Enhancing the agricultural sector in Pacific island economies

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Agriculture continues to play an important role in the growth and development of most Pacific island countries. With increasing populations and desire for higher incomes, the island countries will have to increase agricultural production, especially the Micronesian and Melanesian countries. In most countries, increases in agricultural production can be gained by increases in land area under agriculture, or by increasing efficiency and productivity. In this paper, we examine how selected Pacific island countries have measured up with respect to raising efficiency. Results reveal that efficiency levels in the four countries have not changed over the past four decades.

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In the competitive global market, where larger and more developed countries with scale and resource advantages have progressed well in terms of economic growth by expanding and developing their industrial and services sectors, the growth prospects for most of the Pacific island countries lie in a few sectors only. Agriculture is one of them. Furthermore, global evidence points to growth in agriculture and agricultural productivity as being the basis for sustained economic growth; particularly for countries at very low income levels and where most of the people are living in rural areas.

In Pacific island countries, most of the people live in rural areas and depend heavily on agricultural activities for their livelihoods. With the exception of the Polynesian countries, the populations of these small countries are growing quite rapidly. For this reason, and because prospects for income growth and improvements in welfare depend so heavily on agriculture, the productivity performance of the agricultural sector is critical to the food security of these nations.

Many developing countries made the mistake of believing that the agricultural sector could not be important in economic growth and development. For a long period there was an emphasis on promoting growth through industrialisation by means of protection of manufacturing industries and heavy state involvement in such activities.

This policy failed miserably. Moreover, it held back development of the agricultural sector by raising the costs of agricultural inputs and forcing the exchange rate to be higher than it otherwise would be. There is now greater awareness of the important role of growth in the agricultural sector in promoting growth in the whole economy and thereby reducing poverty.

Given such an important role for agriculture, there are very few studies that have examined the efficiency and productivity status of Pacific islands agriculture. The most recent study on total factor productivity (TFP) was undertaken by Reddy and Duncan (2006). The authors of this study found that TFP in most of the countries studied has been negative or barely positive over the past 42 years. Even in the best performing country, TFP growth has been less than 0.5 per cent per year.

This study examines the efficiency performance of Pacific islands agriculture over the past four decades. Due to data limitations, the analysis is limited to estimation of efficiency levels in only four Pacific island countries.

The article provides an overview of Pacific islands agriculture, describes the statistical technique used for computing indices of efficiency for the agriculture sector, and presents the results for the four countries. It also makes some suggestions for achieving improvements in agricultural sector performance.

Agriculture and the Pacific island economies

The recent economic performance of most of the six Pacific island countries included in Table 1 has been disappointing. Except for Samoa and Tonga, which have had reasonably good growth rates, the other countries have either experienced declining output or only marginal increases in growth. Previously, the explanation for such poor performance was seen as having purely economic causes (for example, low saving and investment rates, poor access to raw materials, low agricultural potential). However, attention in the development literature has shifted to a focus on additional factors such as the role of historical, social and institutional factors (Fukuyama 1995, 1999; North 1990, 1994; Olson 1996; Ostrom 2000; Shleifer and Vishny 1998). In Pacific island countries, particular attention has been given to the institutional environment, which consists of formal rules (constitutions, laws, and property rights) and informal constraints (taboos, traditions, and norms or codes of conduct) that structure political and socioeconomic conduct. Both the formal and informal constraints have an impact on trust, which is an integral part of any transaction. Without trust, it is very difficult for parties to engage in transactions; and without transactions, the economy will collapse.

In most of the Melanesian countries (Fiji, Papua New Guinea, Solomon Islands and Vanuatu), growth via transactions has been adversely affected by political unrest and instability in recent years, leading to a description of these countries as the 'arc of instability' (Duncan and Chand 2002). Poor growth performance has placed pressure on government resources, and the common response has been for government spending to rise, leading to higher inflation, increased budget deficits, and higher debt levels. The lack of a concerted effort to raise the productive capacity of the economy has been reflected in the worsening of the current account balance.

