Feed the Future Policy in Sub-Saharan Africa – Measurement Issues

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Abstract

Following the insights of Tinbergen, this paper reviews the conceptual basis for measurement as a part of the policy process. Based on this review, the manuscript presents some of the standard approaches to measuring the policy impact of Feed the Future programs and presents a couple of new alternatives. Following this development, some of the more salient statistical issues involved with measurement are reviewed.

Key words: food security, value added programs, impact analysis

JEL classification: C10,O12,Q12

Introduction

It is sometimes important to frame the historical basis of a problem set. In this case I have been asked to develop the measurement issues for analyzing the effect of the United States' Feed the Future (FtF) efforts in Sub-Saharan Africa. As a part of this effort, I had a nagging urge to re-examine what we know about the theory of economic policy. While this history is long, from the accusation of economics as the Dismal Science in the 19th century to Truman's alleged search for a one-handed economist, I decided to start with one of the first recipients of the Nobel Prize in Economic Science in Memory of Alfred Nobel – Jan Tinbergen. By using this point, I am claiming a linkage to this trunk of the tree from my work with Henri Theil.

In the years after World War II, Tinbergen and Theil were directly involved in economic policy through the Dutch Central Planning Bureau (CPB). Tinbergen was the director of the CPB from 1945 through 1955. In part, based on this appointment he published two manuscripts – a short book titled *On the Theory of Economic Policy* (1952) and a longer work titled *Economic Policy: Principles and Design* (1956). Both of these works laid out the basic concepts of the design of economic policy and then proceeded to discuss the state of the art of aggregate decision making such as tax rates, monetary growth, and wages. Obviously these particulars are outside the scope of our current discussion; however, certain fundamentals are well worth considering.

As a first step, Tinbergen lays out a sequence of five steps in the policy process.

1. Ascertain the state of affairs in the economy.

2. Determine what the desired state of the economy is and whether the current state of the economy diverges from that state.

3. Estimate the effects of possible alternative policies.

4. Make a choice – decide between alternative policies (including the possibility of no action).

5. Implement or execute the chosen policy (Tinbergen 1956, p.10).

In this sequence, steps 1 through 3 are the planning process. These are typically the venue of academic economists. It would appear that our current enterprise lies somewhat outside this list. Specifically, our efforts under this project involves the evaluation of the effect of policies that have been implemented. Alternatively, we could envision our efforts as informing future policy design and implementation.

With this overall framework in mind, the goals of the policy economist can then be more rigorously defined. As a starting point, Tinbergen (1952) suggests a set of possible interests

of the decision maker (i.e., policy maker) Ω. These interests may include full employment, price stability, etc. Based on these overall goals, the economist employed by the planner identifies measures of general interest y_k such as the number of individuals actually seeking work or the rate of change in some price index. Implicitly, the concept is that the policy maker cam express the general policy interest in terms of the target variables ($\Omega(y_k)$). Of course Tinbergen stops short of recognizing $\Omega(y_k)$ as a social welfare function with reference to the work of Kenneth Arrow.

The basic notion is then that the economist can identify a policy variable z_i that effects these target variables. To complete the formulation, Tinbergen defines a set of incidental variables x_j that represent the internal functioning of the economy. Mathematically the system can then be presented as

$$(1) \quad y_t = \Gamma_z z_t + \Gamma_x x_t \Rightarrow \Omega(y_t)$$

where Γ_x and Γ_y are structural coefficients in the economy. To provide a little more clarity for each variable, suppose that one of the target variables is household income (y_1). One possible policy variable may be the tariff on imported oil (z_1). Without too much attention to detail, the vector x may include the final output markets (e.g., prices and quantities) for goods created by employing labor and using oil. In this formulation we could hypothesize that household income could be increased in part by reducing the tariff on oil.

This policy structure fits nicely into the Policy Matrices for the FtF programs in Africa. Focusing for the moment on Rwanda, Policy Area 1 involves the institutional architecture for agricultural markets. The matrix presents the major issue – there is a weak private sector linking smallholder agriculture to domestic and international markets. Implicitly, this identifies Ω. An area of concern is the income for smallholder agriculture. This identification leads to the definition of numerous target variables. Traditionally, we examine the poverty rate (y_1) defined as that percentage of the population living on less than some spec-

ified level. From my experience in Rwanda, the coffee marketing channel did not provide sufficient quality signals to provide incentives for the development of the coffee marketing sector. The policy actions (z_1) was to provide capital and expertise for the development of coffee washing stations and auctions for quality coffee (e.g. the Cup of Excellence Program). Along the way these efforts generate several other changes in the local economy such as increased coffee plantings (x_1).

