4
Non-farm income	%	15.8	8.6	21.4
Member of land owning unit	%	80.4	74.3	68.3
Member of management group	%	17.5	20.3	18.4

Caution has to be taken with the interpretation of the results, since the correspondence of the farm characteristics with high or low efficiency levels may be coincidental and not causal[12]. The results from the inefficiency model in Table 8 are more precise and should condition the overall conclusions gained from these profiles. A noticeable feature of Table 4, is not only the difference in area harvested between the high performers and the medium and low performers (an average of 23 percent) but also the higher total output and yield. Medium producers, on average, have yields 43 percent higher than low performers and the yields of high performers are 30 percent higher than those of medium performers. The proportion of land in cane is not noticeably different between the high and medium performers but the proportion of ratoon cane that has been replaced with plant cane is significant. Land quality, while significant in the efficiency model (Table 2), is not a significant qualitative characteristic of the efficiency groups.

Note that land quality in the efficiency model is binary (1 = 50 percent or more of the farm on flat land; 0 = otherwise) whereas Table 3 is based on the three nominal FSC categories. These are: 1 = 50 percent or more of the farm on flat land; 2 = 50 percent or more of the farm on rolling land; 3 = 50 percent or more of the farm on steep land. The only noticeable point is that high performers are producing on slightly lower quality land.

The total number of annual labour hours per hectare shows no significant difference between the three efficiency groups. This is confirmed from the estimates of the efficiency model. Use of chemicals for weed control was dropped from the efficiency model because of its low level of significance. However, the efficiency groupings show a marked increase in the use of chemicals by the medium and high performers in comparison to the low performers (an increase of 34 percent). Fertiliser application shows no significant difference between the groups.

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[12] Care must also be taken in the interpretation of the relative rankings of the farms and distribution of the efficiency measures. Neff *et al*. (1993) in a comparison of nonparametric and parametric models using panel data from Illinois grain farmers, points out that while stochastic models result in lower mean

Tractor use by the three groups shows no noticeable differences but tractor ownership is significantly higher among the high performers. Years of farming experience increases with the higher performers but there is no significance difference in the number of years of supplying sugarcane to FSC. The proportion of farmers who reside on their farms or in settlements increases with the improvement in technical efficiency.

Farmers with tertiary qualifications are represented more among the low performers. While the overall number of farmers with tertiary qualifications is low, this result indicates that farmers with alternative skills are likely to seek off-farm employment. This interpretation is corroborated by the higher number of low efficiency farmers with trade or technical skills. Of interest, however, is the higher number of high performers with non-farm income (21.4 percent).

In the efficiency model (Table 3), farming on reserve land (Class J leases) or with *vakavanua* arrangements showed a significant negative influence on technical efficiency (at the 5 percent level). This result is supported by the slightly higher number of farmers in the low efficiency group. The low number of farmers in the low efficiency group who own tractors is also corroborated by the results of the efficiency model.

Results from the stochastic frontier and technical efficiency models indicate that *galala* farmers, residing on-farm or in settlements, and farmers who are members of a formal or informal group are more likely to have a higher level of technical efficiency. Farm residence improves technical efficiency by reducing the farmer's obligation to be part of social and communal activities that would normally remove them from farm work for long periods of time. Living out of the village, however, does not lessen the expectation from the village for farmers to contribute to social activities, nor does it reduce the farmer's willingness to contribute. The key factor appears to be that distance from the village allows farmers to be more selective in their contribution of time and material gifts.

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efficiency measures in comparison to nonparametric models, the distribution of the efficiency ratios is concentrated at a higher level.

Residing out of the village or on the farm alone may increase technical efficiency, but it is difficult for the farmer (and family) to maintain without support. Planting a higher proportion of the farm in cane is dependent on the farmer having access to funding to finance the seasonal costs, and similarly, purchasing a tractor is highly dependent on access to capital. While membership of a group does not necessarily mean that farmers will own a tractor or have a higher proportion of their farm planted to sugarcane, the chance of it occurring, increases.

