A comparison of the efficiency of producers under collective and individual modes of organisation

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Summary

This paper compares collective and individual production systems' technical and allocative efficiency. The producers being studied belong to Honduran agrarian reform cooperatives engaging in collective and/or individual maize production. Debreu-Farrell technical efficiency related to stochastic production is calculated. Allocative efficiency is obtained from an analytically derived cost frontier. Results indicate that collective systems are slightly more efficient than individual production systems. Worker-shirking (one of the most cited theoretical arguments against collective forms of enterprise) would seem to have no empirical basis from these results.

Keywords: cooperative, technical and allocative efficiencies, stochastic production frontier, cooperative enterprises. **JEL Classification:** P13.

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Introduction

The cooperative mode of production has long held theoretical benefits that are appealing to socialist and developing countries. Cooperatives have been promoted to achieve economies of scale and introduce new technologies beyond the reach of small, independent producers. They have also been favoured as a means of organising and integrating low-income and geographically dispersed rural people into modern forms of social and economic interaction.

Unfortunately, the theoretical potential of cooperatives has been superseded by their dismal failure rate. Indeed, the term "collective" is rarely heard in the popular and business media without pejorative antecedents: "inefficient", "lethargic", "bureaucracy-heavy", etc. Many of the economic problems of former communist countries, and of poorly performing developing countries, are attributed to the waste incurred by collective organisations.

Inefficiency obviously exists in cooperatives, but its precise origins are unclear. Furubotn and Pejovich [1970] predicted that cooperatives would degenerate in a capitalist environment as worker/owners have relatively less incentive to make long-term capital investments. However, cooperatives in East Asia, France, Italy, and the former Yugoslavia have enjoyed notable success. Decentralised associative methods in Chinese production appear to improve efficiency through a reduction in monitoring costs [Murakami *et al.* 1994 and Dong and Putterman 1997]. Studies from Northern Italy [Bartlett *et al.* 1992] and the former Yugoslavia [Boyd 1987, Piesse *et al.* 1996] suggest that cooperatives may, in fact, be more efficient than private enterprises.

Conventional wisdom attributes the inefficiencies of collectives to "shirking", or the abdication of personal work responsibilities. However, it is not clear whether shirking is most detrimental at the worker or management level. Alchian and Demsetz [1972] conjectured that individuals in a collective enterprise lack adequate incentives to monitor co-workers because they do not receive the residual claims awarded to managers of private firms. Even if one member is appointed the task of monitoring, they argue, the monitor/manager has no authority to hire and fire, and has no incentive to efficiently utilise and maintain capital investment because the individual portion of capital returns is less than the personal trade-off between labour and leisure. Jensen and Meckling [1979] argue that shirking is most problematic at management level. They consider it "naïve" to believe that managers of collectives would take the same pains to "seek out high pay-off new projects, to weed out projects which have negative pay-offs, to control waste and shirking, etc." without an additional claim on returns.

The distinction between worker shirking and management shirking is important. Widespread shirking by workers may be an exogenous social characteristic irresolvable by policy modifications because it involves substantial monitoring costs. The successes of the Israeli Kibbutz, for example, as well as Amish and Hutterite communities in the United States, are often attributed to pre-existing religious bonds that significantly reduce monitoring costs. Management inefficiency, on the other hand, may be overcome through restructuring and realigning incentives.

Different sources of shirking generate characteristically different inefficiencies. If shirking is so extensive at worker level that it over-rides the gains achieved from economies of size procured through collectivisation, technical efficiencies will be lower in collective systems than individual systems. In other words, labourers systematically relinquish work to other members of the collective to the extent that the output obtainable from a given set of inputs will be less under the collective system than the individual. Scale efficiencies become immaterial.

Allocative efficiency, on the other hand, depends on the optimal selection of input combinations. Input selection is primarily a function of management decisions and input markets. Allocative efficiency can be diminished by poor management or by friction in input distribution systems, which are notably inefficient in developing countries. Labour shirking is less likely to surface in allocative efficiency measures because input selection must occur prior to input utilisation. By the same token, nothing precludes any set of inputs from being used in a technically efficient manner.

One could argue that if labour resources are misallocated so that people skills are mismatched with assigned tasks, allocative inefficiency could be incorrectly attributed to the technical side. The prospect of such misallocation increases as production systems become more complex and labour is divided into a greater number of specific tasks that require training. Fortunately, this study analyses basic maize production in Honduras, a system which has not changed dramatically from traditional practices and in which the division of labour is limited.