The Melanesian countries have large land areas relative to their populations (Table 2). Most of the other Pacific island countries have low land-labour ratios but have the benefit of exclusive economic zones (EEZs) covering large areas of the Pacific Ocean, which provides them with a range of marine products. For the countries shown in Table 2, land areas range in size from 26 square kilometres for Tuvalu to 462,243 square kilometres for Papua New Guinea. While its topography presents great difficulties for transport and communications, Papua New Guinea has good potential for agricultural production and is also well endowed with timber and mineral resources—in particular, gold and copper. Fiji has a land mass of reasonable size (18,270 square kilometres) and a diversity of agricultural, forestry and fishing production. It also produces gold and is exploring the mining of copper. Solomon Islands is the second largest of the Pacific island countries with a land area of 27,540 square kilometres. Its large land area and land-based resources, in particular timber, could play an important role in its development.

The smaller countries are severely limited not only because of their small land areas but also because of the physical nature of these islands. Countries such as Kiribati, Marshall Islands, Tuvalu and Tokelau are atolls with porous, sandy soils and therefore have very limited potential for agriculture. Instead, these countries have to rely on the sea for food and sources of growth.

The share of agricultural output is high in the GDP of most of the Pacific island countries. The country with the highest share is the Federated States of Micronesia (FSM) with 73 per cent, while the lowest is Marshall Islands with 13.8 per cent. Those countries with high agricultural potential have a large proportion of their population in the agricultural sector—ranging from 26.1 per cent for FSM to 74 per cent for Papua New Guinea. In most countries a large proportion of the population is engaged in subsistence activities.

Agricultural production: trends and composition

Data from the FAO show that, apart from Samoa, Tonga and Vanuatu, aggregate agricultural production has increased in the seven countries for which this information is available (Figure 1).[1] Agricultural production in Tonga has been declining since the late 1970s. Samoa's agricultural production declined in the 1980s but has increased since 1990. In Vanuatu, production has declined since the mid 1980s. In Kiribati, Papua New Guinea and Solomon Islands, agriculture sector output has been increasing steadily since the 1960s. Fiji's agricultural growth has been stagnant since the mid 1980s.

The trend in the crop production index is somewhat different to the trend in the overall agricultural production index (Figure 2). Even in the land-rich countries where crop production increased steadily (Kiribati, Papua New Guinea and Solomon Islands), output has been stagnant since the beginning of the 1990s. The explanation for the decline in Fiji's crop production must lie in large part in the decline in sugarcane production associated with the long-term uncertainty about the renewal of land leases.

In contrast to the crops sector, the livestock production indexes (Figure 3) show a generally increasing trend for all countries. However, except for Kiribati and Papua New Guinea the performance of this sector has also been poor since the mid 1980s. A comparison of Figures 1 and 2 show that the long-term decline in agricultural output in Samoa and Tonga is due to the decline in crop production as livestock production increased steadily from the 1960s to the 1980s. The major questions that arise from this overview are the reasons for the stagnation in crop and livestock production since the mid 1980s and the reasons for the differences in performance in the crop and livestock sectors in the period prior to the mid 1980s.

Table 1 **Basic economic indicators for selected Pacific island countries, 1999–2005** (per cent per annum)

