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Survival of the Ayensu Starch Processing Company: A Technical Efficiency Evaluation

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Abstract

The cultivation of cassava is vital for the production of industrial starch by the Ayensu Starch Processing Company in Ghana. The main constraint for starch production has been the unreliability of cassava supply to the factory. This paper estimates technical efficiency of out-growers under the Ayensu Starch Processing Company and identifies sources of efficiency using plot-level data. Stochastic frontier production function was used to estimate the efficiency indices while an econometric analysis of factors affecting the efficiency indices is conducted using the parametric two-step point method. We find that farmers producing cassava are inefficient, with a mean efficiency score of 58% across farms ranging from 2% to 99%. On the basis of the OLS estimation of the determinants of Technical Efficiency, plot size, farm distance and club membership were noted to be negatively significantly related to efficiency while years of farming experience, adoption of hybrid cassava and mono-cropping turned out positively significant. The study recommends that management of the company should negotiate lease of land for the farmers, the road infrastructure should be improved to allow easy access of the farmers to the factory, the out-growers should be encouraged to practise mono-cropping of cassava, the farmers should be given improved varieties of the cassava and the company finds incentives that will attract and retain young and experienced farmers to boost the supply of cassava to the factory.

Keywords: Stochastic frontier, technical efficiency

Background

The launching of the Presidents' Special Initiatives (PSI) in 2001 by the government of Ghana on cassava, oil palm, sorghum, maize, cotton, salt, garments and textiles were designed to achieve four strategic goals which were thought would promote the development of the national economy. These goals were:

- the diversifying of the economy to free it from decades of over reliance on the three major primary export products, namely, cocoa, timber and gold;
- bringing development to the doorsteps of the rural communities to make them part of the mainstream economic activities, generate mass employment and to expand the export revenue base of the country;
- generating multiplier effects on the economy through forward and backward linkages in respect of developing by-products as well as stimulating the growth of ancillary businesses; and
- expanding the export revenue base, through which the country's excessive reliance on external aid to finance her national development expenditure could be minimized (Business News, 2004).

The Presidents' Special Initiative (PSI) on cassava involved the creation of a starch manufacturing industry to help Ghanaian farmers increase the production of cassava and for that matter income. Cassava is a staple crop in Ghana and has historically been subjected to considerable post-harvest losses. The PSI on cassava was intended to build 10 cassava-starch production plants over a five-year period. The first of these plants was the Ayensu Starch Processing Company, established at Awutu-Bawjiase in the Central Region with some 10,000 smallholder farmers registered and organized into co-operative units to feed the company with cassava. Among other considerations, the company was also to explore investment opportunities in the industrial starch sector by producing and selling commercial-grade starch, primarily to the European markets.

The incredible success of this enterprise from the beginning implied that the company might very well prove to be one of the sources of economic growth for Ghana and its continuous operation would have tremendous impact on the economy in achieving the goals outlined under the PSI document, particularly raising $4.4 million over a four-year period through cassava starch export (Daily Graphic, 2001).

Despite the potential of the company and widespread recognition of its importance as to its contribution to the economy, the supply of cassava has, however, been dwindling. The deterioration in output levels has led to a significant decline in starch production, thus worsening the revenue position of the company. What remains uncertain is whether or not the starch production can be sustained in view of the existing output gap and installed plant capacity. Understanding issues related to the technical efficiency of the out-growers might unearth strategies to be adopted to revive the Ayensu Starch Processing Company.

Objectives of the study

The ability of out-growers to produce enough cassava to meet plant capacity depends on their level of efficiency. The objective of production of out-growers in this case is to achieve the maximum output from a given set of inputs. Issues such as minimizing risks and ensuring that inputs are efficiently utilized with attention paid to eliminating waste are thus crucial if the production objective of farmers is to operate on their frontier output.

The objective of the study is to investigate technical efficiency and policy options that are evidently feasible in raising out-growers' level of performance. The specific objectives of the study are to:

- estimate plot specific technical efficiency of smallholder farms producing cassava, the main raw material for starch production.

- determine the influence of out-growers' socio-economic and institutional factors on their technical efficiency levels.
- analyse the relative technical efficiency of the production units
- provide policy options for improving cassava production.

