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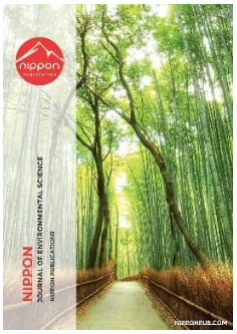

Full Length Research Paper

The economic impact of onion research and extension in Bangladesh: an ex-post analysis

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Abstract. The study estimated the benefit and rates of returns to investment on onion research and development in Bangladesh. The Economic Surplus Model with ex-post analysis was used to determine the returns to investment and their distribution between the production and consumption. Several discounting techniques were also used to assess the efficiency of onion research. The adoption rate was found increasing trend over the period. The yield of BARI Developed Modern varieties of onion was 67 to 80% higher than those of the local variety. Society got net benefit Tk 36356.64 million from the investment of onion research and extension. The internal rate of return (IRR), net present value (NPV) and benefit cost ratio (BCR) were estimated to be 82%, Tk 6536.86 million and 23.99 respectively. The results of sensitivity analysis indicated that investment in research and development of onion was a good investment.

Keywords: Onion, economic impact**,** adoption, yield advantage, benefit and rate of return

1. INTRODUCTION

Onion is one of the important spices crops in Bangladesh. It is widely used as spice in all curries and for many other cooking purposes. It adds flavour of distinctive pungent and has medicinal values also. Bangladesh requires about 1.46 million tons of onion per year, but it produces only 0.89 million tons and the rest of the onion are imported mainly from neighbouring countries spending worth of Tk 2122 million per year (BBS, 2012). This shortage is mainly due to low yield and seasonality of onion production. The yield of onion is very low in Bangladesh as compared to the world average productivity due to the lack of improved variety and poor cultural practices done by the farmers. Its higher demand, scarcity and higher price sometimes create political unrest in the country.

Realizing the importance of onion, Bangladesh government established Spices Research Centre (SRC) in 1994 under Bangladesh Agricultural Research Institute (BARI) for increasing the production of onion throughout the country. SRC has been working on spices research and development since 1995/96. It has already released five number of improved onion varieties namely BARI *Piaz* 1, 2, 3, 4 and 5. These varieties are cultivated in the farmers' fields since the release of these varieties. These varieties are produced and consumed within the country. BARI, BARC (Bangladesh Agricultural Research Council) and DAE (Directorate of Agricultural Extension), to some extent have strengthened their works to onion production.

However, for the research work of onion and its extension, the contribution of BARC and DAE are greatly associated with BARI.

The present analysis thus took into the benefits from past onion research and its farm level extension in the country. However, this study provided information for the policy makers, donors, researchers, extension people and the public on the contribution and the rate of return to investment in onion research in Bangladesh.

2. METHODOLOGY

2.1. Sources of data

For the present study, data were collected from different sources like published and unpublished reports, and informal scientist's interview. The area, production, and yield of BDMVs (BARI Developed Modern Varieties) of

onion were collected from SRC (Spices Research Centre); adoption rates were collected through informal scientist's interview; and harvest price and consumer price index (CPI) were collected from various issues of Statistical Yearbooks (1988-2009) published by the Bangladesh Bureau of Statistics. The supply elasticity was taken from the study conducted by Day and Norton, 1993. Since SRC of BARI is the main organization for onion research, the research cost included mainly from SRC of BARI. The extension and promotion activities were done by DAE and the related costs were collected from this organization. BARC mainly provided the administrative costs. The on-farm yield data of BDMVs onion varieties were collected from the SRC, Bogura. Data on the input cost change was calculated by the researcher through analyzing increased production claimed higher labour costs for harvesting and transporting, expensive of seeds, and used slightly more fertilizers per hectare for improved variety than for traditional varieties.

2.2. Analytical Procedure

The collected data were analyzed using the following statistical techniques.

2.3. Estimation of returns to investment

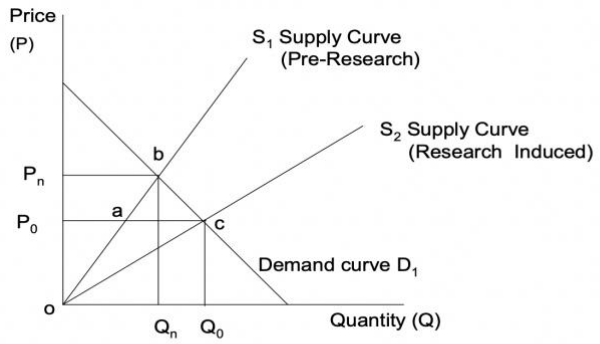
The Economic Surplus Model (ESM) with Ex-Post analysis was used to estimate the rate of returns to investment in onion research and extension. The analysis was done under small open-economy market situation. The theoretical concept of ESM has been illustrated below.