Most research on issues related to collective versus individual production has been based on heuristic insights or theoretical models[1]. Empirical studies are rare because data sets for both types of organisation are difficult to acquire. Moreover, all previous empirical studies have examined cooperatives comprised of individuals who did not own the private enterprises against which the cooperatives were compared. Collectives were compared to individual enterprises in industries whose managers and workers were confined to one of the two organisational modes. Comparing organisational modes within specific regions eliminates the cultural and institutional differences that muddle cross-regional comparisons. However, they do not account for human capital differences which are fundamental to cooperative undertakings. Differences in education, training, family background, and socio-political orientation can affect the performance of economic enterprises and may constitute the basis for forming a particular organisational structure.

This paper overcomes these problems by comparing the technical and allocative efficiencies of the same producers working in alternative modes of production –collective and individual. The study examines production plots in Honduran agrarian reform cooperatives, the majority of which operate under both modes of production. Some basic grain cooperatives in Honduras produce on exclusively individual or collective bases. However, the majority engage both organisational modes in production.

Technical efficiency comparisons enable the testing of Alchian and Demsetz's hypothesis that collective mode of worker organisation induces shirking at the level of the labourer. If widespread labour shirking occurs, which is often conjectured with regard to Honduran basic grain cooperatives, it will dampen the technical efficiency of collective plots vis à vis individual plots. On the other hand, if technical efficiencies are not greater on individual plots, it suggests that collective production is a viable mode of worker organisation and that cooperative failures are more attributable to administrative mismanagement, a shortcoming that may be overcome by the reorganisation of management responsibilities.

[1] See Prychitko and Vanek [1996] for a thorough review of cooperatives and labour managed firms.

The next section describes the methodology for estimating a stochastic frontier production function and for deriving Debreu-Farrell technical and allocative efficiencies. The third section presents the specific form and data used to estimate the production function. The fourth section presents and discusses the results. The final section summarises the findings of this paper and their implications.

Technical and allocative efficiency

The most widely used efficiency measures are rooted in the writings of Debreu [1951] and Farrell [1957]. The Debreu-Farrell measure of technical efficiency (*TE*) is defined as the equiproportionate reduction of all inputs that produces a demonstrated optimal level of outputs. Conventionally, it is measured as the ratio of observed output to optimal output for a given set of inputs.

$$TE = q(x) \,/\, q^{*}(x) \qquad [1]$$

where x are inputs, $q(x)$ is the actual level of output and $q^{*}(x)$ is the optimal level of output. A value of unity represents 100 percent efficiency and values less than one indicate the level of inefficiency.

Following the approach proposed by Farrell [1957], the optimum level of output for a given level of inputs, $q^{*}(x)$, is determined by estimating the "best practice" or frontier production function[2]. Prior to the emergence of frontier functions, the conventional production function model that was estimated took the form of:

$$q = q\,(x) + e \qquad [2]$$

where x is a vector of inputs and e is the random error. OLS necessarily assumes the expected value of the disturbance term, e, is zero because it estimates parameters by minimising the sum of the squared errors. However, neo-classical production theory defines the production function as the maximum output obtainable from a given set of inputs. In the absence of random error, observed levels of output cannot exceed the theoretical maximum. Farrell's initial approach,

[2] For a review of the theoretical and empirical aspects of technical and allocative efficiencies, as well as the frontier production functions upon which they are based, see Fried *et al*. [1993] and Kumbhakar and Lovell [2000].

and subsequent "full" frontier estimations of $q^*(x)$ constrain e to be non-negative, attributing all deviations from the production frontier to inefficiency, precluding random events.

The "stochastic frontier" [Aigner *et al.* 1977, Battese and Corra 1977, and Meeusen and van den Broeck 1977] accounts for random error and has been used extensively to examine production efficiency[3]. Unlike full frontier estimations, the stochastic frontier allows for random deviation from the frontier due to measurement error or events beyond the control of the producer. The error term of the production function in the stochastic frontier is comprised of two components:

$$e = v - u \qquad [3]$$

where $E(v) = 0$ has a symmetric distribution which captures random effects and exogenous shocks across firms; and the one-sided error, $u = 0$, captures technical efficiency of a firm relative to the stochastic frontier. Thus, the estimated frontier accounts for stochastic characteristics likely to affect any production system, isolating systematic effects in the measurement of technical inefficiency.

