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Economic Impact Assessment for Technology: The Case of Improved Soybean Varieties in Southwest Nigeria

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Abstract
The Study on economic impact assessment for the production of improved soybean varieties in Nigeria was carried out in Nigeria using the agronomic data on yield of the nationally coordinated soybean research from two major zones namely the southwest and the middle belt.
The study assesses the economic returns due to improved soybean varieties.
Primary data were collected with the use of structured and validated questionnaires. A sample of 288 respondents was drawn from four states namely Oyo, Ogun, Kwara and Niger State at 72 respondents per state.
Secondary data were collected from Agricultural Development Programme (ADP), International Institute for Tropical Agriculture (IITA), Institute of Agricultural Research and Training, (IAR & T), National Cereals Research Institute (NCRI), Central Bank of Nigeria CBN and Federal Office of Statistics (FOS).
An internal rate of return (IRR) of 38 percent was estimated from the stream of netted real social gains at 1985 constant.
The return to investment in soybean production technology is attractive and justifies the investments made on the technologies. The policy implication is that there is underinvestment in soybean production research.

Keywords: soybean, economic impact assessment, improved varieties, Nigeria

1 Introduction

Improvements in technology, driven by application of scientific research to practical problems are at the heart of economic growth and development. However, the economic value of public investment in research may not be obvious. It is particularly difficult to observe the impact of agricultural research, because the benefits are diffused over many years and to millions of dispersed producers and consumers.

Funds and resources allocated to agricultural research and development (R&D) are not available for use in other productive activities. Agricultural R&D therefore have a real cost to the society because of forgone alternatives. The economic aspect of the project evaluation requires a determination of the likelihood that the project contributes significantly to the development of the total economy and that its contribution significantly

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to the development of the total economy and that is contribution is great enough to justify the resources devoted. Economic studies are needed to measure those benefits, in order to compare them with cost of research and extension. This is with a view to come up with project cash flow on which investment appraisal method can be used to determine whether investment earns a rate of return which exceeds the interest rate or cost of borrowed funds. Soybean is a crop which has enjoyed investments in research and development in Nigeria because of the promise it has, being a highly proteins edible oil seed with the potential of reverting the protein-carbohydrate in balance in the diet of Nigerians. Further, is the importance of soybean utilization in live stock feed ration formulation because unlike groundnut cake, it does not pose the danger of aflatoxin. As far back as 1932, soybean has been in the cropping system in the area around Benue State. It is well adapted to the area because of the climate and edaphic factor of sandy soil. It was grown in mixture with other staple crops of sorghum, groundnut and maize. Maize is often grown in rotation with soybeans.

In 1947, an output of about 9 tonnes was produced on about 30 hectares of land in Benue area with an average yield of 300 kg per hectare. The variety planted was Malaya. By 1962, output has risen to 26,400 tones on about 70,212 hectare of land. What encourages increased hectare cultivation of the crop was the readily available external market for the commodity. The multinational companies of UAC and John Holt made the business to boom, and given the high demand output expansion was achieved through hectare expansion. With the outbreak of war in 1966, the export for soybean collapsed, and multinational companies' demand was dampened. The consequence of the war was that the output for the crop decreased over the years due to lack of marketing outlet. 1977 put the national soybean output, put at the low ebb of 258 tonnes on 686 hectares land. For a long time after the civil war, national output was on the decline and reached a mark of zero in 1978. In 1980, there was a turn around in the crop when at Mokwa, a Dutch scientist; Van Eighteen released a variety that was put into field trial in many locations. This resulted in the release of many lines. Many varieties of the crop were introduced to the farmers after the initial effort. With feed back from farmers to scientists, research was conducted into promising lines and increases in the yield of the crop on the field were observed. Researchers have released many improved varieties, which have higher yields than Malayan variety. Among these are TGx 344, SAMSOY2, TGx 306-036c, TGx 536- 02D, TGx 849-31, TGx 1019-2EN, TGx 923-2E 1448-2E, TGx 1440-IE, Tx1485-ID. Presently the Malayan variety no longer exists. Research effort on them however led to the release of other varieties, which have higher yield, better resistance to pests and better adaptability to location. This study proposes to undertake the economic impact of the research project that led to the production of the improved soybean varieties in Nigeria.

2 Analytical Technique

Economic impact assessment of research can be done through four approaches of

(1) indicator,

(2) econometric,

(3) programming and

(4) economic surplus

This study will adopt the economic surplus approach given its relative simplicity and lower demand for data. This impact assessment of soybean research proposed in this study is an expose assessment since the varieties are already on the field, at varying levels of adoption by the farmers.