		GDP growth rate	Inflation	Growth rate of exports	Growth rate of imports	Agricultural sector growth rate
Fiji	1999	9.2	0.2	19.4	25.3	13.5
	2000	–2.8	3.0	–6.8	–7.9	–1.2
	2001	2.7	2.3	–4.7	4.8	–5.8
	2002	4.3	1.6	1.2	9.2	4.3
	2003	3.0	4.2	34.6	39.1	–3.9
	2004	4.1	3.3	–3.3	14.6	3.4
	2005	1.7	3.0	19.4	13.7	2.0
Papua New Guinea	1999	7.6	14.9	9.1	–0.1	13.8
	2000	–1.2	15.6	7.3	–7.0	2.1
	2001	1.8	9.3	–13.7	–6.4	–4.7
	2002	–1.0	11.8	–9.5	14.6	–4.1
	2003	2.9	14.7	34.4	10.3	4.1
	2004	2.9	2.1	15.6	22.4	4.2
	2005	3.0	1.0	25.5	0.4	4.1
Samoa	1999	2.2	0.3	103.8	26.5	–3.1
	2000	6.1	1.0	8.2	–12.6	0.1
	2001	6.8	3.8	–15.7	19.2	–3.8
	2002	1.2	8.0	–0.7	11.5	–6.3
	2003	3.3	0.1	–10.4	–1.0	–3.5
	2004	3.7	11.7	9.3	12.5	–6.5
	2005	5.6	7.8	–9.9	16.9	..
Solomon Islands	1999	–0.5	8.0	–3.6	–12.9	–5.6
	2000	–14.3	7.1	–46.5	–11.9	–16.3
	2001	–8.7	7.7	–27.6	–7.6	–4.4
	2002	–2.1	9.4	22.7	–31.2	5.1
	2003	5.3	10.0	28.4	36.8	..
	2004	5.0	7.1	30.3	15.8	..
	2005	2.9	6.2	3.6	42.1	..
Tonga	1999	2.3	4.5	12.6	–21.2	–1.9
	2000	5.6	6.3	–11.6	10.2	5.6
	2001	2.5	8.3	2.1	–8.3	1.0
	2002	2.6	10.4	66.8	11.6	3.6
	2003	3.1	11.6	–0.2	22.3	3.8
	2004	1.6	11.0	–21.3	11.4	
	2005	2.8	9.6	14.2	25.5	
Vanuatu	1999	–3.2	2.0	–24.2	9.3	–12.2
	2000	2.7	2.5	5.8	–7.2	6.7
	2001	–2.1	3.7	–26.8	0.8	0.5
	2002	–2.8	2.0	1.0	–4.5	1.7
	2003	2.4	3.0	32.3	16.4	6.2
	2004	3.2	1.4	28.6	6.0	3.5
	2005	2.9	2.5	14.3	14.1	3.2

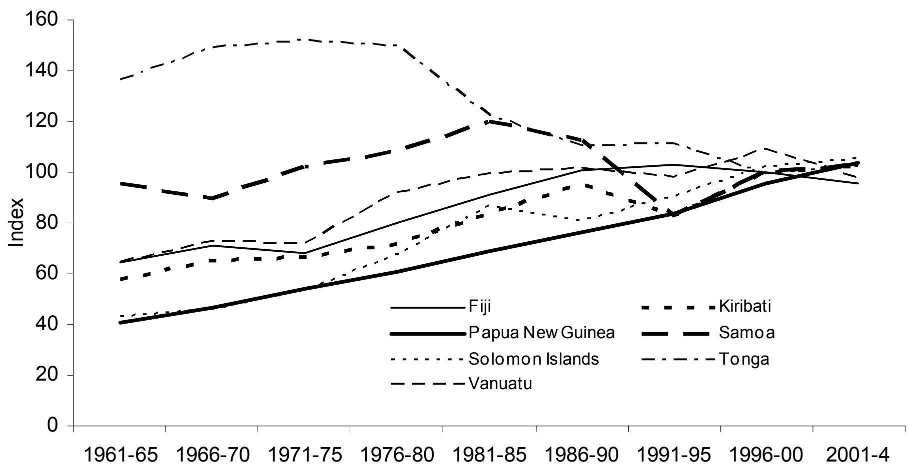
Sources: UNESCAP, 2003. *Economic and Social Survey of Asia and the Pacific*, United Nations Economic Social Commission for Asia and the Pacific, Bangkok; Asian Development Bank, 2007. *Key Indicators of Developing Asian and Pacific Countries*, Asian Development Bank, Manila; Asian Development Bank, 2002. *Asian Development Outlook*, Oxford University Press, New York.

Table 2 **Socioeconomic profile of selected Pacific island countries**

Country	Population	Sea area (km^2)	Agriculture (per cent of GDP)	Land area (km^2)	Share of agricultural population (per cent)
Fiji	819,000	1,290	16	18,272	39.7
Cook Islands	18,000	1,830	14	237	61.1
FSM	107,000	2,978	73.2	701	26.1
Kiribati	87,000	3,550	14.2	810	26.4
Marshall Islands	56,000	2,131	13.8	181	25.0
Papua New Guinea	5,500,000	3,120	26.9	462,243	74.8
Samoa	177,700	120	14.3	2,935	33.8
Solomon Islands	490,000	1,340	43.5	27,556	65.3
Tonga	101,000	700	28.6	747	34.6
Tuvalu	10,880	900	16.8	26	37.0
Vanuatu	202,200	680	16.3	12,190	35.6

