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RESEARCH PAPER

Impact assessment of an agricultural technology using economic surplus model : A case of redgram variety (BRG-1) in Karnataka

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Abstract : Impact assessments significantly differ from monitoring and evaluation. It is essential to demonstrate the success of research outcomes and to understand how research efforts are impact the local communities and thereby accountability to the stakeholders. Economic surplus model is one of the most commonly used methods to assess the economic impact of a technology because of its simplicity and less data requirement. It measures the total economic benefits generated out of a new technology. It is possible to estimate the return to investment by calculating a variation of consumer and producer surplus through a technological change induced by research. The study on economic impact assessment of a technology using economic surplus model for the high yielding variety of Redgram (BRG-1) was carried out in Karnataka in the year 2016. Impact assessment of a technology involves measurement of potential economic benefits generated by the use of new technology. Study uses the agronomic data on yield, production levels, cost of adoption and adoption rate of high yielding variety and farm harvest prices to assess the impact. Net social gain realized out of new variety was Rs. 141 crores. Change in consumer surplus was Rs.106 crores and change in producer surplus was Rs. 35 crores. The internal rate of return was 66 per cent with net present value of Rs. 67 crores from the stream of net social gains at 2011-12 prices. The study on economic impact assessment of a technology using economic surplus model for the high yielding variety of redgram (BRG-1) was carried out in Karnataka in the year 2016. Impact assessment of a technology involves measurement of potential economic benefits generated by the use of new technology. Study uses the agronomic data on yield, production levels, cost of adoption and adoption rate of high yielding variety and farm harvest prices to assess the impact. Net social gain realized out of new variety was Rs. 141 crores. Change in consumer surplus was Rs.106 crores and change in producer surplus was Rs. 35 crores. The internal rate of return was 66 per cent with net present value of Rs. 67 crores from the stream of net social gains at 2011-12 prices.

Key Words : Economic impact assessment, Economic surplus, High yielding variety

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INTRODUCTION

Resources for agricultural research are scarce. Therefore, efficient resource allocation and necessity to justify their use to the society require the assessment of economic impacts of research. Without the economic analysis, it would be hard to know the social value of scientific knowledge and technologies and to make judgments about the trade-offs in the allocation of scarce resources in research (Alston *et al.*, 1998). Impact assessment is very important in understanding the nature of the change and its significance to the stakeholders, and quantifying potential economic benefits generated out of new technology. Investment in technology development by the application of sound scientific knowledge plays a crucial role in increasing production, productivity levels thereby improves farmer's welfare.

Economic impact assessment of a technology can be done before the release of technology *i.e.*, Ex-ante analysis, forms the basis for allocation of resources among competiting research projects and to assess the potential economic benefits of a new technology or research investments. Ex-post analysis can be done after release of technology to assess the economic benefits generated out of the project or technology.

Change indicators or dimensions of change in impact assessment are as follows :

Economic impact assessment of agricultural technology mainly concentrates on the following change indicators,

– Yield change due to new technology
– Production change
– Price changes
– Change in cost of cultivation
– Consumer surplus
– Producer surplus
– Economic surplus
– Net present value (NPV)
– Internal rate of return (IRR)

Analytical framework :

The more common methods of economic impact assessment belongs to three main groups (Masters, 1996).

– Econometric methods
– Programming methods
– Economic surplus method

The econometric methods aim to estimate a marginal productivity of research over a long time period (Masters, 1996). Thus, the econometric models use production function, cost function or an analysis of total productivity of factors to estimate a change in productivity due to investment in research (Maredia *et al.,* 2000). The programming methods try to identify one or more optimal technologies or research activities from a set of options. Thus, these methods try to maximize one objective, *i.e.* farmers' profit subjected to constraints like availability of land, labour and other inputs. The economic surplus method is used to measure the total economic benefits of a technology or a research project. It is possible to estimate the return to investment by calculating a variation of consumer and producer surplus through a technological change originated by research. Afterwards, the economic surplus is utilized together with the research costs to calculate the net present value (NPV), the internal rate of return (IRR) (Maredia *et al.,* 2000).