2.4. Theoretical concept of Economic Surplus Model (ESM)

The concept of economic surplus was used to measure economic welfare and the changes in economic welfare from policy and other interventions (Alston et al., 1995, Currie et al., 1971). Usually the economic surplus concept is adopted to estimate the benefits from the adoption of improved varieties. The components of economic surplus are consumer surplus and producer surplus. Given the initial condition (i.e., pre-research supply curve S_1 and demand curve D_1), consumer surplus is depicted as Area P_oP_nb in Figure 1. This is the surplus or benefit to consumers because of a functioning market. Consumer surplus is that area beneath the demand curve less the cost of consumption. The cost of consumption is the area below the price line P_n. Producer surplus is defined by area P_nbO in Figure 1. Area P_nbO in the surplus left to the farmers after they have paid for the total costs of production, area ObQ_n (Alston et al., 1995).

The adoption of an intervention by farmers, such as an improved variety usually means one of two things: (i) A farmer can supply more of the commodity using the same level of resources (i.e, same land area and other inputs), or (ii). A farmer can supply the same level of commodity output but do it with fewer resources.

In either case, this is depicted by a shift to the right of the supply curve as shown in Figure 1 (the shift is from S_1 to S_2). The shift is the supply curve from the adoption of an intervention changes the initial equilibrium price and quantity of the commodity. This new price quantity equilibrium increases economic surplus. The change in economic surplus (economic benefits) is measured by comparing the difference in economic surplus between the pre-adoption period and the post-adoption period.



Change in Consumer Surplus = Area abc + Area P_nbaP_o
Change in Producer Surplus = Area Oac-Area P_nbaP_o
Change in Total Economic Surplus = Area abc+ Area Oac

Figure 1: Economic Surplus Model (Closed Economy)

Given a shift in the supply curve S_1 to S_2, the change in consumer surplus is depicted in Figure 1 as Area abc + Area P_nbaP_0. The shift in the supply curve (due to the adoption of an intervention) has decreased the price consumers now have to pay for the commodity.

Given a shift in the supply curve S_1 to S_2, the change in producer surplus is depicted in Figure1 as Area Oac-Area P_nbaP_0. Area Oac represents the decrease in the cost of production the same unit of the commodity that farmers now enjoy because they are using the intervention. This represents the benefits to the farmers from adopting the intervention and can be measured and quantified in monetary terms. The adoption of the intervention, however, has increased the quantity produced thereby decreasing the price of the commodity (P_n to P_0 in Figure 1) and is a loss to farmers income. Farmers can recover some of this loss since they can sell more quantity (Q_n to Q_0 in Figure 1) of the commodity.

The total social benefits to society from the adoption of an intervention is the summation of the change in consumer surplus plus the change in producer surplus (Area abc + Area Oac) minus the input cost change from adopting the new interventions.

For a closed economy model, the estimated price elasticity of demand is used in the above formulas. For small open-economy model where the elasticity of demand is perfectly elastic, use a sufficiently large number of η (Nagy et al., 2000). A small open economy market is one where the amount of exports or imports is small relative to total world trade in the commodity. Thus, there is little or no effect on the world price of the commodity (the small country assumption). In this case, the price of commodity does not change with the shift in the supply curve. For this study, the Bangladesh onion market is modeled as a small open economy market.

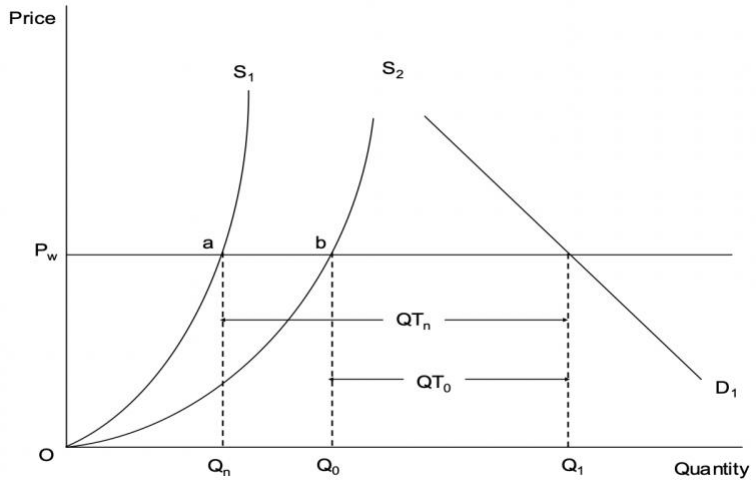


Figure 2: Small Open-economy Importer Economic Surplus Model

The change in economic surplus for a small open-economy that is domestically produced but allows imports to cover shortfall (i.e., the Bangladesh spices market) is depicted Figure 2. The world price P_w and quantity demanded by Bangladeshi consumers Q_1 defines the initial equilibrium. At price P_w, producers supply Q_n amount of spices when faced by the pre-research supply curve S_1. Spices imports are equal to QT_n. When faced by the research induced supply curve S_2 (the supply curve that exist because farmers have adopted new high yielding varieties). Spices producers increased production to quantity Q_n, and increase Q_nQ_0. Spices imports are decreased by the same amount as the increase in production Q_nQ_0 and are now at QT_0. Since P_w does not change (small economy assumption), there is no change in consumer surplus- consumers are neither better off nor worse off. The enter change in economic surplus from the adoption of new spices varieties is thus a change in producer surplus only and is identified by area Oab in Figure 2 (corresponds to area oac in Figure 1). The amount of foreign exchange saved by the adoption of improved varieties is equal to P_w x (Q_nQ_0).