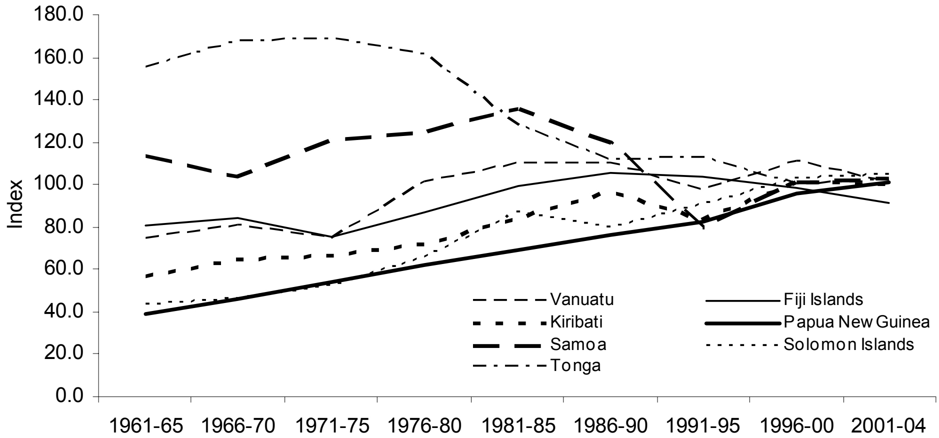
Note: The agricultural population share data is for year 2000.
Source: Asian Development Bank, 2004. *Key Indicators of Developing Asian and Pacific Countries*, Asian Development Bank, Manila.

Figure 1 **Pacific island countries' agricultural production index, 1961–65 to 2001–04** (1999–2001=100)



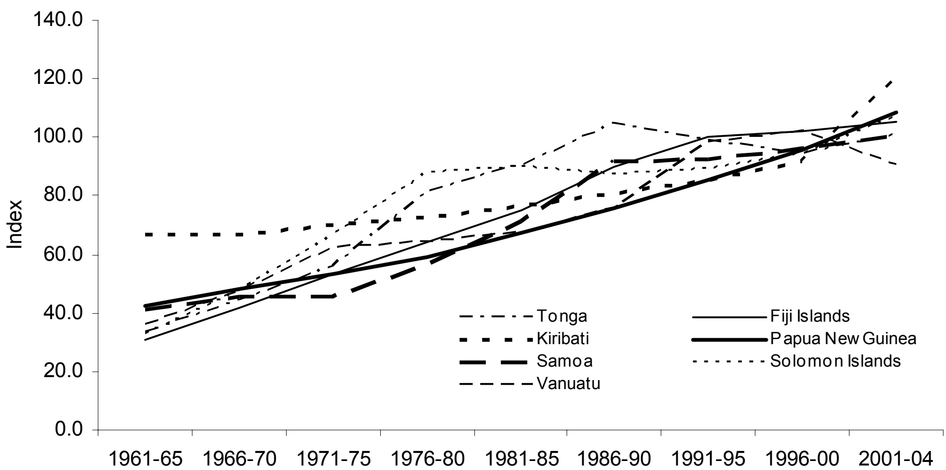
Source: Food and Agriculture Organization (FAO), 2004. *FAO Statistics*, Food and Agriculture Organization of the United Nations, Rome.

Figure 2 **Pacific island countries' crop production index, 1961–65 to 2001–04** (1999–2001=100)



Source: Food and Agriculture Organization (FAO), 2004. *FAO Statistics*, Food and Agriculture Organization of the United Nations, Rome.

Figure 3 **Pacific island countries' livestock production index, 1961–65 to 2001–04** (1999–2001=100)



Source: Food and Agriculture Organization (FAO), 2004. *FAO Statistics*, Food and Agriculture Organization of the United Nations, Rome.