Although Aigner *et al.* [1977] distinguished the variances of u and v within the residual e for the entire data sample, they were not able to decompose the residual into its individual components for each observation. Efficiency scores were calculated as averages for the entire sample. Decomposition of the variances for each observation, a distinguishing attribute of mathematical programming techniques, remained beyond the scope of statistically estimated frontiers until Jondrow *et al.* [1982] derived the conditional distribution $(u_i | e_i)$. By specifying a functional form for the distribution of u given the composed error term e, Jondrow *et al.* demonstrated that point estimates of efficiency are obtainable for each observation. These indirect estimates of u can be shown to be unbiased. However, they are not consistent because, with a mean truncated at zero, the variance of the coefficients can never be zero.

3 Stochastic frontiers have been used in LDC's to measure the effectiveness of credit programmes [Ekanayake 1987 and Taylor *et al.* 1986]. Several studies examined extension programmes [Kalirajin and Shand 1985, Kalirajan 1984, Kalirajan and Finn 1983, and Bravo-Ureta and Evenson 1991] and education [Kalirajan 1990]. The stochastic frontier has also been used to identify firm and managerial characteristics that influence efficiency [Seale 1990].

Analogous to technical efficiency, a measure of "economic efficiency" (*EE*) is obtained from the ratios of minimum observed total cost to actual total cost:

$$EE = c^*(q^*,w) \; / \; c(q,w) = TE * AE \qquad [4]$$

where $c(q,w)$ is actual cost incurred to produce q at input prices w, and $c^*(q^*,w)$ is the minimum level of cost incurred to produce $q^*(x)$. Values less than one denote the level of economic inefficiency. Economic efficiency is the product of technical and allocative efficiency (*AE*), as it requires both the optimum level of physical output for a given set of inputs and the optimum input mix given input prices. A measure of allocative efficiency is thus obtainable from technical and economic efficiencies:

$$AE = EE \; / \; TE \qquad [5]$$

In the case of the Cobb-Douglas functional form, it is not necessary to statistically estimate the dual cost frontier, $c^*(q^*,w)$, as it can be analytically derived from the production function. The cost function is a dual representation of the production technology [Shepard 1970]; thus coefficients from the frontier production function can be incorporated into the frontier cost function, $c^*(q^*,w)$ [Kopp and Diewert 1982][4]. Actual prices of all inputs are used to derive the cost frontier, along with output and total cost of each producer.

Empirical model and data

The Cobb-Douglas model was selected as the functional form for empirical analysis. Although considered restrictive in some instances, the Cobb-Douglas model has been used extensively in agriculture in both developed and developing countries. As the interest of this paper is centred on efficiency measurement rather than specific relationships concerning production structure, this choice is appropriate. Moreover, functional form has been shown to have minimal impact on efficiency estimates [Kopp and Smith 1980]. The Cobb-Douglas model can

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[4] In the case of the Cobb-Douglas production function $q(x) = A\Pi x_i^{\beta_i}$ the dual cost frontier is: $c^*(q,w) = k\Pi w_i^{\alpha_i} q^m$ where w is the vector of input prices. The cost function parameters α and m, are analytically derived directly from the estimated parameters of the production function where: $\alpha_i = m\beta_i$, $m = (\Sigma_i \beta_i)^{-1}$, and $k = \frac{1}{m}[\hat{A}\Pi_i \beta_i^{\beta_i}]^{-m}$.

also be analytically inverted into its dual cost function, facilitating the calculation of allocative efficiencies. For our present purposes, the Cobb-Douglas model takes the form of:

$$q = A \prod_{i=1}^{k} x_i^{\beta_i} \prod_{i=1}^{m} h_i^{\alpha_i} \prod_{i=1}^{n} o_i^{\gamma_i} u = q^* u, \qquad 0 \le u \le 1 \qquad [6]$$

where q is a producer's output measured in quintals of maize, A is a given level of technology, x_i represents the set of $i = 1...k$ inputs and the β_i's are the corresponding input coefficients. The standard production function estimates output, q, solely as a function of physical inputs x_i. However, Jensen and Meckling [1979] suggested an extended form of the production function which recognised that production did not occur in a physical vacuum. Knowledge h_i (human capital) and "organisational forms" o_i also influence the level of output by their parameters α_i and γ_i respectively. Frontier output, q^* is reduced by the systematic inefficiency, u.