Impact Studies

Oehmke et al. (2012) provide an overview of several impact studies conducted between 2008 and 2012 in Sub-Saharan Africa for USAID projects. The objectives of these impact studies were to

1. Quantify the effect of USAID supported projects on smallholder income and poverty status or child nutritional status;

2. Provide empirical validation or falsification of the causal pathways from intervention to poverty reduction, by which the projects operate; and

3. Learn lessons about what has made the projects most successful in augmenting smallholder income, particularly with respect to new activities to be funded under FtF (Oehmke et al. 2012, p.2).

In general, these studies applied quasi-experimental modeling methods relying largely on difference-in-difference specifications to estimate the effect of specific policies on smallholder income and child nutritional status. While the programs evaluated were fairly diverse, several focused explicitly on the development of value chains. In Ghana the program focused on the value chain for pineapple and mango, in Kenya the focus was on the value chain for dairy, the Kenyan value chains were for horticulture and maize, and the Rwanda program improved the value chain for coffee. In each case, the improved value chain

yielded quantitative increases in smallholder income, qualitative improvements in livelihoods, and reduced poverty. Other results include the reduction in the periodic food gap in Ethiopia. Relying on traditional benefit/cost ratios, each program provided a cost-effective mechanism to address the objectives of FtF.

In addition to meeting the overall policy goals, Oehmke et al. (2012) examine some of the challenges and benefits associated with each program. In general they conclude that changes in the value chain will not occur quickly. Smallholders need time to adjust to quality signals. Other investments require time to implement – many of the improvements in Rwanda coffee activities occurred in the second five-year program. On the positive side, while significant increases in the yields for smallholder agriculture may be problematic, improved access to value chains provides immediate incentives and increased profitability to smaller farmers.

Other than the direct effects of value chain programs, these programs provide asset values that improve smallholder resilience. In Ethiopia and Ghana, value chains facilitate the investment in land, livestock and human capital. The additional income increases the investment in household assets which increases the opportunity to generate income from both agribusiness and other commercial activities.

Development of Traditional and Non-Traditional Measures

Most of the measurement impact studies discussed in Oehmke et al. (2012) follow fairly traditional approaches to measure the impact of FtF initiatives. Most of the studies start with a comparison of household income between control and treatment groups. Moss, Oehmke, and Lyambabaje (2014a) found that household income for the group affected by SPREAD/PEARL was statistically different from the control group. In this case, the treatment group was defined as those households who sold at least 90 kg of coffee in a given year. Building on the the changes in household expenditures Moss, Oehmke, and Lyambabaje (2014a) next estimated the effect of SPREAD/PEARL on the poverty rate.

Specifically, they defined a household as being impoverished if the its income was less than 64,000 RWF per year. The effect of SPREAD/PEARL on the poverty rate could then be estimated by estimating the change in the probability that a household was impoverished as a function of whether the household marketed at least 90 kg of coffee in a given year.

Extending the analysis beyond the direct effect on income, another policy issue is typically the effect of the intervention on the distribution of incomes across households – the effect of the policy on income inequality. Typically, programs focusing on smallholder farmers could be hypothesized to reduce the inequality of income. Intuitively, these interventions are intended to increase the ability of small farmers to generate income – reducing the lower tail of the income distribution. Popular measures of income inequality include the Gini Coefficient and Theil's Inequality Measure (Theil 1967). Foster (1983) demonstrates that Theil's inequality measure is preferred because it is consistent with the Pigou-Dalton Transfer Principle which states that redistribution of income from a more wealthy individual to a poorer individual must always reduce the income inequality. Mishra, Moss, and Erickson (2006) provide an extension of Theil's Inequality Measure to the individual household.