Table 3 **Pacific island countries' per capita agricultural production index, 1961–65 to 2001–03** (1999–2001=100)

	Fiji Islands	Kiribati	PNG	Samoa	Solomon Islands	Tonga	Vanuatu
1961–65	119.76	112.34	97.82	135.46	125.20	162.22	192.78
1966–70	114.76	115.54	102.10	113.02	115.26	153.12	187.38
1971–75	100.30	108.66	104.84	119.80	113.00	143.58	157.38
1976–80	105.70	107.48	104.8	121.68	118.00	143.34	174.66
1981–85	108.08	108.28	104.76	132.34	128.84	117.00	165.20
1986–90	112.76	95.20	103.04	122.98	102.20	106.38	149.12
1991–95	111.04	92.62	99.54	88.34	97.44	109.54	125.28
1996–00	102.82	103.00	99.80	102.24	99.56	98.84	122.02
2001–03	95.50	98.30	97.40	100.00	98.80	100.20	86.20

Source: Food and Agriculture Organization (FAO), 2004. *FAO Statistics*, Food and Agriculture Organization of the United Nations, Rome.

The per capita agricultural production indexes for the Pacific island countries present an even more pessimistic picture than do the production indexes (Table 3). The trend in per capita agricultural production is declining in all seven countries, even in the Polynesian countries (Samoa and Tonga) where population growth has been less than one per cent due to the high rate of emigration. Even given the qualifications about the accuracy of the measures of subsistence production, the declining trends in per capita agricultural output must raise concerns with respect to food security in these societies—given the large proportion of the population living in rural areas and depending on agriculture for their livelihoods.

Most of the commercial crops produced across the Pacific island countries are similar. Copra is common to almost all Pacific island countries and is the only commercial crop produced by the atoll island countries. Fish production is also common to all Pacific island countries. All have large EEZs that form part of the migratory path of the large Pacific tuna stocks. As well, all countries depend heavily on their inshore fisheries for subsistence. The two most industrialised countries, Fiji Islands and Papua New Guinea, have the most diverse agricultural sectors, although the crops produced are different. Papua New Guinea's commercial crop output is concentrated in tree crops (coffee, cocoa, palm oil, and tea) while sugar has long been the mainstay of the Fiji economy.

As emphasised by the work of Mundlak et al. (2004), growth in productivity and efficiency is the ultimate source of sustained economic growth and improved welfare. It is hoped that efficiency analysis of Pacific agriculture will help in some understanding of the reasons for the poor agricultural sector performance in the Pacific island countries. Subsistence agriculture is a large part of total agricultural production in the Pacific. Moreover, subsistence and commercial production are generally joint household activities. Separate measures of subsistence and commercial production are not available. The only available measures of total agricultural activity are the crop and livestock and total agricultural indices compiled by FAO. Therefore, in order to gain some understanding of developments in the totality of agriculture in the region, analysis is necessarily limited to use of the

FAO production indexes. Furthermore, full efficiency analysis is limited to Fiji, Papua New Guinea, Samoa and Tonga as complete data for other countries are not available. The qualifications about the accuracy of these data therefore have to be kept in mind.

The stochastic production frontier function method

The stochastic production function approach is used in this article to estimate technical efficiency. This methodology has been widely used in developing countries. Battese (1992), Bravo-Ureta and Pinheiro (1993) and Coelli (1995) provide surveys of applications in this field. Some recent studies include Battese and Coelli (1995), Battese et al. (1996), Coelli and Battese (1996), Bravo-Ureta and Pinheiro (1997), Heshmati and Kumbhakar (1997), Lachaal et al. (2005), Balcombe et al. (2007), Bravo-Ureta et al. (2007) and Bonds et al. (2007).

Theoretical model

The theoretical model can be expressed as follows

$$Y_i = x_i\beta + E_{i,} \qquad (1)$$

and

$$E_i = V_i - U_i \qquad (2)$$

where Y_i denotes the output for the ith sample firm (i=1,2,….,N); x_i is a (1 x k) vector of the inputs associated with the ith sample firm; β is a (k x 1) vector of the coefficients for the associated independent variables in the production function; V_{it} are assumed to be independent and identically distributed as N (0, σ^2_v), independently distributed of U_i; U_i are non-negative, technical inefficiency effects, which are assumed to be independently and identically distributed non-negative random variables that can follow such distributions as half normal, truncated normal, exponential and gamma distributions (Aigner, Lovell and Schmidt 1977; Greene 1980; Meeusen and Van den Broeck 1977).