Settlements or farming communities made up of one or more *mataqali* play an important role in providing a support structure. Farmers in a settlement in the Bulivou sector were adamant that distancing themselves from the village is an important step in developing an independent attitude. Determination to succeed among the farmers is high. Two Methodist churches have been built in the settlement and they have developed an effective support group among themselves. Contact with their village occurs infrequently and is restricted to significant social occasions. However, while living in settlements or on farms may free up the time of farmers it does not always improve farmers' capacity to save and accumulate farm capital.

6. POLICY IMPLICATIONS AND CONCLUSIONS

This paper indicates that traditional group membership may provide a mechanism to overcome problems that an individual farmer may face. In particular, increased technical efficiency was a result of centralising of management decisions to improve the coordination of farm inputs and management of labour. It also enables key farm management activities to be carried out on each of the farms with minimal input from the individual leaseholder, for example, fertiliser applications carried out mechanically by tractor and mechanical spreader. If a farmer lives in the village and their involvement in communal activities reduces their time spent on farm work, the effect on the farm is minimised. The amalgamation of leases into a contiguous single production unit increases the scale efficiencies, and enables the pooling of resources to purchase expensive capital items such as tractors. A single organisation also improves access to debt finance and lowers transaction and administrative costs.

An additional, but less tangible benefit, is the cultural legitimacy that group membership carries. Incorporating cultural concepts (e.g. *solesolevaki*) in the organisation's mode of practice improves its acceptability with the wider social unit. Farmers who belong to a group where the resources are collectively owned, seem to have greater acceptance. Farmers are also less constrained in refusing to give more than they are prepared to contribute if the asset is collectively owned.

Formal groups also have several distinct advantages over informal arrangements. Most informal 'co-operatives' have been formed primarily to pool resources to purchase a tractor or another capital item that would be too expensive for an individual. Land leases are kept separate, membership is voluntary and there is no centralised management system. While effective as a mechanism to raise capital, they are subject to the problem of common ownership: that is, assets are open to abuse. A tractor with several drivers but no one with the responsibility of maintenance has a very limited useful life.

While these organisations have shown the capacity to improve the technical efficiency of farmers and provide a mechanism for capital accumulation, their application outside of the sugar industry is not known. The sugarcane farming system lends itself favourably toward a centralised management system. Crops with greater husbandry requirements (i.e. higher technical skills) are perhaps less likely to respond to a mechanised farming approach.

REFERENCES

Aigner, D. J., Lovell, C. A. K., & Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics, 5*, 21-38.

Amara, N., Traore, N., Labdry, R., & Romain, R. (1999). Technical efficiency and farmers' attitudes toward technological innovations: The case of the potato farmers in Quebec. *Canadian Journal of Agricultural Economics, 47*, 31-43.

Audibert, M. (1997). Technical inefficiency effects among paddy farmers in the villages of the "Office du Niger", Mali, West Africa. *Journal of Productivity Analysis, 8*, 379-394.

Battese, G. E., & Coelli, T. (1988). Prediction of firm-level technical efficiencies with a generalised frontier production function and panel data. *Journal of Econometrics, 38*(387-99).

Battese, G. E., & Coelli, T. (1995). A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical Economics, 20*, 325-332.

Battese, G. E., & Corra, G. (1977). Estimation of a production frontier model with applications to the pastoral zone of Eastern Australia. *Australian Journal of Agricultural Economics, 21*(3), 167-179.

Battese, G. E., Malik, S. J., & Gill, M. A. (1996). An investigation of technical inefficiencies of production of wheat farmers in four districts of Pakistan. *Journal of Agricultural Economics, 47*(1), 37-49.

Battese, G. E., & Tessema, G. A. (1993). Estimation of stochastic frontier production functions with time-varying parameters and technical efficiencies using panel data form Indian villages. *Agricultural Economics, 9*, 313-333.

Burns, S. A., Watson, T. W., & Peacock, A. T. (1960). *Report of the Commission of Enquiry into the natural resources and population trends of the colony of Fiji*. Suva: Fiji Legislative Council Paper C.P.1/1960. Government Printer.