2.5. Empirical approach

The Akino and Hayami (1975) approximation formulas for calculating changes to producer and consumer economic surplus are described below and these are used in this study. The Akino and Hayami (1975) approximation formulas for calculating the change in economic surplus for a closed economy analysis (Figure 1) is as follows:

$$\text{Area A (abc)} = 0.5\, P_oQ_o\,((k(1+\gamma))^2/(\gamma+\eta)) \quad (1)$$

$$\text{Area B (Oac)} = kP_oQ_o \quad (2)$$

$$\text{Area C } (P_nbaP_o) = ((P_oQ_ok\,(1+\gamma))/(\gamma+\eta)) \text{ x } (1-((0.5k(1+\gamma)\,\eta)/(\gamma+\eta))-0.5k\,(1+\gamma)) \quad (3)$$

Where,

P_o = Price of onion (Tk/ton) (Existing market price)
Q_o = Production of BDMVs onion (ton) (Existing production)
P_n = Quantity price that would exist in absence of research
Q_n = Quantity of the onion produced that would exist in absence of research
k = Horizontal supply shifter
γ = Price elasticity of onion supply
η = Absolute price elasticity of the demand for the commodity.

2.6. The supply shifter (k)

The supply shifter 'k' is the overall yield advantage of improved varieties of onion over the local variety weighed by the area sown to the improved varieties of onion. In the case of the Akino and Hayami (1975) approximation formulas, k is the horizontal shift from the equilibrium price P_n given S_1 to the equilibrium price P_o given S_2 which corresponds to a distance equal to Q_nQ_o in Figure 1 (Gardener et al., 1986; Nagy and Furtan, 1978). The supply shifter k is calculated as follows:

$$k_t = \sum_{i=1}^{n} [1 - \frac{Y_t}{Y_{it}})] \times A_{it}$$

Where,
Yit = Yield of the improve varieties of onion in year t
Yt = The yield of a base (or average yield of local variety onion) that has been gown in the past and that would still be grown if no new varieties had been developed
Ait = The proportion of the total area sown to improved varieties of onion in year t
n = The number of improved onion varieties

2.7. Estimation of net present value (NPV)

The amount of total funds returned from the investment in research is called NPV. The NPV of the benefits was calculated by using the following formula:

$$NPV = \left[\sum_{i=1}^{n} (TSB_t - C_t)(1+r)^{-t} \right]$$

Where,
C_t = The cost of research and extension investment in year t
r = The discount rate
n = The time horizon over which the benefits of the research investments are realized

2.8. Internal rate of return (IRR)

The IRR was calculated relating to the total social benefit (TSB) minus an input cost change, if any, in each year to the research expenditure © in each year and is the discount rate that results in a zero net present value of the benefits. The IRR is calculated as

$$O = \left[\sum_{t=1}^{n} (TSB_t - C_t)(1+IRR)^{-t} \right]$$

The IRR can be defined as the rate of interest that makes the accumulated present value of the flow of costs equal to the discounted present value of the flow of returns, at a given point in time (Peterson, 1971).

3. RESULTS AND DISCUSSION

3.1. Adoption Status of BARI Developed Modern Varieties of Onion

The adoption of improved variety is very important factors by which the volume of change in economic surplus is determined. The more the adoption of improved varieties over traditional one, higher the change in surplus will be. Apart from this, it gives us feedback as to why and how well a technology is being accepted by the farmers. There was no onion varietal adoption survey conducted in Bangladesh. The existing variety survey information

along with the considerable field experience of the spices scientists is used to sketch out the percentage area sown by variety grouping which are presented in Table 1.

Table 1 presents the year wise area both in hectare and percentage coverage of BARI Developed Modern Varieties (BDMVs) over traditional varieties of onion in Bangladesh. BARI *Piaz*-1 was the most popular variety since 1995-96 and it replaced first to traditional variety of onion. The overall area coverage of BARI *Piaz*-1 increased from 1.88% in 1995-96 to 80.94% in 2007-08. BARI *Piaz*- 2 and 3 were released in 1999-2000. Due to non-availability of seed and complexity of seedling raising, area coverage of BARI *Piaz* 2 and 3 were not satisfactory and they covered only 0.51 and 0.58% of total onion growing area, respectively. BARI *Piaz* 4 and 5 were released in 2007-08 and they covered 0.32 and 0.004% respectively of the total onion growing area. Area covered by all BDMVs of onion occupies about 82.35% of the area sown to onion (Table 1).