The maximum likelihood estimation of Equation 1 yields consistent estimators for β, λ, and σ^2, where β is a vector of unknown parameters, $\lambda = \sigma_u/\sigma_v$ and $\sigma^2 = \sigma_u^{\,2} + \sigma_v^{\,2}$. Jondrow et al. (1982) have shown that inferences about the technical inefficiency of individual farmers can be made by considering the conditional distribution of *u* given the fitted values of ε and the respective parameters. Based on the assumptions: v~N(0, $\sigma_v^{\,2}$), u~$|N(0, \sigma_u^{\,2})|$, and E(v)=0, he computed the conditional mean of u_i given $\varepsilon_I = v_i - u_i$ as a measure of technical efficiency as

$$u_j|\varepsilon_j) = \sigma * \left[\frac{f*(\varepsilon_j\lambda/\sigma)}{1-F*(\varepsilon_j\lambda/\sigma)} - \frac{\varepsilon_j}{\sigma}\right] \qquad (3)$$

where f* and F* respectively are standard normal density and cumulative distributions evaluated at $\varepsilon_i\lambda/\sigma$, $\sigma^2=\sigma_v^{\,2}+\sigma_u^{\,2}$, $\lambda=\sigma_u/\sigma_v$, and $\sigma^*=\sigma_u^{\,2}\sigma_v^{\,2}/\sigma^2$. The estimates of σ^2, λ, and parameter vector β are obtained by maximum likelihood estimation. Jondrow et al. (1982) derived a similar formula for the exponential distribution, while Greene (1990) derived a formula for the gamma distribution. Replacing ε, σ_*, and λ by their estimates in Equations 1 and 3, we derive the estimates for *v* and *u*. Subtracting *v* from both sides of Equation 1 yields the stochastic production frontier

$$Y^* = f(X_i;\beta) - u = Y - v \qquad (4)$$

where Y* is defined as the farm's observed output adjusted for the statistical noise contained in v (Bravo-Ureta and Rieger 1991; Bravo-Ureta and Pinheiro 1997).

Empirical studies have estimated stochastic frontiers and predicted firm-level efficiencies using these estimated functions, and then regressed the predicted efficiencies upon firm-specific variables (such as education, age, etc) in an attempt to identify some of the reasons for differences in predicted efficiencies between firms in an industry. However, the two-stage estimation procedure has also been long recognised as one which is inconsistent in its assumptions regarding the independence of the inefficiency effects in the two estimation stages. Therefore, following Kumbhakar, Ghosh and McGukin (1991) and Reifschneider and Stevenson (1991), who propose stochastic frontier models in which the inefficiency effects (U_i) are expressed as an explicit function of a vector of firm-specific variables and a random error, Battese and Coelli (1995) propose a model in which the inefficiency model can be estimated in single step. This study adopts this approach and estimates the stochastic frontier production and the inefficiency model in one step using the Frontier 4.1 software.

Empirical model

The specification of the empirical model requires the choice of an appropriate functional form. In this study, the Cobb-Douglas functional form was chosen because of the ease it provides in computation and interpretation. Therefore, the stochastic frontier production function is specified as

$$\ln Y = \beta_0 + \beta_1 \ln(X_1) + \beta_2 \ln(X_2) + \beta_3 \ln(X_3) + \beta_4 \ln(X_4) + V_i - U_i \qquad (5)$$

The production frontier was estimated for a single output (Y), the FAO Agricultural Production Index (1999–2001 base $). The inputs are defined as

X_1 land area under cultivation ('000 hectares)

X_2 value of fertiliser consumption (in US$'000 in real terms) or in volume (tonnes)

X_3 machinery, using number of tractors as a proxy

X_4 agricultural population (as a proxy for agricultural labour, '000)

V_{it} are assumed to be independent and identically distributed normal random variables with mean, zero, and variance, σ^2_v, independently distributed of U_i; U_i are non-negative technical inefficiency effects, which are assumed to be independently distributed and arise from the truncation (at zero) of the normal distribution with variance, σ^2, and mean, μ_i.

The β coefficients are unknown parameters to be estimated, together with variance parameters that are expressed in terms of

$$\sigma_s^2 = \sigma_v^2 + \sigma^2 \text{ and} \qquad (6)$$
$$\gamma = \sigma^2 / \sigma_s^2 \qquad (7)$$

where the parameters have values between zero and one.