Literature

Technical efficiency (TE) otherwise known as pure technical efficiency (PTE) like its counterparts (allocative, scale and scope efficiencies) according to Fare et al (1994), Farrell (1957), and Coelli et al (1998) is a major component of productivity, which in itself is a measure of a firm's performance. The level of technical efficiency of a particular firm is characterized by the relationship between observed production and some ideal or potential production (Baeur, 1990; Cornwell et al, 1990; Green,1993;)

The measurement of a firm's specific efficiency is based upon deviation of observed output from the best production or efficient production frontier. If a firm's actual production point lies on the frontier, then it is technically efficient, but if it lies below the frontier, it is technically inefficient. With the ratio of observed output to potential production, the level of technical efficiency of a firm or any decision-making unit can be determined (Coelli et al, 1998).

Agbabiaje (2003) empirically investigated the performance of intensive poultry farms in the Ogun State of Nigeria and estimated the technical efficiency by farm size. The stochastic frontier production functions analysis was adopted to determine the technical efficiency indices of the resources used on the different farm sizes. Maximum likelihood estimates of the econometric model revealed that flock size, labour, feed, fixed inputs and chemical input resources were the major factors associated with changes in poultry production.

The level of technical efficiency varied across farm sizes and efficiency was found to be higher among small and medium sized farms than the large sized farm. The mean farm specific technical efficiency indices were found to be 0.9984, 0.9952 and 0.9771 for small, medium and large sized farms. He concluded that technical efficiency decreased with farm size. The limitation of this study is that farm size was the only variable considered in the estimation. This result is consistent with findings obtained by Tadesse and Krishnarmorthy (1997). Amo (2004) measured the technical efficiency of small-scale farmers in Nigeria by employing the stochastic frontier production function analysis. Results obtained indicate that farmers were in the rational stage of production as depicted by the returns to scale 0.27. The technical efficiency of the sole maize farmers was lower (0.52.66) compared with that of the mixed (yam/maize) cropping farmers (0.7172). A mean efficiency of 0.622 was observed for all farmers. Over fifty percent (50%) of the mixed crop farmers had technical efficiency exceeding 0.70 as compared with 100% sole farmers who had less than 0.60. The study further indicated that the years of schooling, farming experience, cropping pattern and access to credit positively affected technical efficiency while increase in the age led to a decrease in technical efficiency.

Amaza and Olayemi (2002) investigated technical inefficiency in food crop production among farmers in Gombe State in Nigeria . A stochastic frontier production function, which incorporates technical inefficiency effects, using the Maximum-Likelihood Estimation (MLE,) was used as the analytical technique. Given the specification of the stochastic frontier production function, the first hypothesis, which specified that the explanatory variable in the model for technical inefficiency factors have zero coefficients was rejected.

The study revealed that the explanatory variables such as plot size, age, extension services, and access to credit in the technical inefficiency effects contribute significantly to the explanation of inefficiency in food crop production in Gombe State, Nigeria. Predicted technical efficiencies varied widely among farms, ranging between 12% and 89%, and a mean technical efficiency of 69%.

Ahmed, Benin, Ehui and Gebremedhin (2001) applied the stochastic frontier production function and examined the technical inefficiency and the determinants of inefficiency of alternative land tenure arrangement in Ethiopia. This was against the background that the degree to which the prevailing tenure arrangement constraints agricultural productivity and the sources of inefficiency with land tenure system remained unresolved. The results show that sharecropping and borrowing land were less technically efficient than owner-cultivation or fixed rentals due to the restriction imposed on them by landowners and the interaction of the land market with other imperfect markets and the absence of a perfect input market. Thus, a policy to facilitate more efficient transaction of land between farmers and functioning of input market are expected to reduce inefficiency associated with these land tenure systems.

Ajibefun and Abdulkadri (1999) investigate technical inefficiency in production among the food crop farmers under the National Directorate of Employment in Ondo State of Nigeria. The study applied translog stochastic frontier production functions in which the technical efficiency effects were defined by three different sub models. Given the specification of the stochastic frontier production function, the null hypothesis, that the frontier is adequately represented by the Coo-Douglas function, was accepted, but the null hypothesis that the farmers were fully technically efficient, which implied that inefficiency effects were absent from the model was rejected. Furthermore, the null hypothesis of half-normal distribution for the inefficiency effects was rejected.