The primal production function in this paper was estimated with exact quantities of inputs and outputs. Similarly, the cost function was analytically derived from the production function [Kopp and Diewert 1982] using price data from all inputs, total cost and total output data for each producer. To satisfy these requirements, the recording of complete production and price data was supervised directly by the authors for one production cycle. All inputs utilised on a production plot, as well as their corresponding input prices, were measured and recorded. Data was gathered from agrarian reform cooperatives in the contiguous El Paraíso and Olancho regions of Honduras. 385 farmers belonging to 27 cooperatives were surveyed. Individual production data was collected by literate cooperative members or young adult sons of cooperative members under the regular supervision of the authors. Cooperatives provide an excellent network for collecting individual data from a large number of farmers because contacts can be developed with a trusted enumerator who is familiar with cooperative members' production activities. The data covers a cross-section of collective and individual production plots for one maize growing season, 1988-89. Fortunately, good to average rains occurred during the data gathering period.

All members of each cooperative participated in an extension programme offered by the Honduran Integrated Pest Management programme (MIPH in Spanish), sponsored by the Pan-American School of Agriculture in Zamorano, Honduras.

MIPH experimented with four forms of agricultural extension. One group of cooperatives received direct lectures without visual aids or printed material. A second group of cooperatives received personal lectures accompanied by electronic visual aids. A third group of cooperatives received lectures accompanied by printed material that contained illustrations and written instructions. A fourth group of cooperatives received printed material with illustrations and written instructions, but no personal lectures. A fifth group served as a control group and received no assistance of any kind. The type of extension service each coop received was randomly determined. Trained agronomists visited the coops on a regular basis to give lectures and/or supply printed information.

MIPH focused on common problems faced by basic grain producers and suggested cost-effective means for overcoming them. Amiable assistance from MIPH and government agronomists was invaluable in corroborating data and understanding the various institutions influencing cooperative operations.

The specific variables included in the model, their mean values and standard deviations are shown on Table 1. The variables fall into three categories, traditional physical input variables, extension variables and institutional variables. Land, Labour, Seed, Fertiliser, Herbicide and Landprep, represent traditional inputs. Since the model being estimated is the Cobb-Douglas model, continuous variable inputs are in natural log form.

All extension techniques are included in the model as binary variables. Extension factors are included because cooperatives agreed to participate directly in an extension programme and were taught under distinct extension techniques, each of which may influence the frontier differently. In many extension studies, binary variables are included for particular areas where extension is provided, but farmers may not have had direct exposure to those services. All the participants in this study, with the exception of the control group, received a specific form of extension service. If certain forms of extension were better than others in improving efficiency, then cooperatives benefiting from those forms are held to a higher frontier than those who were not. Including extension variables attributes the real source of efficiency for individual cooperatives and clarifies the comparison of efficiencies across cooperatives.

Table 1
Variable list

Variable	Coefficient	Mean	Standard Deviation	Max	Min
Output	Maiz measured in quintals	88.42	271.15	4,136.00	1.48
Traditional variables					
Technology (A)	Constant				
Land	Land measured in manzanas[a]	3.63	10.40	0.5	130.0
Labour	Labour measured in work days89.63	263.20	3.0	2,814.0	
Seed	Seed measured in pounds	132.14	451.68	10.0	6,500.0
Fertiliser	Fertiliser measured in quintals	11.39	43.39	0.0	676
Herbicide	Herbicide measured in pounds9.55	26.42	0.0	231.0	
Landprep	Total cost of land preparation	296.83	990.87	1.0	9,750.0
Institutional variables					
Collectivity	Degree of collective work arrangements[b]	0.24	0.22		
Paraíso Region	= 1 if producer is from the region of El Paraíso, 0 otherwise.	0.61			
Extension variables					
Lecture	= 1 if coop received extension lectures without additional teaching aids, 0 otherwise	0.21			
Publication	= 1 if coop received printed extension publications and no personal lecture, 0 otherwise	0.11			
Lectureaid	= 1 if coop received lectures accompanied by electronic visual aids, 0 otherwise	0.23			
Lecturepub	= 1 if coop received both lectures and printed extension publications, 0 otherwise	0.25			

[a] Manzana = 0.705 hectare
[b] The measure of collectivity corresponds to the point in time at which collective production was turned over to individual production. Parcels used completely in the collective mode are scored as one, those fertilised and planted prior to parcelisation are scored as one half, and those for which the only collective activity was mechanical land preparation are scored as one fourth. Completely individual production is registered as zero.

Collectively, the organisational form variable [Jensen and Meckling 1979] is calibrated according to the point in the production season at which collective operations are yielded to the individual responsibility of each cooperative member. Collectivity is included because the extent of collective work differed across cooperatives. All agrarian reform cooperatives were initially established primarily as collective operations, but because of widespread financial breakdowns that were often attributed to collective production, cooperatives began to experiment with the extension of the scope of individual production. Some cooperative plots were completely individual, others began the production season collectively but later parcelled collective plots to individual members, and some were completely collective. In this study, 106 of the individual systems were completely individual; 253 plots were turned over to individual production immediately after mechanical land preparation and 26 plots were tilled, planted and fertilised before they were turned over to individual production (principally for weed cleaning and harvesting). A completely collective mode of production was used in 19 plots. The Collectivity variable represents an objective point in the production season at which collective production was yielded to individual production. Precise and separate records were maintained for the activities conducted on each type of system.