Coelli, T. (1996). *A guide to FRONTIER Version 4.1: A computer program for stochastic frontier production and cost function estimation*. CEPA Working Paper 96/07: Centre for Efficiency and Productivity Analysis, University of New England, Armidale.

Coelli, T., Prasada Rao, D. S., & Battese, G. E. (1998). *An introduction to efficiency and productivity analysis*. Boston: Kluwer Academic Publishers.

FDB. (2003). *Communal effort integrating Fijian lifestyle in the business world - successfully*. Suva: Fiji Development Bank Annual Report (pp. 17-18).

Forsund, F. R., C. A. K. Lovell, et al. (1980). A survey of frontier production functions and their relationship to efficiency measurement. *Journal of Econometrics* **13**(1): 5-25.

Gavian, S., & Ehui, S. (1999). Measuring the production efficiency of alternative land tenure contracts in a mixed crop-livestock system in Ethiopia. *Agricultural Economics, 20*, 37-49.

Griffiths, W.E., Hill, R.C., & Judge, G.G. (1993). *Learning and practicing econometrics.* Toronto: John Wiley & Sons.

Hasnah, A., Flemming, E., & Coelli, T. (2004). Assessing the performance of a nucleus estate and smallholder scheme for oil palm production in West Sumatra: A stochastic frontier analysis. *Agricultural Systems, 79*, 17-30.

Kalirajan, K. P., & Obwona, M. (1994). Frontier production functions: The stochastic coefficients approach. *Oxford Bulletin of Economics and Statistics, 56*, 87-94.

Kodde, D. A., & Palm, F. C. (1986). Wald criteria for jointly testing equality and inequality restrictions. *Econometrica, 54*(5), 1243-1248.

Kompas, T., & Che, T. N. (2004). Technology choice and efficiency among Australian dairy farms. International and Development Economics Working Paper 04-1, Canberra: Asia Pacific School of Economics and Government, Australian National University, *Australian Journal of Agricultural and Resource Economics,* (in press).

Kumbhakar, S. C., & Lovell, C. A. K. (2000). *Stochastic Frontier Analysis*. Cambridge: Cambridge University Press.

Lal, P., Lim-Applegate, H., & Reddy, M. (2001). *ALTA or NLTA? What's in the name? Land tenure and the Fiji sugar industry*. Madison: Working Paper No. 46: Land Tenure Centre, University of Wisconsin.

Mathijs, E., & Vranken, L. (2001). Human capital, gender and organisation in transition agriculture: Measuring and explaining the technical efficiency of Bulgarian and Hungarian farms. *Post-Communist Economies, 13*(2), 171-187.

Meeusen, W., & van den Broeck, J. (1977). Efficiency estimation from Cobb-Douglas production functions with composed error. *International Economic Review, 8*, 435-455.

Neff, D. L., Garcia, P., & Nelson, C. H. (1993). Technical efficiency: A comparison of production frontier methods. *Journal of Agricultural Economics, 44*, 479-489.

NLTB. (2003). *Fijian cane farmers must live by new code,* . Suva: Native Land Trust Board, Vanua: Issue 2, August.

Rao, G. (2003). Leading trends in the sugar cane sector. *Fijian Studies, 1*(2), 301-314.

Sherland, S. M., Barrett, C. B., & Adesina, A. A. (2002). Smallholder technical efficiency controlling for environmental production conditions. *Journal of Development Economics, 69*, 85-101.

Singh, V., & Partap, T. (1999). Animal draught power output during different operations in mountain agriculture: a study of Indian Central Himalaya. *Envis Bulletin, 7*(2), 36-52.

Spate, O. H. K. (1959). *The Fijian people: economic problems and prospects*. Suva, Government Press: Legislative Council of Fiji, Council Paper No. 13.

Stevenson, R. E. (1980). Likelihood functions for generalised stochastic frontier estimation. *Journal of Econometrics, 13*(1), 57-66.

Wilson, P., Hadley, D., & Asby, C. (2001). The influence of management characteristics on the technical efficiency of wheat farmers in eastern England. *Agricultural Economics, 24*, 329-338.