Predicted technical efficiencies varied widely across farms, ranging between 21.7% and 87.8% and a mean technical efficiency of 67.0%. Explanatory variables such as: farm size, credit availability, extension services and experience were found to have positively influenced the technical efficiency of the farmers. In other words, these variables decrease with technical inefficiency.

Theoretical framework

Economic efficiency at the micro-level focuses on the ability of firms to utilize the best available technology and to allocate resources productively (Chavas et al., 2005). It is typically decomposed into three sources: technical, allocative and scale efficiency. Technical efficiency is attained when the best available technology is used. The level of technical efficiency of a firm is characterized by the relationship between observed production and some ideal or potential production (Baeur, 1990; Cornwell et al, 1990; Green,1993;). The measurement of a firm's efficiency is then based upon closeness of observed output to the best production or efficient production frontier. Deviations from the frontier are assumed to be the result of technical inefficiency pertaining to the firm itself and other random events (Tong and Chan, 2003).

In estimating the stochastic frontier function of a firm and finding explanations for the differences in technical efficiencies, we applied the basic frontier model used by Aignér et al. (1977), Meeusen and van den Broeck (1977). The model used in the literature to describe the frontier function can be written as follows:

$$lnY_i = f(x_i, \beta)e^{(v_i - u_i)}$$

where lnY denotes the logarithm of the output for the *ith* sampled firm in a function such as Cobb-Douglas or translog functions, $(i = 1,...N) f(.)$ is a measure of the maximum output for any particular input vector x_i. x_i. is a (1 x k) vector of the logarithm of the inputs associated with the *ith* sampled firm (the first element would be one when an intercept term is included) and β is a (k x 1) vector of unknown parameters. v_i is the stochastic disturbance term, which is normally distributed with mean zero (0) and variance σ_v^2, while, u_i is a one-sided disturbance which is half normally distributed of the form $u_i \sim |(0, \sigma_u^2)|$, reflecting the fact that each firm's production should lie on or below its frontier, but v_i and u_i are independent with variances σ_v^2 *and* σ_u^2 respectively. u_i is half-normally distributed with mode of zero, implying that a high proportion of firms being examined are perfectly efficient. The total variance of output, σ^2, is expressed as $\sigma^2 = \sigma_v^2 + \sigma_u^2$ .The ratio of the two standard errors as applied by Jondrow et al. (1982) is expressed as $\lambda = \sigma_u/\sigma_v$, and this measures total variation of output from the frontier that can be attributed to inefficiency. The ratio of the variance of u_i to the total variances, $\gamma = \sigma_u^2/(\sigma_v^2 + \sigma_u^2)$, lies between 0 and 1. A γ value equals to 0 means that the inefficiency is not technical while a value close or equal to 1 implies that the inefficiency is technical (Kalirajan and Shand, 1985).

The stochastic frontier function is such that technical efficiency of a firm is defined as the ratio of observed output relative to what could be produced by fully efficient firms using the same vector

$$lnY_i = f(x_i,\beta)e^{v_i}$$

and the observed output written as x of inputs specified as

$$lnY_i = f(x_i,\beta)e^{(v_i-u_i)}$$

and the technical efficiency ratio is given as

$$Te_i = \frac{f(x_i,\beta)e^{(v_i-u_i)}}{f(x_i,\beta)e^{v_i}}$$

This would imply that

$$Te_i = e^{-u_i}$$

If the firm is efficient in production, then technical inefficiency is 0 and its technical efficiency is 1. In general, $0 \leq e^{-u_i} \leq 1$. If $Te_i = 1$, the firm is producing on the production frontier and is said to be technically efficient but if $Te_i \leq 1$, the firm is not producing on its frontier.

Let us consider that an out-grower is involved in cassava production characterized by the use of inputs x consisting of $\vartheta, \omega, \rho, \varphi$ and ∂ to produce an output Y, where ϑ is land area under cultivation, ω is the number of labour employed, ρ is the number of hoes employed, φ denotes the number of cutlasses used and ∂ is the quantities of stems planted. Let us assume that, the general form of an out-grower's model is represented by the feasible set as follows

$$(\vartheta, \omega, \rho, \varphi, \partial; Y) \in x$$

This specification implies that the chosen inputs can feasibly produce an output and that cassava production is allowed to vary across different plots. The efficient transformation of these inputs into the output Y is characterized by the production function defined as

$$Y = f(\vartheta, \omega, \rho, \varphi, \partial)$$

The production function specified is assumed to allow for obtaining the maximum feasible output from the various input vectors, which are under the control of the out-growers. This information makes it possible to adopt econometric approach to assess the effects of the input vector on cassava output. This general form of the production function can be estimated using any theoretical form and testing which best fits the data involved.