The annual adoption rates were estimated to 7.05 % for BARI *Piaz* -1 (1995/96 to 2007/08), 0.06% for BARI *Piaz*-2 (1999/00 to 2007/08) and 0.07% for BARI *Piaz* -3 (1999/00 to 2007/08) as depicted from Table 2 and Figures 3, 4 and 5. The table also showed that the adoption rate of all BDMVs of onion was 7.14% (Table 2 and Figure 6).

Figure 3: Adoption trend of BARI *Piaz*-1

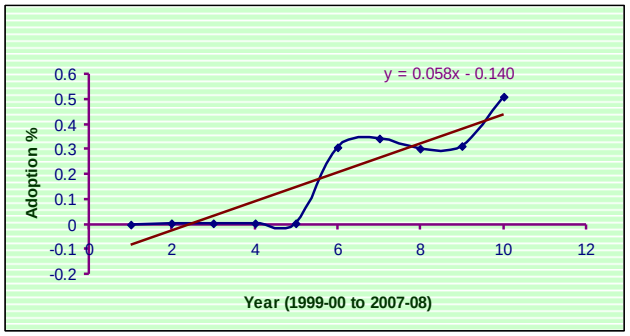


Figure 4: Adoption trend of BARI *Piaz*-2

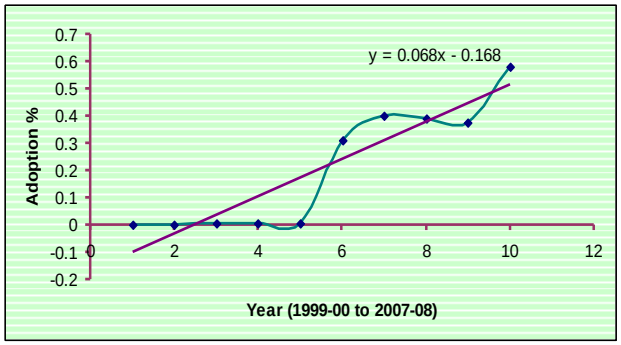


Figure 5: Adoption trend of BARI *Piaz*-3

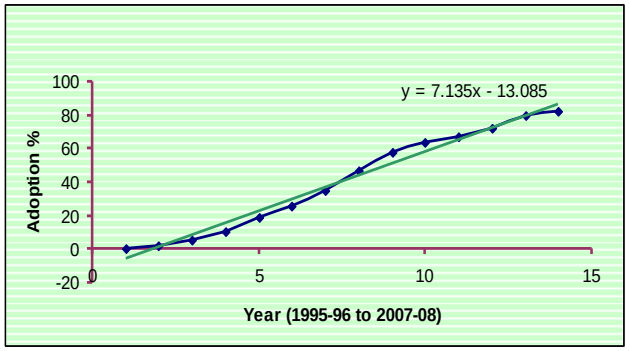


Figure 6: Adoption trend of BDMVs of onion

Table 1: Area of traditional variety replaced by BDMVs of onion

Year	Total onion area		Area of LVs		Area covered by BARI *Piaz*-1		Area covered by BARI *Piaz*-2		Area covered by BARI *Piaz*-3		Area covered by BARI *Piaz*-4		Area covered by BARI *Piaz*-5		Area covered by all BDMVs of onion	
	Hectare	%	Hectare	%	Hectare	%	Hectare	%	Hectare	%	Hectare	%	Hectare	%	Hectare	%
1990/91	34777	100	34777.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1991/92	34445	100	34445.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992/93	34206	100	34206.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993/94	34538	100	34538.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994/95	34180	100	34180.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995/96	34047	100	33406.92	98.12	640.08	1.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	640.08	1.88
1996/97	34421	100	32527.85	94.50	1893.16	5.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1893.16	5.50
1997/98	34468	100	30783.37	89.31	3684.63	10.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3684.63	10.69
1998/99	33259	100	26983.03	81.13	6275.97	18.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6275.97	18.87
1999/00	33858	100	25075.23	74.06	8782.77	25.94	0.68	0.002	0.68	0.002	0.00	0.00	0.00	0.00	8782.77	25.94
2000/01	34085	100	22271.14	65.34	11810.45	34.65	1.02	0.003	1.36	0.004	0.00	0.00	0.00	0.00	11813.86	34.66
2001/02	36895	100	19760.96	53.56	17130.35	46.43	1.48	0.004	1.11	0.003	0.00	0.00	0.00	0.00	17134.04	46.44
2002/03	37654	100	15927.64	42.30	21722.59	57.69	1.51	0.004	2.26	0.006	0.00	0.00	0.00	0.00	21726.36	57.70
2003/04	51968	100	18916.35	36.40	32729.45	62.98	160.06	0.308	161.10	0.310	0.00	0.00	0.00	0.00	33051.65	63.60
2004/05	86429	100	28633.93	33.13	57155.50	66.13	295.59	0.342	347.44	0.402	0.00	0.00	0.00	0.00	57795.07	66.87
2005/06	115650	100	32185.40	27.83	82666.62	71.48	346.95	0.300	449.88	0.389	0.00	0.00	0.00	0.00	83487.74	72.19
2006/07	128745	100	26637.34	20.69	101219.32	78.62	399.11	0.310	482.79	0.375	0.00	0.00	0.00	0.00	102107.66	79.31
2007/08	125101	100	22080.33	17.65	101256.75	80.94	638.02	0.510	725.59	0.580	400.32	0.320	5.00	0.004	103020.67	82.35

Note: BDMVs- BARI Developed Modern Varieties, LVs- Traditional Varieties and Shaded area indicates no improved varieties were released.