While the estimation of policy impacts through changes in household income, the incidence of poverty, and income inequality are well accepted measures, they may not paint a complete picture of the effect of a policy intervention. One of the overriding concerns in policy goals in the FtF initiative is the reduction of hunger and/or food insecurity. An alternative approach would be to examine the effect of the FtF programs on a measure of food security through changes in income. A model particularly suited to this estimation is the Working's model of the share of income spent on food Working (1943) (Clements and Theil (1996) refer to the formulation as the Working-Leser model where Leser (1953) focuses on the formulation as an Engel curve). Mathematically, food is hypothesized to be the ultimate necessity; as such the share of the expenditure on food is hypothesized to be a decreasing function of the natural logarithm of total expenditures

(2) $w_F = \alpha_F + \beta_F \ln(E)$

where w_F is the share of expenditures on food, E is the level of total expenditures, and α_F and β_F are coefficients. In general, Working's model hypothesizes that $\beta_F < 0$. Based on this insight, Clements and Theil (1996) developed a formulation of the demand system which grew to be called the Working - Preference Independence (e.g., the Working-PI model) which was renamed the Florida Model by Theil (1997).

For our purposes we use the Florida model as developed by Theil, Ching-Fan, and Seale (1989). The formulation is based on the differential approach to demand (i.e., the basic approach used to develop the Rotterdam demand model). The primary difference is that preferences are assumed to be independent across goods

(3) $U(q) = U_1(q_1) + U_2(q_2) + \cdots U_n(q_n)$

where q_i is the quantity of each good consumed and $U_i(q_i)$ is the utility function for each good (see Theil, Ching-Fan and Seale 1989, pp.155-156). The resulting time series formulation (see Theil, Ching-Fan, and Seale 1989, pp.157-158) includes the basic Working's formulation in Equation 2

(4) $w_{it} - w_{i,t-1} = \beta_i DQ_t + \bar{w}_{it}(Dp_{it} - DP_t) + \phi(\bar{w}_{it} + \beta_i)(Dp_{it} - DP_t^*) + \varepsilon_{it}$

where w_{it} is the budget share for good i at time t, DQ_t is the overall quantity index (i.e., total demand), Dp_{it} is the change in the price for good i at time t, DP_t is a divisia price index, ϕ is the income flexibility, DP_t^* is a Frisch price index, and ε_{it} is the residual. In this demand formulation the substitution effect is primarily through the income constraint. As

one price increases, consumers shift between goods based on the income elasticity for each good. A similar concept was suggested by Becker (2008) to describe demand curves.

Theil, Ching-Fan, and Seale (1989) use a cross-section formulation of the Florida Model to analyze consumer demand across countries using the International Comparison Project data. Their analysis focuses on differences in relative prices and incomes between countries. A dominant theme in their results is that a significant portion of variations in the consumer demand across countries can be explained by the Working's model for food. Specifically, one empirical regularity in the data is that poorer countries devote a large portion of their income (or total expenditures) to food. This regularity would appear to be important for the objectives of FtF. Specifically, consider a simplified version of the n good model where households allocate income between food and non-food items

$$U\left(q_F, q_{NF}\right) = U_F\left(q_F\right) + U_{NF}\left(q_{NF}\right). \tag{5}$$

where q_F is the quantity of food consumed and q_{NF} is the quantity of non-food consumed. Next, consider a couple of specific forms for each utility function

$$\begin{array}{l} U_F\left(q_F\right) \Rightarrow \begin{cases} \ln\left(\gamma\left[q_f - k\right]\right) \text{ if } q_F > k \Rightarrow \lim_{q_F \to k^+} \dfrac{\partial U_F\left(q_f\right)}{\partial q_F} = \infty \\ -\infty \text{ if } q_F \leq k \end{cases} \\ U_{NF}\left(q_{NF}\right) \Rightarrow \lim\limits_{q_{NF} \to 0^+} \dfrac{\partial U_{NF}\left(q_{NF}\right)}{\partial q_{NF}} = \psi \ll \infty \end{array} . \tag{6}$$

These restrictions are sufficient to generate a specific corner solution. If $E \leq p_F k$ then $w_F = 1.0$, or the household allocates all its budget to food (i.e., $w_{NF} = 0$). Note that this solution does not imply that the household meets its nutritional need. Specifically, if $Y \ll p_F k \Rightarrow q_F \ll k$. However, if $E > p_F k$ then $w_F < 1.0$ and $w_{NF} > 0$.