Empirical results

Two alternative stochastic specifications (the half-normal and exponential distributions) are assumed for the one-sided error, u, in estimating frontier function. The distinct effect each distribution has on the frontier is not well known [Bauer 1990], but Greene [1990] suggests that there is not much difference between the two.

Table 2 displays ordinary least squares (OLS) and maximum likelihood (ML) estimates of the stochastic frontiers. The Cobb-Douglas model fits the data well. The R^2 of the OLS is 0.88. All but one of the standard physical input variables (herbicide), are significant at the 0.01 probability level for all three regressions. The coefficients in the Collectivity and Paraíso Regions are positive and significant at the 0.01 level of probability for all estimations. All but one of the extension variables is significant at the 0.1 level of probability in the frontier functions.

Estimates of Cobb-Douglas production functions are elasticities of output with respect to variable input. The elasticity on Land is the largest in magnitude, over four times greater than the next highest variable input elasticity, on Labour. Land elasticity is also 0.09 greater in the frontier functions than in the average function, suggesting that best practice farmers obtain more output per land than other farmers. Insecure land tenure is widely acknowledged to reduce producer incentives and efficiency, though few empirical studies have examined the impact of land reforms relative to the amount of money spent on the reforms [Deininger and Feder 1998]. Seed elasticity is 0.06 less in the frontier functions than in the average function, which implies that farmers below the frontier could improve overall efficiency by using more seeds. Maize production is emerging from traditional slash and burn methods in which land was abundant enough to allow soil rejuvenation cycles and seeds could be used more extensively. In current systems, more efficient farmers use more seeds. The other variable input elasticities show less than 0.01 changes between frontier and average functions.

Table 2
Maize production functions

Variable	OLS	MLE Frontier	
		Half-Normal	Exponential
Constant	2.295[c]	2.806[c]	2.800[c]
	(9.938)	(14.49)	(15.74)
Land	0.464[c]	0.556[c]	0.559[c]
	(7.028)	(10.78)	(11.36)
Labour	0.129[c]	0.122[c]	0.123[c]
	(3.287)	(4.317)	(4.557)
Seed	0.175[c]	0.116[c]	0.115[c]
	(3.010)	(2.690)	(2.732)
Fertiliser	0.035[c]	0.023[c]	0.022[c]
	(2.889)	(2.540)	(2.511)
Herbicide	0.016[b]	0.011[a]	0.010[a]
	(2.222)	(1.693)	(1.688)
Land Preparation	0.044[c]	0.049[c]	0.050[c]
	(2.533)	(3.738)	(3.921)
Collectivity	0.112[c]	0.085[c]	0.086[c]
	(6.900)	(5.997)	(6.258)
Paraíso Region	0.151[c]	0.099[c]	0.095[c]
	(3.691)	(2.872)	(2.854)
Lecture	0.052	0.020	0.015
	(0.861)	(0.336)	(0.271)
Publication	0.212[c]	0.129[b]	0.125[b]
	(3.065)	(2.088)	(2.089)
Lectureaid	0.039	0.093[a]	0.097[a]
	(0.67)	(1.717)	(1.830)
Lecturepub	0.171[c]	0.131[b]	0.127[b]
	(2.756)	(2.209)	(2.230)
$\mu/\sigma u$		2.856	
		(0.704)	
$\sigma u/\sigma v$		5.098[b]	
		(2.124)	
$\sqrt{\sigma^2 v+\sigma^2 u}$		1.031[b]	
		(1.961)	
σv			0.198[c]
			(11.54)

t statistics are in parentheses
[a] Significant at the 0.10 probability level.
[b] Significant at the 0.05 probability level.
[c] Significant at the 0.01 probability level.

	OLS	Half-Normal	Exponential
	R squared:0.877 Adjusted R squared: 0.873	Log Likelihood: -11, 7.0200	Log Likelihood: -114.7641
		Variance components: $s^2(v) = 0.03935$ $s^2(u) = 1.02273$	Variance components: $s^2(v) = 0.03907$ $s^2(u) = 0.08053$

The positive parameter estimates on Collectivity suggest that organising work in a collective manner increases the potential for obtaining more output from given levels of input. The general effect of collectivisation on all producers in the study is examined below through the comparison of technical and allocative efficiencies of each production system. The coefficients on Paraíso are positive and significant, perhaps because it has a slightly longer tradition than the other region in its modernisation process.