Data and Estimation

The study area covers Awutu-Bawjiase, one of the operational zones under the company for cassava production and its supply. This area is selected for two reasons. First, it is well noted for cassava production owing to its proximity to the company, and second, it has a large number of small-scale farmers engaged in cassava cultivation.

Since the analysis of technical efficiency requires input-output data on cassava production, the main data were gathered through out-growers' questionnaire administered to 120 out-growers who were selected randomly. The sample frame was the 2006 farmers' register. Questions were asked on plot level output of cassava, the inputs used in the production process (including land, labour and other farm capital assets such as hoes, cutlasses and cassava stems) on each plot, the socio-economic and institutional characteristics of farmers.

Table 1: Measurement of Variables

Variables	Units of Measurement
Cassava	Quantity of cassava produce (in tons)
Land	Total land holding under cassava cultivation (in acres)
Labour	Number of labourers engaged in the cassava cultivation (in man-hours)
Hoes	Number of hoes employed (units)
Cutlasses	Number of cutlasses employed (units)
Stems	Number of stems planted (based on planting space)
Plot Size	Plot size under cultivation (acres)
Framing Experience	Years of cassava farming (years)
Farm Distance	Distance of plot from out-grower's home (km)
Formal Schooling	Years of formal schooling attained by out-grower (Years)
Hybrid Cassava	1 if the main type of cassava on the plot is hybrid, 0 otherwise
Club Membership	1 if out-grower belongs to farmer's association, 0 otherwise
Mono-cropping	1 if main crop on the plot is cassava, 0 otherwise
Tenure Contract	1 if out-grower practises any plot contracts, 0 otherwise

Table 2 reports summaries of the variables involved in the estimation of the technical efficiency and the determinants of technical efficiency. The mean farming experience was 16.4 years, implying that a majority of out-growers have been cultivating cassava for many years. The average years of farming experience could afford out-growers to accumulate knowledge necessary for planning, keeping of simple farm record, utilization of plot resources and managing their farm accurately. Accumulated experience could also help the farmers do early planting and timely weeding.

With schooling the mean was 4.28 years with a maximum of 13 years. The maximum years of schooling showed that the highest level of schooling attained by an out-grower was higher than primary school and this would suggest that illiteracy was low among the farmers.

Table 2: Summary of statistics on inputs/output of the stochastic frontier function

Variable	Mean	Standard Deviation	Minimum Value	Maximum Value
Cassava	28.00	21.50	4.00	29.00
Land	1.05	0.66	0.44	3.00
Labour	18.10	62.50	8.00	270.00
Hoes	12.30	10.50	2.00	49.00
Cutlasses	5.89	5.23	2.00	28.00
Stems	4149.00	2647.00	873.00	11907.00
Plot size	1.05	0.66	0.44	3.00
Experience	16.40	4.66	2.00	44.00
Distance	0.80	1.86	1.00	4.00
Schooling	4.28	2.16	0.00	13.00
Hybrid Cassava	0.90	0.28	0.00	1.00
Club Membership	0.79	0.43	0.00	1.00
Mono-cropping	0.73	0.46	0.00	1.00
Tenure Contract	0.80	0.40	0.00	1.00

Source: Computed from Survey Data, 2006

The mean farm distance was 0.8km with the longest being 4km. This would suggest that on the average out-growers would have to walk for almost 1km on daily basis in undertaking their farm activities. Again, if an out-grower had to travel a distance of 4km on foot before getting to his/her farm and a similar distance back home at the end of the day's work, it could reduce his/her productivity and efficiency.

The stochastic frontier function was estimated using the Cobb-Douglas and the Translog Production functions, following Battese et al. (1993). The Cobb-Douglas function had a better fit and was adopted for the study. The results of the estimation are reported in Table 3.