Table 2: Adoption rate of BARI developed modern varieties of onion

Name of crop	Varietals Name	Adoption rate (%)
Onion	BARI *Piaz* -1 (1995-96 to 2007-08)	7.05
	BARI *Piaz* -2 (1999-00 to 2007-08)	0.06
	BARI *Piaz* -3 (1999-00 to 2007-08)	0.07
	Total BDMVs of Onion (1995-96 to 2007-08)	7.14

Note: 'Piaz' is the local name of onion

3.2. Supply shifter k

The supply shifter k identifies the amount of production that can be attributed to the varietals improvement research in each year (i.e., the shift in the supply curve). The more the value of supply shifter the more is the shift in the supply curve, resulting higher benefit to the society. The supply shifter is the outcome of the simultaneous force of adoption percentage and yield advantage. It was calculated using the formula discussed in methodology.

Table 3 shows each year adoption percentage and supply shifter of onion. It was found that the rate of shift gradually increased. The shifter accounted for the yield advantage of BARI developed onion varieties over the traditional varieties. The supply shifter of onion was found to be 0.552 for the year 2007/08, meaning that 55% more onion production was made available during 2007/08 because of farmers' adoption of BARI developed onion variety.

Table 3: Calculation of the supply shifter (k) of BARI Piaz over traditional variety

Year	% Area BARI *Piaz* -1 Replacing LVs	% Area BARI *Piaz* -2 Replacing LVs	% Area BARI *Piaz* -3 Replacing LVs	% Area BARI *Piaz* 4 Replacing LVs	% Area BARI *Piaz* -5 Replacing LVs	Supply Shifter k
1994/95	0	0	0	0	0	0.000
1995/96	1.88	0	0	0	0	0.013
1996/97	5.50	0	0	0	0	0.037
1997/98	10.69	0	0	0	0	0.072
1998/99	18.87	0	0	0	0	0.126
1999/00	25.94	0.00	0.00	0	0	0.174
2000/01	34.65	0.00	0.00	0	0	0.232
2001/02	46.43	0.00	0.00	0	0	0.311
2002/03	57.69	0.00	0.01	0	0	0.386
2003/04	62.98	0.31	0.31	0	0	0.426
2004/05	66.13	0.34	0.40	0	0	0.448
2005/06	71.48	0.30	0.39	0	0	0.483
2006/07	78.62	0.31	0.38	0	0	0.531
2007/08	80.94	0.51	0.58	0.32	0.004	0.552

Example : Supply shifter k of BARI *Piaz*-1over traditional varieties= 0.669x101256.75/ 125101=0.5415 and aggregate Shifter k of improved variety in 2007-08=0.5415+0.0000+0.0043+0.0024+0.0000=0.552

3.3. Yield advantages

This is very important factor to determine the economic surplus. The higher yield advantage always ensures higher level of economic surplus. Two types of data exist in most of the less developed countries for good estimation of yield advantage (YA) as well as the aggregate production function shifter. They are on-station yield trial data and on-farm yield data. The on-station yield data is readily available and most often the only reliable source. One of the arguments against using on-station yield trial data is that superior management practices and techniques are used and therefore, the results may not reflect on the on-farm situation. Another argument placed by different author (Hertford et al., 1971 and 1977, Ayer et al., 1972, Akino, et al., 1975, Scobie, et al., 1977 and Nagy et al., 1978) and showed that the yield advantage estimation from the on-station yield trial data would be biased upward because the estimation might also include the contribution made by inputs such as fertilizer and water. To account for this problem, the estimated yield advantage of new varieties by estimating production functions of yield as a function of new varieties and other inputs. This process requires a substantial data which is not readily available in Bangladesh.

For the present study, on-farm yield trial data were considered as a more reliable source for the calculation of yield advantage rather than the on-station yield data in Bangladesh. The yield advantages have been calculated for this study following Gardiner et al. (1986), Nagy et al. (1978), and Nagy (1991).

Developed varieties of Spices Research Centre (SRC) of BARI have replaced the traditional varieties starting in 1995-96 for BARI *Piaz*-1, 1999-00 for BARI *Piaz*-2 & 3 and 2007-08 for BARI *Piaz*-4 & 5. Yield advantage data was required for the groupings mentioned above.