Debreu-Farrell technical efficiency measures are presented in Table 3. Allocative efficiencies are presented in Tables 4 and 5. Parameters from the frontier production function were incorporated into the cost function [Kopp and Diewert 1982] to analytically derive the cost frontier. Allocative efficiencies were calculated from the cost function, which uses actual input prices for all inputs, total cost and total output. Collective efficiencies are the calculated efficiency measure for the collective parcel of each cooperative and individual plot efficiencies are presented as averages for each cooperative. Two allocative efficiencies are presented. In an approach similar to that of Nguyen and Martinez [1979], who imputed the standard wage for free labour in examining the relative efficiency of the Mexican ejido sector, allocative efficiencies are calculated for free labour and for labour that receives an imputed market wage. In the first, ($w=0$ for free labour), the price of labour is the total cost of all labour devoted to a given plot divided by the total number of labour days, both free and paid. Some paid labour was used on over 85 percent of the plots. The second allocative efficiency, ($w=5$,), imputes the standard per-day wage of five Lempiras per day to account for the opportunity cost of labour. Prices for all other inputs were included in the cost function.

The standard deviations of individual technical efficiency averages are less than a third of the average for all but two cases, suggesting that technical efficiency does not vary substantially within cooperatives. The uniformity of efficiencies within cooperatives may be explained by the communication provided by cooperatives; they are in part established to facilitate communication between large numbers of farmers. Empirical evidence [Martin and Taylor 1995] attests to the facilitating role cooperatives play in communicating new technologies. It was also observed throughout the course of fieldwork that new inputs and new techniques were duplicated by other farmers within cooperatives, although in some cases reinforcing errors.

Table 3
Technical efficiencies

	Half Normal			Exponential		
	Collective	Individual		Collective	Individual	
		Average[a]	Std. error		Average[a]	Std. error
19 de Abril	0.74	0.70	0.21	0.76	0.71	0.21
Los Almendros	0.79	0.70	0.10	0.80	0.71	0.10
El Benque		0.71	0.19		0.72	0.02
Los Bienvenidos	0.91	0.76	0.13	0.91	0.77	0.13
El Boqueron	0.78	0.41	0.16	0.79	0.41	0.16
Cayo Blanco	0.84	0.75	0.14	0.84	0.76	0.14
La Concepción	0.91	0.81	0.10	0.92	0.82	0.10
El Coyolar	0.32	0.86	0.07	0.32	0.87	0.06
Los Dos Naranjos	0.87	0.82	0.06	0.88	0.83	0.05
Empalizada	0.87	0.71	0.15	0.87	0.72	0.15
El Esfuerzo		0.81	0.06		0.82	0.05
La Esperanza	0.79	0.73	0.14	0.79	0.74	0.14
Esquilinchuche		0.79	0.19		0.80	0.19
Guaymuras	0.91			0.91		
Ideas en Marcha		0.80	0.07		0.82	0.06
La Libertad	0.54	0.72	0.15	0.55	0.74	0.14
Montañuelas	0.08			0.81		
Los Peregrinos	0.77	0.78	0.08	0.78	0.79	0.07
El Plomo	0.81	0.77	0.14	0.82	0.79	0.14
La Providencia	0.56	0.68	0.21	0.56	0.69	0.22
La Puzunca		0.78	0.08		0.80	0.08
San Juan de Linaca	0.90	0.85	0.06	0.91	0.86	0.06
San Nicolas	0.50	0.52	0.55	0.51	0.52	0.55
Santa Cruz		0.77	0.11		0.79	0.11
Tempiscapa		0.74	0.12		0.75	0.12
Los Venecianos		0.76	0.11		0.78	0.10
Zopilotepe	0.79			0.80		
Average all coops		0.76	0.15		0.77	0.15

[a] Averages are mean efficiencies within each group.

The most salient feature of our results is that individual plots appear not to be more technically efficient than collective plots. Efficiencies based on the half-normal and exponential distributions show that collective plots are more technically efficient than individual plots for 11 out of the 16 cooperatives that employed both modes of production. Two of the five remaining cooperatives show individual plots are only slightly more efficient. Individual technical efficiencies for Los Peregrinos and San Nicholas (the only cooperative for which the standard error is higher than the average) exceed their collective measurement by one and two points respectively. Differences are much greater in the cases where collectives are more technically efficient; at least nine points for seven coops, two show five point differences and the remaining two coops register differences of four points. Moreover, collective production modes are measured against a higher standard (observed best practice frontier) than individual production modes because of the positive value of the collectivity coefficient.

