Analyzing pest management in Indonesian cocoa production:
a heteroskedastic production function approach

Overview

In the tropics, pest infestation is often a major constraint to agricultural production. Moreover, research earmarked for pest control and pest knowledge is minimal compared to that of research conducted with application to industrialized countries. When pests are not easily controlled this may lead to substantial decreases in yield and high yield variability. This research provides insight into sources of yield variability that in turn generates information for farmers, local extension agents, and the international development community. This research will also contribute to the improvement of outcomes on smallholder cocoa farms in the tropics.

Cacao trees are exclusively grown in lesser-developed nations. West Africa alone produces 70% of the world cocoa supply. With persistent political and economic problems, as well as declining productivity in West Africa, cocoa buyers are seeking alternative sources of cocoa and cocoa products. As quality and flavor characteristics are fairly uniform across these two regions, Asia has emerged as a substitute source.

Indonesian cocoa has proven to be a sufficient source of supply for the growth in demand (The World Cocoa Foundation reports a 3% increase per year in demand) and in the wake of West Africa’s tribulations. Indonesia quickly scaled-up production during the 1990’s and is now the worlds third largest producer. However, in recent times, the Indonesian cocoa industry, characterized by inefficient agricultural and management practices, has suffered from substantial losses in yields (up to 40%) and income (collectively $300 million annually) due to a pest infestation by the Cocoa Pod Borer (CPB) moth. CPB infestation and the inability to control the pest have reduced the industry’s reliance on purchasing a consistent supply of quality beans.

Shedding light on reducing CBP infestation will enable future development aid projects to better target efforts. Measuring the welfare of cocoa farmers by identifying blocks or groups of successful farmers and by comparing efficient use of available technologies will contribute to the gap in knowledge. This paper analyzes different technologies and management strategies currently in use to answer three questions: (1) How do current treatments affect output levels? (2) To what extent do these treatments have differential impacts on yields and yield variability? and; (3) What is the profitability of each treatment?

Data and Methods

A baseline survey of 731 cocoa farmers in the Luwu Province of South Sulawesi was conducted in 2003. This survey examined household characteristics, farming practices, infestation rates, labor uses, profits, costs as well as the role of off-farm income. The survey collected information on production levels prior to CPB infestation. Experimental data were collected from 2003 through 2004. These data examined the effects of various treatments on yields. This survey is unique in that it provides both insights into the production and consumption choices made by a group of Indonesian cocoa farmers and information on the efficacy of various experimental field trials.

To adequately represent production responses to interventions, we employ a model that takes into account the mean and the variance of yields. As Just and Pope (1979) remarked, “intelligent public policy formulation should consider not only the marginal contribution of pesticide use to the mean of output but also the marginal reduction in variance of output.” Accordingly, we use a conditionally heteroskedastic production model to study cocoa yields. The model for yield (in kg/ha) is specified as:

$$\text{Yield}_i = \alpha_0 + \alpha_1 \text{Labor}_i + \alpha_2 \text{Fertilizer}_i + \alpha_3 \text{Infestation}_i + \alpha_4 \text{Age}_i + \alpha_5 (\text{Age}_i)^2 + \varepsilon_i$$

$$\varepsilon_i \sim (0, \sigma^2 h_i), \quad E(\varepsilon_i ' \varepsilon_j) = 0 \text{ for all } i \neq j$$

$$h_i = \beta_0 + \beta_0 \text{Pesticide}_i + \beta_0 \text{Infestation}_i$$

where i is an index over farms. Labor is measured in labor-hours/ha and fertilizer is measured in kg/ha. Infestation is a binary indicator variable for pod-borer infestation (1: Infestation, 0: No Infestation). Age is the average age of the cocoa tree. Finally, h_i is the covariance matrix. We model infestation as dependent on treatment, where:

Pr(Infestation = 1) = f(Treatment effect)

where treatment effects include: Black Ant (natural predator), Nabati (locally developed pesticide), Commercial (trail of farmers who completed the Farmer Field School (FFS) program), Foliar Spraying, NutriTech (fertilizer treatment), and Control (farmers who have not participated in the FFS and maintain farm on own accord).

The best solution would be to treat infestation as a continuous variable as opposed to a discrete binary variable. Due to data collection constraints, we employ the second best information.

<u>Results</u>

Results indicate that labor and fertilizer contribute to higher yields. The presence of infestation substantially reduces the yield. The parameter estimates accounting for tree's age reflect the expected trend that the yield increases up to a certain age and then declines. Parameters for the variance equation indicate that higher pesticide use contributes to higher variance in yield. Surprisingly, higher infestation levels show lower variance in yield, perhaps because infestation reduces high levels of output more than it reduces output at the lower tail of the yield distribution.

Furthermore, results show that some treatments are more effective than others. The most effective treatment is Nabati, followed by Black Ant and Commercial treatments. Farmers using Nabati report higher yields than farmers using either Black Ant or Commercial treatments. It is somewhat surprising that the Black Ant treatment was statistically significant. Farmers repeatedly reported the Black Ant treatment to be ineffective at controlling CPB but the data explains otherwise.

<u>Further Analysis</u>

The final paper will include several refinements not yet reflected in this abstract. We will test a range of functional forms for the mean and variance equations and examine in econometric detail the connection between treatment and infestation. Marginal physical products will be calculated and examined to determine whether cocoa farmers are operating at allocatively efficient levels. Given that farmers may be risk averse towards new practices, we also plan to subject the data to stochastic dominance analysis to determine whether some treatments are superior to others.

<u>References</u>

Just, Richard, and Rulon Pope. "Production Function Estimation and Related Risk Considerations." American Journal of Agricultural Economics, Vol. 61, No.2, May 1979.