Table 3: Cobb-Douglas Stochastic Frontier Estimation

Dependent variable: Cassava Output

Variables	Parameters	Coefficients	Std err	prob>|t|
Constant	δ_0	0.5943	0.3145	0.066**
ln(Land)	δ_1	0.5734	0.1813	0.000*
ln(Labour)	δ_2	0.2635	0.0667	0.002*
ln(Hoes)	δ_3	0.0731	0.0837	0.084**
ln(Cutlasses)	δ_4	0.0398	0.0727	0.126
ln(Stems)	δ_5	0.2252	0.1598	0.061**
sigmaυ	σ_u	0.3359	0.1187	0.1681
	σ_v	0.3068	0.0474	0.2267
sigmaυ^2	σ_u^2	0.1128	0.1188	0.2042
sigmav^2	σ_v^2	0.0941	0.0472	0.8768
lambda	λ	1.0948	0.1597	0.7818
sigma^2	σ^2	0.2069	0.0586	0.0922
gamma	γ	0.5426	0.7654	
log*likelihood*		-49.99		
Number of observations		120		

Source: Estimation from Survey Data, 2006

From Table 3, the estimate of λ is 1.0948, implying a good fit. This implies that results obtained in the use of this function in estimating the technical efficiencies of the out-growers is efficient and reliable thus authenticating distributional assumptions about the one-sided disturbance term in our analysis.

The estimated value of gamma, γ, is 0.5426. This result would imply that there is technical inefficiency in the production of cassava that is to say, the variation between the observed and the frontier production is due to technical inefficiency. The conclusion is that the production of cassava lies below the frontier and hence the frontier production of out-growers is characterized by technical inefficiency.

From the estimation of the stochastic frontier function, the ratios of technical efficiency were generated and are shown in the appendix. The lowest level of efficiency is about 2 percent and the best plot achieved a 99 percent level of efficiency. The average efficiency is 58 percent, indicating that out-growers are producing cassava far below their productive frontier. The low level of efficiency may be associated with production risk or bottlenecks (such as management and weather), which limit their ability to expand output considerably. The modal class is 61 percent to 80 percent and about 62 farmers representing 51.66 percent had efficiency scores below 61 percent.

The observed efficiency indices were regressed on the out-growers' characteristics in the final step

$$e^{-u_i} = f(\phi, \alpha)$$

where ϕ denotes a set of out-growers attributes and α being unknown parameters to be estimated.

Table 4: OLS estimates of Determinants of Technical Efficiency

Variables	Parameters	Coefficients	Std err	t-prob
Constant	α_0	2.0000	0.1757	0.001***
Plot size	α_1	-09287	0.0473	0.001***
Farming experience	α_2	0.1256	0.0342	0.001***
Farm distance	α_3	-0.2172	0.0395	0.080*
Formal schooling	α_4	0.0143	0.0145	0.346
Hybrid cassava	α_5	0.1973	0.0976	0.057*
Club membership	α_6	-0.0216	0.0658	0.060*
Mono-cropping	α_7	0.1215	0.0674	0.061*
Tenure contract	α_8	-0.1109	0.0478	0.142
$R-squared$	R^2	0.8743		
$Adjusted R^2$	$AdjR^2$	0.8687		
Number of observations N		120		

*** Significant at 1%, ** Significant at 5%, * Significant at 10%

Source: Estimation from Survey Data, 2006

The relationship between technical efficiency and out-growers' characteristics is estimated using the ordinary least squares and the results are indicated in Table 4. The coefficient of determination is very high with an estimated value of 0.87. This means that 87 per cent of the variation in the technical efficiency has been explained. While plot size negatively affected efficiency, experience had a positive effect on efficiency. On the other hand, farm distance, hybrid cassava usage, club membership and mono-cropping technology turned out significant at the 10 per cent level. While distance and club membership had negative effects on efficiency, hybrid cassava usage and mono-cropping had positive effects on efficiency.

Discussion

The positive coefficient obtained for years of farming experience follow our a priori expectation. Thus, more experienced out-growers were expected to improve upon their technical performance and hence would be more technically efficient by raising crop yield as compared to those with little or no farming experience. The significance of farming experience in this case might be attributed to the fact that experienced out-growers applied their farming experience acquired and which would positively improve productivity.

Regarding the coefficient of hybrid cassava, out-growers who grew hybrid variety of cassava were more technically efficient than those who did not. This result may be attributed to the fact that hybrid cassava variety gave more output than the traditional varieties. The positively significant effect of hybrid cassava on efficiency might be confirming that the policy intervention by the management of the company to diffuse newly improved cassava varieties has been embraced by out-growers.