One of the most cited theoretical arguments against collective forms of enterprise, worker shirking, appears to have no empirical basis in these results. These findings are in agreement with Carter *et al.* [1996], who report that 90 percent of surveyed Honduran co-operatives did not consider shirking a problem. Although shirking does occur in collective production systems, it does not counteract the economies of scale generated by collectivism. The absence of shirking at worker level could well be attributed to the mutual monitoring which occurs in co-operatives.

Allocative efficiencies are markedly lower than technical efficiencies for both collective and individual systems. They vary consistently with technical efficiencies across cooperatives. That allocative efficiencies demonstrate a pattern similar to technical efficiencies may be attributed to the facilitating role played by cooperatives in transferring mixed technological inputs. Allocative efficiencies increased in 16 of the individual production systems in both half-normal and exponential distributions, when the standard wage of five Lempiras was imputed for any free labour used during production. That allocative efficiencies are higher when the standard wage is imputed for all labour suggests that there is an opportunity cost for labour on individual plots vis à vis other opportunities available to farmers. If labour had been over-employed on individual plots, allocative efficiencies would have decreased when the standard wage was imputed. It would suggest that the shadow price of labour for cooperative households is less than the average wage.

Averages for differences in technical and allocative efficiency between collective and individual systems for all coops, and separately those with mixed systems, are displayed in Table 6. Although degrees of freedom are limited due to the small number of collective plots, a statistically significant difference in mean efficiency scores occurs in allocative efficiency when free labour receives no direct remuneration. Collective plots in this instance are more allocatively efficient. These results demonstrate that free labour is used on individual plots, but when free labour receives the standard daily wage of five Lempiras (which is paid for all work on collective plots), allocative efficiencies are not statistically nor significantly different.

Table 4
Allocative efficiencies - half normal

	Collective	Individual			
		w = 0 for free labor[b]		w = 5 for all labor[b]	
		Average	[a]Standard error	Average[a]	Standard error
19 de Abril	0.26	0.16	0.11	0.18	0.10
Los Almendros	0.38	0.15	0.11	0.24	0.07
El Benque		0.18	0.13	0.22	0.15
Los Bienvenidos	0.47	0.14	0.11	0.20	0.09
El Boqueron	0.24	0.08	0.09	0.09	0.09
Cayo Blanco	0.25	0.10	0.06	0.12	0.06
La Concepción	0.46	0.26	0.11	0.30	0.08
El Coyolar	0.05	0.37	0.07	0.36	0.08
Los Dos Naranjos	0.43	0.31	0.05	0.31	0.06
Empalizada	0.32	0.30	0.24	0.32	0.23
El Esfuerzo		0.33	0.05	0.33	0.05
La Esperanza	0.24	0.17	0.13	0.24	0.12
Esquilinchuche		0.30	0.20	0.37	0.20
Guaymuras	0.42				
Ideas en Marcha		0.37	0.10	0.52	0.10
La Libertad	0.10	0.19	0.12	0.19	0.11
Montañuelas	0.34				
Los Peregrinos	0.35	0.31	0.12	0.35	0.10
El Plomo	0.29	0.22	0.12	0.20	0.07
La Providencia	0.16	0.20	0.16	0.24	0.16
La Puzunca		0.24	0.13	0.28	0.09
San Juan de Linaca	0.63	0.33	0.14	0.39	0.12
San Nicolas	0.13	0.14	0.18	0.17	0.23
Santa Cruz		0.28	0.15	0.37	0.15
Tempiscapa		0.20	0.10	0.17	0.08
Los Venecianos		0.21	0.11	0.22	0.12
Zopilotepe	0.24				
Average all coops		0.25	0.14	0.29	0.14

[a]Averages are mean efficiencies within each group
[b]Recorded prices of all inputs, including labour inputs, were used to calculate allocative efficiencies. Allocative efficiencies are presented for the case when some free labour was used (w = 0) on some individual parcels and for the case when all labour is imputed the standard wage of five Lempiras (w = 5).