The estimation of a stochastic production frontier only provides estimates of technical efficiency. *A priori*, the signs of all production function parameters specified above are expected to be positive. The stochastic frontier production function is estimated using Limdep version 8.0 (Limdep 1996).

The data for the study was obtained from the FAO database. The countries of the South Pacific region for which the estimations were carried out were Fiji, Papua New Guinea, Samoa, and Tonga. Other countries were not included because of the non-availability of data. The period for which data were available was from 1961 to 2004 (44 observations).

Results

Maximum likelihood estimates of the three models as defined in Equation 5 were obtained using Frontier 4.1 (Coelli 1992). The models were estimated under the general truncated normal distribution. The maximum likelihood estimates of the model with the appropriate specification of the error terms are presented in Table 4. The estimated γ parameter values in the model are significantly different from 1.0, indicating that the stochastic frontier model is significantly different from the deterministic frontier in which there are no random errors.

As per *a priori* expectations, most of the input coefficients have appropriate signs. For Fiji, the agricultural machinery input is positive and significant. The agricultural fertiliser input is negative, but insignificant. This is a surprising result as fertiliser use in Fiji, particularly in sugarcane farming, is quite widespread. More detailed examination of this input use is needed to provide an explanation. For Tonga, the land and machinery variables are significant. However, the machinery variable contributes negatively. A possible explanation for this may be that given the small farm sizes in Tonga, machinery use may not be able to make a positive contribution. For Samoa, the only variable that is significant is labour. Samoa's agriculture is labour-intensive and thus this input is quite critical for its growth. For Papua New Guinea, agricultural productivity can be raised by increases in both land and labour.

The efficiency estimates for the four countries provide interesting revelations (Table 5). Samoa, Fiji, Papua New Guinea and Tonga have average efficiency levels of 87.6, 91.2, 97.1 and 89.4 per cent, respectively. This implies that for Papua New Guinea, there is very little room to increase efficiency under existing technology. Increases in

Table 4 **Maximum-likelihood estimates for parameters of the stochastic frontiers for Fiji, Tonga, Samoa and Papua New Guinea**[a]

Variable	Parameter	Fiji	Tonga	Samoa	PNG
Constant	β_0	9.035*	12.96*	8.097*	3.867*
		(0.369)	(1.054)	(2.952)	(0.746)
Agricultural land	β_1	0.237	1.054*	–0.003	1.269
		(0.136)	(0.333)	(0.297)	(0.125)*
Agricultural machinery	β_2	0.183*	–1.242*	0.107	0.005
		(0.075)	(0.289)	(0.102)	
Agricultural fertiliser (volume)	β_3	–0.004			
		(0.006)			
Agricultural fertiliser (cost)	β_4			0.002	
				(0.005)	
Agricultural labour	β_5		–0.147	0.468*	0.212*
			(0.211)	(0.222)	(0.090)
Log-likelihood function		44.24	44.96	31.59	
Mean efficiency		91.2	89.4	87.6	97.1

Notes: Figures in parentheses are standard errors. * denotes a 5 per cent level of significance.
Source: Author's calculations.

Table 5 **Agricultural efficiency estimates for Samoa, Fiji, Papua New Guinea and Tonga, 1961–2004** (average)

	Samoa	Fiji	Papua New Guinea	Tonga
1961–65	89.1	91.0	96.9	87.5
1966–70	79.5	94.0	98.3	93.4
1971–75	89.8	86.2	95.2	91.7
1976–80	91.3	89.8	96.9	94.6
1981–85	95.5	92.2	98.1	83.5
1986–90	91.5	93.1	98.0	81.3
1991–95	72.9	92.4	95.0	87.1
1996–00	87.8	91.1	97.5	91.6
2001–04	91.3	90.7	97.8	95.5
Average	87.6	91.2	97.1	89.4

Source: Author's calculations.

agricultural output will have to be obtained from technological change and increases in land area under agriculture. For the other three countries, increases in agricultural output can be obtained from both technical efficiency gains and technological change.