3 Methodology

The data needed to calculate social gains fall into four broad categories namely:

(1) Market data on observed prices and quantities

(2) Agronomic evidence and costs of the technology being adopted

(3) Economic parameters on the market response to change (elasticity of supply and demand ϵ and e)

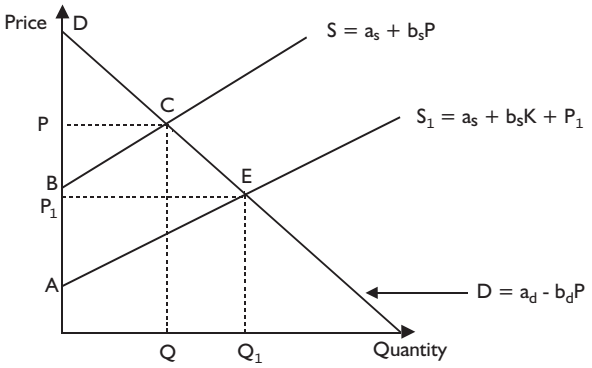
(4) Research and extension costs incurred in obtaining the new technology.

The most fundamental data required for the impact assessments are the Price (P) and quantity (Q) of the soybeans that is affected by technology change. Data for price were obtained from CBN publication. Data on quantity of soybean output over the years were source from the national statistics of CBN. For ex-post studies that use past prices, it is usually necessary to deflate them in order to remove the effects of inflation by dividing the observed prices by consumer price index (CPI). The base period used is 1985 with $CPI = 1.0$. Therefore all observed prices were transferred into real price at 1985 values. Agronomic data on yield gains and adoption costs were procured from field trials and farm surveys. The field trials were conducted at IAR&T, Moor Plantation and out stations. Information on adoption rates came from a combination of farm surveys and extension workers estimates.
Adoption rate (t) defined as the ratio of area on improved variety to total area to the crop in the area was found and it served as input in economic impact assessment determination. Information on adoption costs, which include value of labour, capital inputs provided by the respondent households as well as purchased inputs such as fertilizers, seeds and chemical required to obtain the yield increased associated with the new technology were procured from the surveyed households.

4 Theoretical Framework

An important step in economic impact assessment of technology development and promotion is the measurement of total social gain. In this study, this is done using economic surplus approach. The rational, are the technology adoption results in a rightward shift of supply curve from S to S_1. On the condition that a constant demand curve (D) prevails, this results in a new equilibrium with lower price P_1 and an increased quantity Q_1 demanded for the commodity (Figure 1). Without the technology, the surplus represented by area ABCE would not have arisen. Economic qualification of the area measures the social gain arising from the technology adoption. Economic impact assessment is based on estimating the magnitude of cost reductions given the observed

Figure 1: An ex-post economic impact assessment.



level of output and then making an adjustment for the change in quantity associated with the change in price.

The social gains (SG) as estimated by AHMED *et al.* (1995) and DALTON (1997) is given by

$$SG = kPQ - \frac{1}{2}kP\Delta Q \tag{1}$$

where Q is the observed quantity produced of the commodity, ΔQ is the change in quantity caused by the technology and k is the vertical shift in supply.
Deduction of research and extension costs from social gains in a year would produce the net social gain for the year. Armed with suitable computer software programmes of spread sheet like Excel or Lotus 1-2-3, the internal rate of return (IRR) on investments in the technology can be estimated from the flow of net social gains over years.

From the equation of social gain (1), P and Q are observable through a census of agriculture or can be estimated from statistics published by the Central Bank of Nigeria (CBN) or Federal Office of Statistics (FOS). The unknown variables, which must be estimated, are K and ΔQ. In order to calculate K and ΔQ we need first to estimate the parameters J, I and k which represent:
J: the total increase of production caused by adopting the new technology (J),
I: the increase in per-unit input costs required to obtain the given production increase (J) and
k: the net reduction in production cost induced by the new technology (i.e. the vertical shift in the supply curve).
These are not directly observable but can be estimated in terms of research results of yield increases (ΔY), adoption costs (ΔC), adoption rates (t), total hectarage planted to the crop (A), total production (Q) and the overall average yield ($Y = Q/A$).

According to AHMED *et al.* (1995), the J-parameter is the total increase in production that would be caused by adopting the new technology in the absence of any change

costs or price and is given as

$$J = \Delta Y * t * A \tag{2}$$

Computing J-parameter in proportional terms, as the increase in quantity produced as a share of total quantity, we have

$$j = \frac{J}{Q} \tag{3}$$

This transformation permits us to estimate the supply shift parameter (j) in terms of the yield gains, adoption rates and the overall average yield level (Y) i.e.

$$j = \frac{\Delta Y * t}{Y} \tag{4}$$

It is important to note that this is valid only if Y is defined as the overall average yield $Y = Q/A$.