To transform this formulation into a model of food security, assume that expenditures are distributed Bernoulli

$$(7) \quad \mathrm{P}[\xi,\theta] = \theta^{\xi}(1-\theta)^{1-\xi} \ni: \xi = 0 \Rightarrow E_0 \,\text{and}\, \xi = 1 \Rightarrow E_1.$$

Assuming that $E_0 \ll p_F k$ and $E_1 \gg p_F k$ the solution implies $w_F = 1.0$ with probability θ and $w_F \ll 1.0$ with probability $1-\theta$. Assuming that food and non-food prices are constant, the variation in the expenditure on food as a share of total spending is a measure of food insecurity. I could envision this model working two ways. First, I could hold the two levels of income constant (i.e., $E_0 = \bar{E}_0$ and $E_1 = \bar{E}_1$) and then develop the probability of income being low enough to generate insufficient food purchases (i.e., estimate θ). Alternatively, I could hold the probability of a low income constant and change the level of income.

In the end, this derivation suggests using the share of income spent on food as a measure of the effect of an agricultural policy intervention such as value chain enhancement of food security. The soft corner of this analysis is that it assumes that all the food is purchased. The problem with the formulation is comparing market oriented approaches to food security with programs intended to enhance household self-sufficiency. It may be possible that impoverished households trade market income for labor used to produce non-market household consumption.

Another non-traditional approach to measuring the impact of value chain programs involves quantifying the distribution of production and/or firm profit. To develop this model, consider a simple model of a smallholder who chooses between the production of two outputs using two inputs – one variable ($x_1 = x_{11} + x_{12}$) and one fixed ($x_2 = x_{21} + x_{22}$) –

$$(8) \quad \begin{aligned} \max_{x_{11},x_{12},x_{21},x_{22}} \; & (p_1 - \alpha_1) f_1(x_{11},x_{21}) + (p_2 - \alpha_2) f_2(x_{12},x_{22}) - w_1(x_{11} + x_{12}) \\ & x_{21} + x_{22} \leq x_2 \end{aligned}$$

where p_1 and p_2 are market prices, α_1 and α_2 are marketing costs, and $f_1(.)$ and $f_2(.)$ are production functions for good 1 and 2 respectively. Using this simple formulation, I can

model the effect of a value chain. Specifically, I start by assuming that output 1 (i.e., $f_1(.)$) is a commodity with limited returns to quality while output 2 (i.e., $f_2(.)$) is a good with a positive return from a policy intervention in the marketing channel. In addition, I assume that the marketing cost is a function of the size of the firm. Hence, I rewrite Equation 8 as

$$\begin{aligned} &\max_{x_{11},x_{12},x_{21},x_{22}} p_1 f_1(x_{11},x_{21}) + (p_2 - \alpha_2(x_{22})) f_2(x_{12},x_{22}) - w_1(x_{11}+x_{12}) \\ &\qquad x_{21}+x_{22} \leq x_2 \\ &\qquad \frac{\partial \alpha_2(x_{22})}{\partial x_{22}} \leq 0 \end{aligned} \tag{9}$$

or I assume that larger firms have a smaller marketing cost for the quality-oriented product. In the limit, this solution yields a bifurcated agriculture with larger producers producing the higher valued output and smallholders producing the lower valued commodity. Within this context being programs such as SPREAD/PEARL, donor capital can be used to reduce the price margin, increasing the quantity of the higher quality output produced by smallholders. An inequality measure similar to Thiel's Income Inequality can be used to measure whether FtF investment increases the share of higher valued products produced by smaller farmers. Moss, Oehmke, and Lyambabaje (2014b) have developed the theoretical foundations of this model using Zellner's 1951 production function.