Redgram is an important pulse crop. It is largly cultivated in trophics and subtrophical countries of the world. It is also known as Tur, Arhar, and pigeonpea. Redgram is a rich source of protein and it contains 20 per cent of the protein which is a chief source of dietary protein. India ranks first in the world redgram production and consumption. In India, it is largely grown in Maharashtra, Karnataka, Uttar Pradesh, Gujarat and Andhra Pradesh. Karnataka is one of the major producers of redgram in India, cultivating redgram in an area of 7.66 lakh ha with a production of 3.5 lakh tones and a yield of 482 kg/ha. Bangalore redgram-1 (BRG) is an improved high yielding variety of redgram developed by the team of scientists working in UAS, Bangalore in the year 2001. It is a short duration variety matures at 120-140 days, cultivated for both vegetable and dal purpose in the southern parts of Karnataka. Towards this endeavor, the estimation of economic efficiency of technologies released and economic benefits due to the new technologies (varieties) in redgram is attempted with the following specific objective:

– Estimation of economic surplus (social gain) due to varietal development in redgram.

Hypotheses :

The following hypotheses were proposed

– The improved variety released are economically efficient than check varieties

– Substantial social gains are generated due to adoption of improved variety in redgram

MATERIAL AND METHODS

Present impact assessment study specifically uses the economic surplus model because of its simplicity and demanding less data requirement. Impact assessment of redgram variety is an ex-post analysis since the varieties are already in the field at the varying levels of adoption by the farmers. Additionally, it can produce useful and effective outputs in showing the benefits generated by agricultural research. Data requirement for calculating economic benefits of a technology or net social gains are as follows.

– Output/production
– Farm harvest prices
– Cost of cultivation
– Cost of adoption
– Elasticity of supply
– Elasticity of demand
– Research and extension cost
– Adoption rate

Data for farm harvest prices and output were taken from annual reports of Directorate of Economics and Statistics (DES), Karnataka. The ex-post studies that use past prices, it is necessary to deflate them in order remove the inflationary pressures by dividing observed prices by the wholesale prices index (WPI). The base period used was 2011-12 with wholesale price index 1. Therefore, all observed prices were transferred into real prices at 2011-12 values. Data on yield change and cost of adoptions were collected from sample farmers cultivating check variety (TTB-7) and improved variety (BRG-1). Information on adoption rate came from combination of farm surveys, research and extension worker estimates. Rate of adoption was defined as the ratio of area under improved variety to the total area of the crop in the area. Data on research and extension costs incurred by the University of Agricultural Sciences, GKVK, Bangalore in the release of BRG-1 variety of red gram was collected from concerned scientist. Economic parameters like price elasticity of demand and price elasticity of supply for a commodity were obtained from Rosegrant (2012).

Theoretical framework (Ogunsumi *et al.*, 2007) :

An important step in economic impact assessment of a technology is the measurement of social gain. In this study, this is done by using economic surplus model. The rational, are the technology adoption results in a rightward shift of supply curve from S_0 to S_1. On the condition that a constant demand curve (*D*) prevails, this result in a new equilibrium with lower price P_1 and an increased quantity Q_1 demanded for the commodity (Fig. 1). Without the technology, the surplus represented by area 'abcd' would not have arisen.

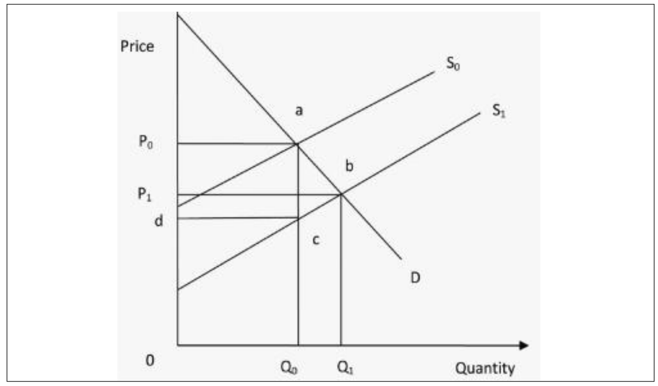

Fig. 1 : Impact of new technology on economic surplus (Alston *et al.*, 1995)

Economic impact assessment is based on estimating the magnitude of cost reductions given the observed level of output and then making an adjustment for the change in quantity associated with change in price.

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

$$SG = kPQ - \frac{1}{2} k PaQ \qquad (1)$$

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, net present value and (NPV) and 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 observed through a census of agriculture or can be estimated from secondary data. The unknown variables which must be estimated are k and ΔQ. In order to calculate k and ΔQ we need first to estimate 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 increase (ΔY), adoption costs (C), adoption rates (t), total hectare 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,

$$J = aY * t * A \quad (2)$$

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

$$j = \frac{J}{Q} \quad (3)$$

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.*

$$j = \frac{\Delta Y * t}{Y} \quad (4)$$

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

I-parameter is the increase in per-unit input cost required obtaining the production increase J. It is, therefore, given as: $I = \Delta C * \frac{t}{Y}$