The weighted yields were calculated by taking the average of the irrigated optimum, late irrigated and non irrigated yield multiplied by the mean of irrigated, late irrigated and non irrigated area of onion. Per hectare average yield of high yielding varieties of onion i.e. BARI *Piaz*-1, 2, 3, 4 and 5 were found to be 12.28, 17.54, 16.22, 17.10 and 20.61 tonnes, respectively. In case of traditional variety it was only 4.06 tonnes. Therefore, the yield advantages of BARI *Piaz*-1, 2, 3, 4 and 5 over traditional variety were found to be 67, 77, 75, 76 and 80%, respectively (Table 4).

Table 4: Yield advantages of improved varieties of onion over traditional varieties

Name of onion crop	Average (weighted) yield of Improved variety (t/ha)	Average yield of traditional variety (t/ha)	Yield difference (t/ha)	Yield advantage
BARI *Piaz* -1	12.28	4.06	8.22	0.669
BARI *Piaz* -2	17.54	4.06	13.48	0.769
BARI *Piaz* -3	16.22	4.06	12.16	0.750
BARI *Piaz* -4	17.10	4.06	13.04	0.763
BARI *Piaz* -5	20.61	4.06	16.55	0.803

Example : Yield advantage of BARI *Piaz*-1 = 1-(4.06/12.280)=0.669

3.4. Estimating Benefits from Onion Research and Extension

This section deals with the estimation of returns to investment in onion research and extension using the economic surplus approach. This approach estimates the benefits to agricultural research by measuring the change in consumers' surplus (CS) and producers' surplus (PS) from a rightward shift in the supply curve that is brought about through technological change. It should be mentioned here that aggregate consumers' surplus , producers' surplus and total surplus were calculated by summing up corresponding surpluses of all onion rather than summing up from the areas of the model. In order to calculate the net benefits (NB) research and extension expenditures are subtracted from total surplus. All these estimates of benefits are expressed in real term by using 2007-08 constant prices. The rates of return and NB are then discounted using 10% interest rate for obtaining the efficiency of investment. All these estimates are embedded into a computer spreadsheet for it's computation. First, the yearly total social benefits are estimated using the small-open economy model (Figure 2).

This is done by assigning a very high number to the demand elasticity parameter (ŋ) since in a small open-economy model, ŋ is perfectly elastic. The analysis is undertaken for each year 1988/89 to 2007/08 for onion.

Onion research and extension in Bangladesh are seemed to be continued by three different organizations. The Organizations are Bangladesh Agricultural Research Institute (BARI), Bangladesh Agricultural Research Council (BARC) and Directorate of Agricultural Extension (DAE). The onion research and extension expenditure comprised the expenditure of three organizations are furnished in the following sequence.

Table 5: Onion research and extension expenditures by source 1988/89-2007/08

Year	**Total SRC/BARI Research Expenditures** (current Taka)	**BARC Administrative Expenditures** (current Taka)	**Total Extension Expenditures** (current Taka)	**Input cost change** (current Taka)	**Total Expenditures** (current Taka)	**Total Expenditures** (2007-08 Tk)
1988/89	177950	562700	0	0	740650	1948342
1989/90	284450	819500	0	0	1103950	2678522
1990/91	635100	746050	0	0	1381150	3086921
1991/92	755700	1107250	0	0	1862950	3965028
1992/93	1630450	1346100	0	0	2976550	6279878
1993/94	2741150	798650	0	0	3539800	7245232
1994/95	660000	225500	0	0	885500	1721160
1995/96	1980000	171400	12435370	736092	15322862	28527728

1996/97	7788000	261250	13381450	2307762	23738462	43421249
1997/98	8699064	675850	14780040	4761058	28916012	50633337
1998/99	2882220	1181750	15591510	8595998	28251478	47114005
1999/00	1728804	1221000	18402150	12751251	34103205	54164503
2000/01	2132064	1114500	18635350	18181051	40062965	60229645
2001/02	1985280	645000	19022655	27950708	49603643	70351753
2002/03	3334320	173500	19955925	37568674	61032420	81661259
2003/04	3859020	271300	23423720	60581205	88135245	111249799
2004/05	14129808	301300	26968600	112290088	153689796	183015886
2005/06	13091496	442200	30186680	171940901	215661277	242275814
2006/07	11586960	724950	38383780	222905447	273601137	289967900
2007/08	14171520	690350	39216020	238392503	292470393	292420670
Total	**94253356**	**13480100**	**290383250**	**918962738**	**1317079445**	**1581958631**

Note : $1.00 =Tk. 80.00

The year wise expenditures behind variety development and dissemination for the new varieties to the farmers of onion are shown in Table 5. The expenditures of BARI/SRC and BARC were estimated from 1988/89 to 2007/08. The accumulated expenditures over the years of BARI/SRC and BARC were estimated at Tk 94.25 and 13.48 million, respectively. Extension expenditures and input cost change were estimated after development of improved variety and they were started since 1995/96. The cumulative expenditures of extension and input cost changes were respectively amounted at Tk 290.38 and 918.96 million. Over the years, expenditures accruing for BARI/SRC, BARC and DAE were Tk 131.71 million. For the analysis, the current total expenditures were converted to 2007/08 constant prices using the Bangladesh Middle Income Group CPI Index.