In relation to mono-cropping, it was observed that where out-growers cultivated sole crop, it tended to improve crop yield. The positive sign obtained again confirmed our a priori expectation. Our conclusion is that out-growers' decision regarding the cultivation of sole crop on the land has significantly paid off.

By contrast, efficiency tends to fall with plot size. The negative and significant relationship with efficiency might be suggesting that the optimum combination of resources may not be achieved on large plot sizes. If the farmer is unable to manage the larger plot size and productivity falls, this would be reflected in the negative relationship.

The distance from the out-growers' home to farm plot was negatively related to efficiency. While the expectation regarding the sign was confirmed, this result revealed that home-to-plot distance could have a huge adverse effect on the ability of the out-growers to efficiently utilize their resources.

Social capital showed a negative relationship in our result. Although the result did not follow our a priori expectation, the effect relised may be due to the presence of poorly functioning farmers' association where sharing vital information on crop husbandry was relaxed to the extent that many of the farmers may not have fully benefited from the social network of their association as they ought to.

Policy Recommendations

The policy implications of the study point to the need for major reforms in the organization of the out-grower of the Ayensu Starch Processing Company in order to improve the efficiency of out-growers so that the purpose for which the company was set up can be accomplished. The specific policy suggestions are:

- The company should focus on understanding the production pattern of farmers and factors affecting them so as to help improve upon their production. In view of the challenges, the policy interventions which would be appropriate at raising observed efficiencies at plot level are proposed below.
- A policy should be designed to make out-growers more specialized in sole crop production rather than producing two or more crops on the same piece of land. Evidence suggests that due to food insecurity in developing countries, rural farmers tend to cultivate two or more crops simultaneously on the same plot, this is to reduce risks of crop failure and to enable them harvest several crop at the same time. In order to motivate these out-growers to adopt mono-cropping, management of the company should as a matter of urgency introduce Agricultural Insurance Policy in the company in order to reduce the risk associated with single crop production.
- The company should implement a permanent crop policy that would focus on the cultivation of improved cassava varieties which can considerably improve output. The positive impact of hybrid cassava on efficiency requires that greater effort be taken to create the capacity at the various research institutions to continue to develop new varieties and their diffusion to farmers as evidence suggests that such yield increasing varieties can increase production substantially.

- A policy should be designed by management to encourage young but experienced out-growers to remain as farmers in the production of cassava as long as their health could permit them. This calls for the provision of incentives in the form of scholarship for their wards, housing schemes and insurance policy as it is done in the cocoa sector in Ghana.

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Appendix: Estimated Technical Efficiency Scores

0.6889	0.6152	0.5454	0.0698
0.5968	0.2295	0.6822	0.8967
0.9476	0.1625	0.9231	0.2798
0.5153	0.8150	0.0589	0.7305
0.4218	0.2899	0.5261	0.6544
0.2979	0.9198	0.5213	0.8133
0.3183	0.6191	0.8496	0.2316
0.5870	0.8822	0.3708	0.6687
0.0728	0.6697	0.9761	0.2972
0.9764	0.8657	0.7763	0.8822
0.2463	0.6148	0.2719	0.8345
0.5696	0.5577	0.6961	0.5466
0.8729	0.2022	0.8763	0.1721
0.6925	0.5419	0.4179	0.5499
0.4245	0.1917	0.3889	0.6465
0.5702	0.7917	0.4907	0.4029
0.6660	0.2424	0.8338	0.8563
0.3187	0.7311	0.7040	0.6889
0.6168	0.2505	0.1949	0.5670
0.4133	0.9315	0.9668	0.4265
0.5323	0.4953	0.6048	0.1124
0.7401	0.5036	0.2682	0.5542
0.3484	0.4683	0.6936	0.7076
0.7225	0.2847	0.2685	0.7961
0.2295	0.2294	0.7699	0.3946
0.8795	0.4700	0.9994	0.9581
0.5203	0.7324	0.8627	0.8356
0.0440	0.4120	0.1934	0.4618
0.0244	0.2536	0.6753	0.8846
0.8321	0.8569	0.0926	0.8070

Source: Estimated from Survey Data, 2006