A final measure of the impact of the value chain programs implemented by FtF involves the effect of the increased profitability of environmentally friendly outputs on village employment. While these effects lie somewhat outside the scope of the current consortium agenda, their development may yield insights that will be useful in estimating the direct impact of FtF efforts. Moss, Mbaye, and Oehmke (2014a) and Moss, Mbaye, and Oehmke (2014b) examine the impact of Wula Nafaa on village employment in Senegal using two somewhat different statistical approaches. In general, Wula Nafaa attempts to shift agribusiness in the Teambacounda and Kedougou regions of Senegal from less environmentally friendly activities such as charcoal production toward production of natural products

such as baobab fruit and lalo. Again, the approach is to reduce the cost of marketing the natural products. As depicted in Figure 1, agribusinesses producing natural products face a net demand curve of D_2 (i.e., $D_2 - \tau$ where τ is the marginal cost of market channel). By investing in human and physical capital, the goal of Wula Nafaa is to reduce the cost of the marketing channel yielding a right-ward shift in the net demand curve for natural products to $\tilde{D}_2$. If this shift is successful, the returns to agribusinesses will increase from p_2ab to $\tilde{p}_2cb$ (see Just, Hueth, and Schmitz 2005). While most economic benefit/cost analyses stop with this measure, the area under the supply function also has implications. Specifically, in Figure 1 the area $acq_2'q_2$ implies additional payments to factors of production. These factors of production include payments to labor.

Figure 2 depicts the effect of the enhanced value chain for natural products on the villages labor market. The shift in net demand curve from D_2 to $\tilde{D}_2$ implies a shift in the marginal value product of labor for natural products from MVP_L^B to MVP_L^{B*}. This shift implies an increase in the wage rate at the village level and an increase in the relative amount of labor employed in the production of natural products such as baobab from L_0^B to L_1^B. At the same time, the increased wage rate reduces the labor used in the production of charcoal from L_0^C to L_1^C. Hence, the shift in employment shares can be used as target variables. An increase in the share of employment in natural products implies that Walu Nafaa is meeting its objectives.

Statistical Considerations of Measures

Each of the policy measures developed above have slightly different challenges, but all share the difficulty that they are quasi-experimental. The most common adjustment for this consideration is the use of difference-in-difference methods. For example, Moss, Oehmke, and Lyambabaje (2014a) use a difference-in-difference method to analyze the effect of SPREAD/PEARL on household expenditures in Rwanda. As a part of this analysis, they use the Integrated Household Living Conditions Survey (EICV – Enquete Integrale sur les

Conditions de Vie des Menages) data which is collected every five years (e.g., 2000, 2005, and 2010). The difference in difference methodology involves estimating two relationships

$$
\begin{aligned}
\Delta x_{it} &= \alpha_{01} + \alpha_{11} z_{it} + \varepsilon_{it}\; i \notin T \\
\Delta x_{jt} &= \alpha_{02} + \alpha_{21} z_{jt} + \varepsilon_{jt}\; j \in T
\end{aligned} \tag{10}
$$

where Δx_{it} and Δx_{jt} are changes in the levels of household expenditures, $i \notin T$ implies that i is not a member of the treatment group (i.e., the household would not benefit from SPREAD/PEARL) and $j \in T$ implies that the household was a member of the treatment group that benefited from SPREAD/PEARL. The statistical analysis then examines whether $\alpha_{11} \neq \alpha_{21}$ and/or $\alpha_{02} \geq \alpha_{01}$. This application would imply two observations on a single household. An alternative approach involves estimating the model with multiple dummy variables

$$
x_{it} = \tilde{\alpha}_0 + \tilde{\alpha}_1 D_{1t} + \tilde{\alpha}_2 D_{2i} + \tilde{\alpha}_3 z_{it} + \tilde{\alpha}_4 D_{1t} z_{it} + \tilde{\alpha}_5 D_{2i} z_{it} \tag{11}
$$

where D_{1t} is a dummy variable that is 1 if $t = 1$ and 0 if $t = 0$, D_{2i} is a dummy variable which is a 1 if $i \in T$ and 0 if $i \notin T$, and the remaining variables remain unchanged. In this specification, $\tilde{\alpha}_2$ is the treatment effect – if $\tilde{\alpha}_2 > 0$ then coffee producers have benefited from SPREAD/PEARL through higher expenditures.

Other applications such as the estimation of the change in the poverty rate can be implemented using a modification of Equation 11. Specifically, Moss, Oehmke, and Lyambabaje (2014a) estimate the effect of SPREAD/PEARL on the incidence of poverty using a difference-in-difference specification of the standard Logit model. In the Logit specification, the dependent variable is a binary variable that takes on a value of 1 if the household is in poverty and a 0 otherwise. This probability of being in poverty is then parametrized using a Logit function

$$(12) \quad y_{it} \propto f(x_{it}, \beta) = \frac{\exp\left[z_{it}'\beta\right]}{1+\exp\left[z_{it}'\beta\right]}.$$

The difference-in-difference specification for this Logit without repeated observations then follows the linear specification in Equation 11.