Table 5
Allocative efficiencies - exponential

	Collective	Individual			
		w = 0 for free labor[b]		w = 5 for all labor[b]	
		Average[a]	Standard error	Average[a]	Standard error
19 de Abril	0.36	0.20	0.13	0.23	0.11
Los Almendros	0.48	0.20	0.14	0.32	0.09
El Benque		0.23	0.14	0.27	0.16
Los Bienvenidos	0.51	0.17	0.13	0.25	0.11
El Boqueron	0.31	0.11	0.12	0.12	0.12
Cayo Blanco	0.31	0.12	0.08	0.14	0.06
La Concepción	0.51	0.31	0.12	0.37	0.08
El Coyolar	0.06	0.44	0.07	0.43	0.08
Los Dos Naranjos	0.49	0.38	0.05	0.38	0.05
Empalizada	0.38	0.37	0.24	0.40	0.23
El Esfuerzo		0.41	0.05	0.41	0.05
La Esperanza	0.32	0.22	0.15	0.21	0.12
Esquilinchuche		0.34	0.21	0.42	0.21
Guaymuras	0.46				
Ideas en Marcha		0.46	0.09	0.52	0.08
La Libertad	0.15	0.24	0.14	0.24	0.12
Montañuelas	0.43				
Los Peregrinos	0.46	0.39	0.13	0.45	0.09
El Plomo	0.36	0.27	0.13	0.24	0.07
La Providencia	0.23	0.24	0.18	0.29	0.17
La Puzunca		0.30	0.13	0.35	0.08
San Juan de Linaca	0.68	0.38	0.16	0.46	0.13
San Nicolas	0.18	0.15	0.20	0.18	0.26
Santa Cruz		0.34	0.17	0.45	0.14
Tempiscapa		0.25	0.10	0.22	0.08
Los Venecianos		0.28	0.13	0.27	0.13
Zopilotepe	0.31				
Average all coops		0.30	0.16	0.35	0.15

[a]Averages are mean efficiencies within each group

[b]Recorded prices of all inputs, including labour inputs, were used to calculate allocative efficiencies. Allocative efficiencies are presented for the case when some free labour was used (w = 0) on some individual parcels, and for the case when all labour is imputed the standard wage of five Lempiras (w = 5).

Table 6
Differences[a] in efficiency averages between collective and individual parcels

	Mixed[b] Coops		All Coops	
	Half-Normal	Exponential	Half-Normal	Exponential
Technical Efficiency				
Difference	0.00	0.00	0.02	0.02
	(0.01)[c]	(0.06)	(0.55)	(0.66)
Allocative Efficiency				
[f]wage = 0 for free labour				
Difference	0.09	0.08	0.06(	0.05
	(1.82[e])	(1.53[d])	1.32[d])	(1.03)
[f]wage = L5.00 for all labour				
Difference	0.04	0.03	0.01	0.00
	(0.86)	(0.59)	(0.19)	(0.05)

Summary and conclusions

This paper has empirically examined the relative efficiency of Honduran farmers with alternative modes of individual and collective production. Debreu-Farrell technical and allocative efficiency measures, derived from a stochastic production frontier, formed the basis of the comparison. Estimates of technical and allocative efficiencies were calculated for each production system. The technical and allocative efficiency of the collectively worked plot was compared for each cooperative, with the efficiency averages of the individual producers who belonged to the cooperative.

The results of this paper counter conventional wisdom in that collective plots appear no less technically nor allocatively efficient than individual plots. These results indicate the nature of cooperative failure may be more attributable to managerial problems than to the popular notion of labour shirking, as suggested by Alchian and Demsetz [1972]. The policy implications of different sources of shirking are significant. Widespread worker shirking cannot be easily overcome, as it incurs high monitoring costs, but managerial weaknesses may be rectified through restructuring. An institutional analysis conducted in the light of these findings [Martin 1996] suggests that misaligned incentives between co-operatives and government support agencies prevent the co-operatives from operating as stable business enterprises. Agriculture is distinct from other industries in that it exhibits varying forms of contracting. Incentives are inherently different across the organisational spectrum, both in terms of contracting within the organisation itself and in terms of relationships with external suppliers and clients [Sykuta and Cook 2001]. Persistent management problems that counteract efficiency gains of resource pooling may improve performance by consistently realigning incentives and by organising "transactions so as to economize on bounded rationality while simultaneously safeguarding them against the hazards of opportunism" [Williamson 1985]. Honduran cooperatives that abandoned the support of government agencies and formed alliances with private fruit companies synchronised incentives sufficiently to quadruple member income [Martin 1996].

A further result is that individual producers are more allocatively efficient when a standard wage is imputed for free labour, indicating that there is an opportunity cost for labour devoted to individual plots. Collective allocative efficiency is also significantly higher than the allocative efficiency of individual producers when a standard wage is not imputed for free labour.

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