The I-parameter is the increase in per-unit input cost required obtaining the production increase J. It is therefore given as: $I = \Delta C * t/Y$.
Expressing I in proportional terms as a share of the product price P, the proportional cost increase parameter (c) is

$$c = \frac{I}{P} = \frac{\Delta C * t}{Y * P} \tag{5}$$

The K-parameter is the net reduction in production costs induced by the technology and can be obtained from combining the effects of increased productivity (J) and adoption costs (I). It corresponds to a vertical shift in the supply curve. Given J and I, it can be computed using the slope of the supply curve (b_s) as $K = (J * b_s) - I$
As the slopes of the suply curves (b_s) are associated with units of measurement, preference is for the use of the supply elasticity (ϵ) which is independent of units of measurement:

$$K = \frac{J}{\epsilon * Q/P} - I = \frac{J * P}{\epsilon * Q} - I \tag{6}$$

Using proportional terms i.e. the net-reduction in production cost as a proportion of the production price results in:

$$k = \frac{K}{P} = \frac{J * P}{\epsilon * Q * P} - \frac{I}{P} = \frac{j}{\epsilon} - c \tag{7}$$

The change in quantity (ΔQ) actually caused by technology depends on the shift in supply and the responsiveness of supply and demand. The equilibrium situation without technology would be that price and quantity, which satisfy both, demand and supply:

$$\begin{aligned} Q_d &= Q_s \\ a_d + b_d P &= a_s + b_s P \\ P &= \frac{a_s - a_d}{b_d - b_s} \end{aligned} \tag{8}$$

With the adoption of new technology, the equilibrium must be on a new supply curve, which is shifted in the direction of a price increase:

$$\begin{aligned} Q_d &= Q_s \\ a_d + b_d P_1 &= a_s + b_s K + b_s P_1 \\ P_1 &= \frac{a_s - a_d + b_s K}{b_d - b_s} \end{aligned} \tag{9}$$

The resulting change in price is:

$$\Delta P = \frac{-b_s * K}{b_d - b_s} = \frac{b_s * K}{b_s - b_d} \tag{10}$$

And hence change in quantity is

$$\Delta Q = b_d * \Delta P = \frac{b_d * b_s * K}{b_s - b_d} \tag{11}$$

To substitute elasticities for slopes, assume elasticity of demand is e, then

$$e = \frac{\%\Delta Q}{\%\Delta P} = \frac{\Delta Q/Q}{\Delta P/P} = \frac{\Delta Q}{\Delta P}\frac{P}{Q} = b_d \frac{P}{Q} \Rightarrow b_d = e\frac{Q}{P} \tag{12}$$

Thus

$$\begin{aligned} \Delta Q &= \frac{e * Q}{P} * \frac{\epsilon * Q}{P} * \frac{K}{(e * Q/P) + (\epsilon * Q/P)} \\ \Delta Q &= \frac{e * \epsilon * K \frac{Q^2}{P^2}}{(e+\epsilon) * \frac{Q}{P}} = \frac{e * \epsilon * K * Q}{(e+\epsilon) * P} \end{aligned} \tag{13}$$

In proportional terms, this simplifies to:

$$\Delta Q = \frac{Q * e * \epsilon * k}{e + \epsilon} \tag{14}$$

The social gain as given earlier (1): $SG = kPQ \pm \frac{1}{2}kP\Delta Q$
therefore becomes

$$SG = kPQ \pm \frac{1}{2}kP\frac{Qe\epsilon k}{e+\epsilon} = kPQ \pm \frac{1}{2}k^2 PQ\frac{e\epsilon}{e+\epsilon} \tag{15}$$

Since k, P, Q, e, and ϵ can be estimated or observed, the social gain from the technology adoption can be calculated. Deduction of research and extension costs from social gain over the years will produce the flow of net social gain, which should be expressed in constant value, and the internal rate of return can be estimated from cash flow.

5 Results [2]

The period under consideration for this study was from 1975 to 1999. Hectares cultivated to soybean varieties ranged between 4,080 and 195,000 hectares. The output in metric tonnes ranged between 1,544 and 304,600 – the soybean price was ₦66/tonne in 1975 and increased to ₦45,000/tonne in 1999.

The adoption rate of these varieties increased from 4 percent in 1990 to 14 percent in 1999.

Real adoption cost for the improved varieties ranged between ₦66 in 1975 and ₦45,000 in 1999.

The real social returns from the improved soybean varieties ranged between ₦230,791 in 1982 and ₦1,360 mio. in 1999 while the net real social gain was between ₦1,366,575 (m) in 1979 and ₦332 mio. in 1999. From the stream of the net gains, an internal rate of return (IRR) of 38% was estimated for the investment that produced the technology.

The pay off to investment that produced soybean varieties of 38% can be said to be attractive because the return is above the prevailing interest rate during the same period.

The policy implication of the finding is that there is under investment in soybean production (varieties) research, Invitation from donors to invest in soybean research in Nigeria.

6 Conclusion

Considering the result of internal rate of returns of 38 percent observed from the streams of net returns from research that produced soybean varieties in Nigeria between the year 1975 and 1999, the pay-off to soybean production investment is attractive during the period, it's well above the average interest rate of 15 percent during the periods. There is justification for the investment on soybean variety research.

The policy implication is that technology is a veritable tool for poverty avoidance and alleviation bearing in mind the vital role soybean plays in the economy. On the basis of field experience in this study such technology as the case of soybean varietal development should further be encouraged such that ecological settings of the beneficiaries are strongly taking into consideration.

It is therefore vital that more funds should be allocated to soybean research in Nigeria.

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