Some alternatives to these difference-in-difference specifications are useful. Moss, Oehmke, and Lyambabaje (2014a) use a nonparametric Wilcoxin test (Conover 1980) to test whether the treatment and control group are drawn from the same population. They also apply an aggregate form of the Logit specification proposed by Zellner and Lee (1965) at the village level.

Along the lines of the nonparametric approach Moss, Mbaye, and Oehmke (2014a) propose an information approach to inequality for applications such as change in output resulting from investment in the value chain. Specifically, assume that different types of producers can be segregated into groups - $g = 1,2,3$ where group 1 is smallholders, group 2 are intermediate producers, and group 3 are larger commercial farmers. Before the investment in value chains, we assume that either the quantity of high valued output or value of high valued output sold can divided into shares for each group – s_1, s_2, s_3. The question is whether the investment changes this distribution. After the interaction, assume that I can compute the same values – $\tilde{s}_1, \tilde{s}_2, \tilde{s}_3$. The statistical information in the change in production can then be expressed as

$$(13) \quad I = s_1 \ln\left(\frac{s_1}{\tilde{s}_1}\right) + s_2 \ln\left(\frac{s_2}{\tilde{s}_2}\right) + s_3 \ln\left(\frac{s_3}{\tilde{s}_3}\right).$$

If there are no changes in the shares produced $I \to 0$. To define whether I is statistically different from zero Moss, Mbaye, and Oehmke (2014a) suggest jackknifing the original sample by dropping 1/3 of the population from each group. Preliminary evidence suggests that this approach is statistically more powerful than assuming that the shares are asymptot-

ically normal. This approach is similar to the Strobel measures for budget shares employed in Theil, Ching-Fan, and Seale (1989) to test the adequacy of the Florida Demand Model. Hence, the approach may be useful in testing whether the policy interventions affect the share of household expenditures on food.

Conclusions and Implications

Jan Tinbergen participated in the shift in economics from observer to participant in the policy process. In his work at the Dutch Central Planning Bureau, his research helped chart the course of a host of macroeconomic policy decisions. Relying on his discussion, Tinbergen provides an overview of the use of economics including the identification of policy needs and the estimation of the effectiveness of policy instruments. Using his terms, the economist assists by identifying target variables which are associated with concepts that policy makers are interested in. Next, economists identify policy variables and the useful relationships between these policy variables and policy targets. In the context of Feed the Future in Sub-Saharan Africa, our goals may be somewhat different. Our goal is to estimate whether policy interventions such as the investment in marketing channels or facilities to store outputs for seasonal consumption have reduced hunger or increased food security. This paper presents some traditional measures used for this analysis and suggests a couple of non-traditional measures that may provide additional insight. In addition, this manuscript examines some of the statistical issues surrounding these measures.