The total over years changes in consumers' and producer' surplus were estimated Tk 306.00 and Tk 37944.12 million respectively from onion research and extension. The estimated total surplus/total benefits ranged from Tk 22.67 million in 1988/89 to 14492.29 million in 2007/08 and the total surplus accrued as Tk 37944.12 million from the onion research and extension in Bangladesh. Besides, the total net benefits obtained from onion research and extension was Tk 36356.64 million for the year 1988/89 to 2007/08 (Table 6).

Table 6: Estimation of surplus from onion research and extension investments

Year	**Change in consumer surplus (Tk)**	**Change in producer surplus (Tk)**	**Change in total surplus (Tk)**	**Total expenditure (Based on 2007-08 Tk)**	**Net Benefit (Tk)**
A	B	C	D=B+C	E	F=D-E
1988/89	0	0	0	1948342	-1948342
1989/90	0	0	0	2678522	-2678522
1990/91	0	0	0	3086921	-3086921
1991/92	0	0	0	3965028	-3965028
1992/93	0	0	0	6279878	-6279878
1993/94	0	0	0	7245232	-7245232
1994/95	0	0	0	1721160	-7245232
1995/96	0	22673575	22673575	28527728	-5854153
1996/97	1	73552018	73552019	43421249	30130770
1997/98	4	390322361	390322365	50633337	339689029
1998/99	7	703747092	703747100	47114005	656633094
1999/00	6	592119995	592120001	54164503	537955499
2000/01	5	567384476	567384482	60229645	507154837
2001/02	8	852016830	852016838	70351753	781665085
2002/03	9	1042096840	1042096849	81661259	960435589
2003/04	16	1885553711	1885553727	111249799	1774303927
2004/05	29	3478120589	3478120618	183015886	3295104732
2005/06	55	6783441715	6783441770	242275814	6541165955
2006/07	55	7060799346	7060799401	289967900	6770831502
2007/08	111	14492293658	14492293769	292420670	14199873098
Total	**306**	**37944122206**	**37944122514**	**1581958631**	**36356639809**

Note : $1.00 =Tk. 80.00

3.5. Rate of Return to Onion Research and Extension

The rates of returns are the indicators which help estimate the investment efficiency of the research programme. There are many types of measure that can be used to estimate the rates of return. Among them, Net Present Value (NPV) of benefit, External Rare of Return (ERR) and Internal Rate of Return (IRR) was considered as the rates of return to onion research and extension investments in Bangladesh. For comparing the net benefits with the total research costs, Present Value of Research Costs (PVRC) was also calculated. All the estimates were calculated at constant (2007/08) prices with 10% discount rate. Table 7 was used to calculate the NPV, PVRC, ERR, IRR and BCR under small-open economy condition. Under open economy, the producers' benefits were found much higher compared to consumers' benefits since the elasticity of demand for onion were very high.

Society was benefited substantially from the investment in spices research and extension in Bangladesh (Table 7). The NPV of benefit indicates the total social benefit for a country and it was found negative up to 1995/96 and then it was positive. It means that the country did not receive any benefit from onion research up to 1995/96 (Table 6). After 1995/96, the country as a whole benefited with a big amount and found increasing trend up to 2007/08. The NPV was found to be Tk 6536.86 million while PVRC over the period was Tk 353.30 million for onion research and extension investment. The ERR was found to be 2538.06%. This means that the average taka spent on research and extension earn return 10% annually from the start of the initial investment (1988/89) and is now paying off at the rate of 2538.06% annually into perpetuity. In the benefit/cost mode, using 10% external interest rate, a one taka investment returned 253.81 taka over the period. The IRR of 82% means that on the average, each taka invested in onion research and extension returned 82% annually from the date of the initial investment. It implies that the expenditure on onion research and extension (Tk 353.30 million) could have been borrowed at 82% real rate of interest without incurring loss (Table 7).

The benefit cost ratios were found to be 23.99 for onion. The value of the parameter clearly indicated that the investment in research and extension of onion in Bangladesh is a good investment and highly profitable.

Table 7: Estimated rates of returns to onion research and extension

Name of crop	Net present value (NPV)	Present value of research cost (PVRC)	External Rare of Return (ERR)	Internal Rate of Return (IRR)	Benefit Cost Ratio (BCR)
	Million taka in 2007-08 constant prices		%		
Onion	6536.86	353.30	2538.06	82	23.99

Note : $1.00 =Tk. 80.00

3.6. Sensitivity Analysis

Sensitivity analysis is a technique to assess the effects of adverse changes on a project. Therefore, the changes in the parameters of the model were made in the way that adversely affects the net benefit. A sensitivity analysis was undertaken for the study. In the study, five pairs assumption were considered (i) supply shifter K decreased by 25% and expenditure remaining unchanged, (ii) supply shifter K remaining unchanged and expenditure increased by 25% (iii) both supply shifter (K) and expenditure decreased by 25% (iv) both supply shifter (K) and expenditure increased by 25% and (v) supply shifter (K) decreased by 25% and that of expenditure increased by 25%.