Another interesting finding is that over the past forty years technical efficiency has not increased in Pacific agriculture. This implies that public investment in agriculture has basically led to agricultural expansion rather than to an increase in efficiency and productivity. It also implies that either there are limited possibilities for technological progress or a failure to achieve technological progress.

Conclusion

This article has examined the levels and trends of production and technical efficiency of the Pacific islands' agricultural sectors. Due to data limitations, efficiency computations were only possible for Fiji, Samoa, Tonga, and Papua New Guinea.

Results reveal that agricultural output in these countries leveled off after the 1980s. The leveling off was a result of the poor performance of the crop sector rather than the livestock sector. Furthermore, the results of the efficiency analysis indicate that for the four countries studied, the level of technical efficiency has not changed over the past four decades.

For Fiji, Tonga and Samoa, agricultural output can be increased via gains in technical efficiency. However, a large scale boost in agriculture will require expansion of the land area and extension of the production frontier of existing farms. For Papua New Guinea, the agriculture sector has been operating at the technological frontier throughout the study period. Expansion of output will require an outward shift in the production frontier via technological change such as the introduction of high-yielding varieties, new livestock breeds and introduction of mechanisation.

Changes in the systems of farming may also boost agricultural output but country-specific studies are needed to identify how inefficiencies can be removed and the technological frontier shifted outwards. Furthermore, most of the Pacific island countries, except for the small island and atoll countries have a great deal of potential for expanding agricultural production by increasing the land area under agriculture. For this to happen, supply-side constraints such as property rights, crime and violence, and financial constraints need to be removed. These are some of the factors that build trust in the economic system, which is one of the most important factors needed for economic transactions to take place.

Note

1 In most of the Pacific island countries a significant proportion of their total agricultural production is in the form of subsistence production. Estimates of subsistence production are included in the FAO production indexes. However, there has to be a large degree of uncertainty associated with such estimates. Therefore, they can only be used for gaining a broad perspective of changes in agricultural sector activity.

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Appendix

Table A1 **Annual estimates of efficiency of the agricultural sector, selected Pacific countries, 1961–2004** (per cent per annum)

	Samoa	Fiji	Papua New Guinea	Tonga
1961	84.9	79.5	94.3	95.3
1962	89.8	90.8	97.1	83.3
1963	92.9	96.1	98.3	85.9
1964	94.5	96.5	98.5	84.2
1965	83.5	92.1	96.2	88.9
1966	81.5	92.7	98.7	94.8
1967	69.5	90.6	98.9	96.7
1968	80.3	96.6	98.3	96.0
1969	87.6	94.4	98.2	93.3
1970	78.6	95.9	97.2	86.2
1971	92.7	91.1	93.3	86.8
1972	89.2	86.2	94.1	92.1
1973	86.1	88.6	94.8	86.3
1974	91.4	82.7	97.7	95.2
1975	89.9	82.5	96.3	98.1
1976	88.9	81.2	97.4	98.5
1977	92.1	88.9	97.5	97.4
1978	85.7	88.7	97.1	87.8
1979	94.5	96.5	95.2	92.7
1980	95.1	93.9	97.3	96.4
1981	94.8	96.1	96.5	93.4
1982	97.2	96.2	96.8	81.0
1983	95.4	80.7	98.9	81.0
1984	94.4	97.2	99.1	81.0
1985	95.9	90.7	99.2	81.0
1986	95.8	97.0	98.5	81.0
1987	94.2	88.1	99.0	81.0
1988	92.5	88.2	98.6	81.0
1989	90.5	95.7	98.2	81.0
1990	84.2	96.4	95.6	82.4
1991	74.9	91.1	90.9	86.1
1992	62.3	92.0	94.6	82.9
1993	73.6	88.9	97.0	86.9
1994	73.1	94.6	96.4	95.2
1995	80.5	95.3	96.3	84.6
1996	86.9	94.7	97.2	86.6
1997	89.4	93.1	96.8	93.6
1998	89.1	80.7	96.5	88.5
1999	85.8	93.4	98.1	91.6
2000	87.9	93.3	98.9	97.5
2001	91.4	90.1	96.4	94.0
2002	91.1	92.8	97.8	96.2
2003	91.7	88.7	98.3	95.9
2004	91.1	91.2	98.8	95.9