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Figures

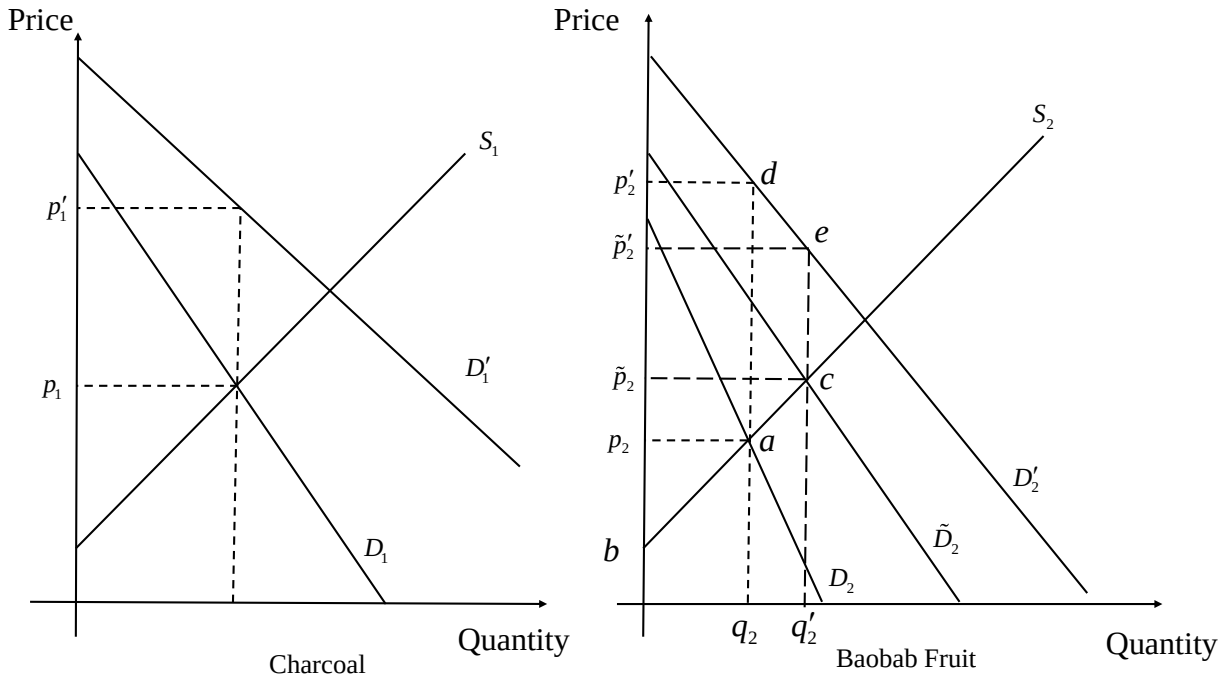

Figure 1. Effect of Value Added Program on Production

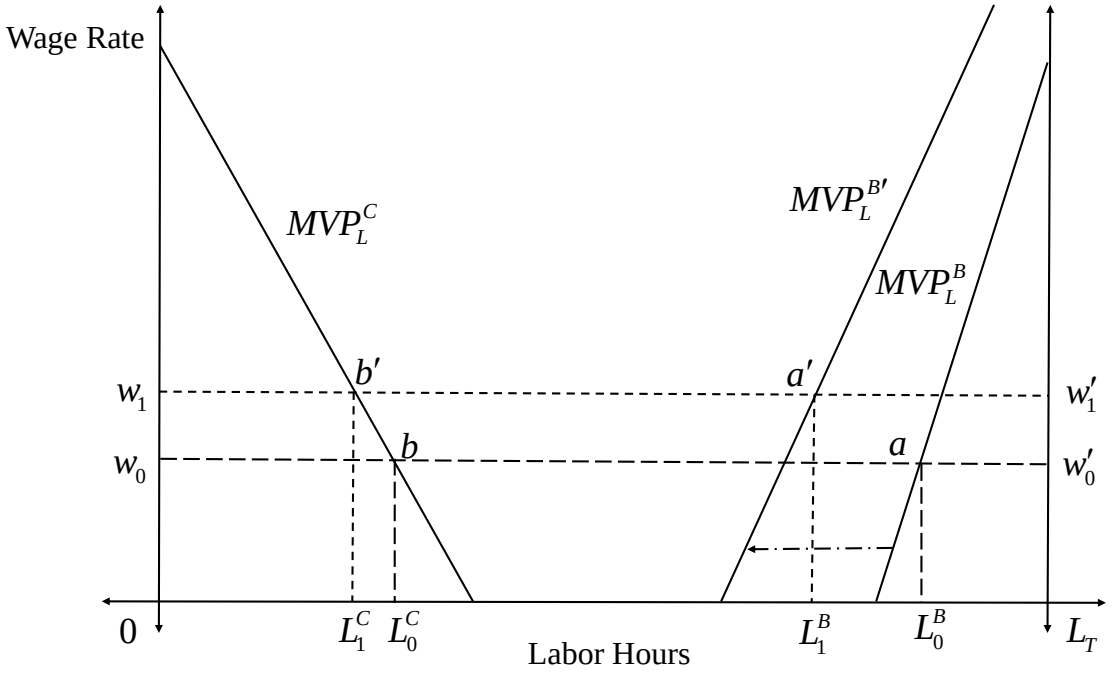

Figure 2. Effect on Village Household Income