Expressing I in proportional terms as a share of the product price P, the proportional cost increase parameter (c) is,

$$c = \frac{1}{P} = \frac{\Delta C * t}{Y * P} \quad (5)$$

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 supply 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:

$$K = \frac{J}{\in * \frac{Q}{P}} - I = \frac{J * P}{\in * Q} - I \quad (6)$$

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

$$K = \frac{K}{P} = \frac{J * P}{\in * Q * P} - \frac{I}{P} = \frac{j}{\in} - c \quad (7)$$

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:

$$Q_d = Q_s \quad (8)$$

$$a_d + b_d P = a_s + b_s P$$

$$P = \frac{as - ad}{bd - bs}$$

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:

$$Q_d = Q_s \quad (9)$$

$$c + b_d P_1 = a_s + b_s K + b_s P_1$$

$$P_1 = \frac{as - ad + bsK}{bd - bs}$$

The resulting change in price is:

$$\Delta P = \frac{-bs * K}{bd - bs} = \frac{bs * K}{bs - bd} \quad (10)$$

And hence change in quantity is,

$$\Delta Q = bd * P = \frac{bd * bs * K}{bs - bd} \quad (11)$$

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

$$e = \frac{\%\Delta Q}{\%\Delta P} = \frac{\frac{\Delta Q}{Q}}{\frac{\Delta P}{P}} = \frac{\Delta Q}{\Delta P}\frac{P}{Q} = bd\frac{P}{Q} => > bd = e\frac{Q}{P} \quad (12)$$

Thus,

$$\Delta Q = \frac{e * Q}{P} = \frac{\in * Q}{P} * \frac{K}{\left(e * \frac{Q}{P}\right) + \left(\in * \frac{Q}{P}\right)} \quad (13)$$

$$\Delta Q = \frac{e * \in * K \frac{Q^2}{P^2}}{(e + \in) * \frac{Q}{P}} = \frac{e * \in * K * k}{(e + \in) * P}$$

In proportional terms, this simplifies to:

$$\Delta Q = \frac{Q * e * \in * k}{e + \in} \quad (14)$$

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

Therefore, becomes,

$$SG = kPQ \pm \frac{1}{2} kP \frac{Qe \in k}{e + \in} = kPQ \pm \frac{1}{2k} k^2 PQ \frac{e \in}{e + \in} \quad (15)$$

Since k, P, Q, e and ∈ 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.

Results and Discussion

The period considered for this study was 1995 to

2012. Redgram varieties cultivated in the state has increased from 4.23 lakh ha to 7.66 lakh ha. Production of redgram (output) ranged between 2.01 lakh tones to 3.50 lakh tones during this period. The farm harvest price of redgram ranged from Rs. 1539 per quintal to Rs. 3604 per quintal. The adoption rates increased from one per cent in 2001 to 24 per cent in 2011-12. Adoption cost of new variety ranged between Rs. 792 in 2001-02 and Rs. 720 in 2011-12.

Table 1 : Potential economic benefits of a new variety (BRG-1): Economic surplus model

Sr. No.	Particulars	Values
1.	Elasticity of supply	0.45
2.	Elasticity of demand	0.15
3.	Adoption cost (Rs./ha)	674
4.	Yield change (Q/ha)	2.88
5.	Net present value (Rs. in crore)	67
6.	Internal rate of return (%)	66
7.	Change in consumer surplus (Rs. in crore)	106
8.	Change in producer surplus (Rs. in crore)	35
9.	Change in economic surplus (Rs. in crore)	141

The net social gains from improved redgram variety ranged from Rs. 68.69 laks in 2001 and Rs. 141 crores in 2012. Change in consumer surplus was Rs.106 crores and change in producer surplus was Rs. 35 crores. From the stream of the net social gains, net present value of research investment was Rs. 67 crores. An internal rate of return (IRR) 66 % was observed for the investment that produced the new variety.

Conclusion :

Considering the results of net present value Rs. 67 crore and internal rate of return 66 per cent and economic surplus was Rs. 141 crores observed from the net social gains out of research investment that produced redgram variety in Karnataka between the periods from 1995 to 2012, the research investment for producing redgram variety is justified during above period.

Policy recommendation:

Technology is an important instrument in increasing agricultural productivity. It has synergistic effect on alleviating poverty levels and making hunger free. Public investment on agriculture research interms of varietal development leads to significant increase in production and yield levels thereby increases the total economic surplus of the economy. Further public investment on agriculture research should be increased to see the hunger free, nutritional and prosperity in the economy.

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