The base parameters included IRR (82%), ERR (2538%), NPV (Tk6536.86 million), and BCR (23.99). When the yearly supply shifter k was decreased by 25%, there was a decrease in the rate of return IRR to 75%, ERR to 1875%, NPV to Tk 4813.61 and that of BCR was 18. But when the supply shifter k remained unchanged and expenditure increased by 25%, the IRR and ERR decreased to 77% and 2010% respectively. Then the NPV and BCR were Tk 6447.83 and 19.19 respectively. In the case of both supply shifter (k) and expenditure decreased by 25%, the IRR, ERR and BCR remained as same just before case but NPV was changed and it was Tk 4835.87. When the expenditure and supply shifter (k) both were increased by 25%, the IRR, ERR and BCR were equal to the base parameter but only NPV were increased to Tk 8171.08 million. A simultaneous decrease of 25% in the supply sifter and 25% increase in expenditures gave less to 70% IRR, 1483% to ERR, NPV to Tk 4724.58 and BCR to 14.39. Thus the sensitivity analysis revealed that under various assumptions about the research and extension

expenditure, the IRR ranged from 70 to 82%, ERR from 1483 to 2538, NPV from Tk 4724.58 to Tk 8171.08 million, and BCR from 14.39 to 23.99 (Table 8).

Table 8: Sensitivity analysis on the rate of return under small open market economy situation of onion

Different assumption	IRR (%)	ERR (%)	NPV (Million Tk)	BCR
Base parameter	82	2538	6536.86	23.99
Supply shifter K decreased by 25% and expenditure remaining unchanged	75	1878	4813.61	18.00
Supply shifter K remaining unchanged and expenditure increased by 25%	77	2010	6447.83	19.19
Both supply shifter (K) and expenditure decreased by 25%	77	2010	4835.87	19.19
Both supply shifter (K) and expenditure increased by 25%	82	2538	8171.08	23.99
Supply shifter (K) decreased by 25% and Expenditure increased by 25%	70	1483	4724.58	14.39

Note : $1.00 =Tk. 80.00

3.7. Foreign Exchange Savings

The yearly increase in production due to research save the country's foreign exchange to a remarkable extends. First, the research induced productions for onion for the past years were calculated by multiplying the country's total onion production by their respective production function shifter k. Multiplying the results by world onion price, foreign exchange savings was obtained.

Table 9: Foreign exchange savings from investment in onion research

Year	Import Price (2007-08) Taka	Supply Shifter K (%)	Onion Production (ton)	Increase in Production from Research (ton)	Foreign Exchange Savings (2007-08) Taka
	1	2	3	4=2x3	5=1x4
1995/96	12035.63	0.013	138190	1738.04	20918439
1996/97	18291.65	0.037	141835	5218.82	95460808
1997/98	18385.50	0.072	138430	9899.97	182015996
1998/99	18377.74	0.126	131090	16548.84	304130215
1999/00	17502.51	0.174	134245	23300.77	407821989
2000/01	22550.62	0.232	126770	29393.09	662832329
2001/02	24199.33	0.311	150015	46605.15	1127813189
2002/03	53116.55	0.386	153455	59236.98	3146464194
2003/04	27159.87	0.426	272230	115977.42	3149931774
2004/05	18338.51	0.448	589410	264086.23	4842948876
2005/06	23591.57	0.483	768655	371585.57	8766288217
2006/07	23316.43	0.531	894000	474858.46	11072002856
2007/08	22373.49	0.552	889000	490931.36	10983847063
	Total Foreign Exchange Savings:			**Tk**	**44762475946**

Note : $1.00 =Tk. 80.00

Considerable amounts of onion are imported in Bangladesh every year to meet the internal demand of its increasing population. In 2006/07, the imported value of onion was Tk 5936 million (BBS 2008). In reality, the amount imported is higher due to the illegal boarder trade of spices from neighboring countries. Thus, the increased production attributed to onion improvement saved foreign exchange amounting to Tk 44762.48 million from onion research and extension (Table 9).

4. POLICY IMPLICATIONS

The empirical results indicate that the expenditure on onion research and development paid a favourable rate of returns and the society were also benefited enormously out of it. The IRR to onion research and development expenditure was found to be 82%. An 82% IRR on investment in onion research and development is a good rate of return. The consumer's surplus is found to be very few only due to small open economy. But this situation might not be the good sign for the economic prosperity. For the survival of the consumer, price support should be given by government.

BARI *Piaz* 2 & 3 are summer variety and they are grown in off season. Due to perishability nature of onion a huge amount of onion damaged by rotten. To meet up the gap caused by rotten and to ensure availability of supply of onion, these two varieties are very much essential to produce largely. But the adoption rates of these two varieties are not good because of non availability of seed. Seed production programme should be taken largely by the government and non governmental organization so that the farmers can get quality seed easily with a reasonable price.

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