Economic Cost and Returns from Research and Development: The Case of Chili in Bangladesh

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ABSTRACT

The study estimated the benefit and rate of returns to investment on chili research and development (R&D) in Bangladesh. The Economic Surplus Model with ex-post analysis was used to determine the returns to investment and their distribution between production and consumption. Several discounting techniques were also used to assess the efficiency of chili research. The adoption rate showed an increasing trend over the period. The yield of modern variety, BARI-Chilli-1, developed by the Bangladesh Agricultural Research Institute (BARI) was 72 percent higher than that of the local variety. Society received a net benefit of BDT 813.12 million (USD 10.42 million) from investment in chili R&D. The net present value and present value of research cost were estimated at BDT 289.14 million (USD 3.71 million) and BDT 78.49 million (USD 1.01 million), respectively. The internal rate of return and benefit cost ratio were estimated to be 55 percent and 5.48, respectively. This indicates that investment in chili R&D was profitable. The seed production program for BARI-Chilli-1should be done to increase production by increasing its area of adoption.

Keywords: chili, economic cost, adoption, yield advantage, benefit and rate of return
JEL Classification: Q16

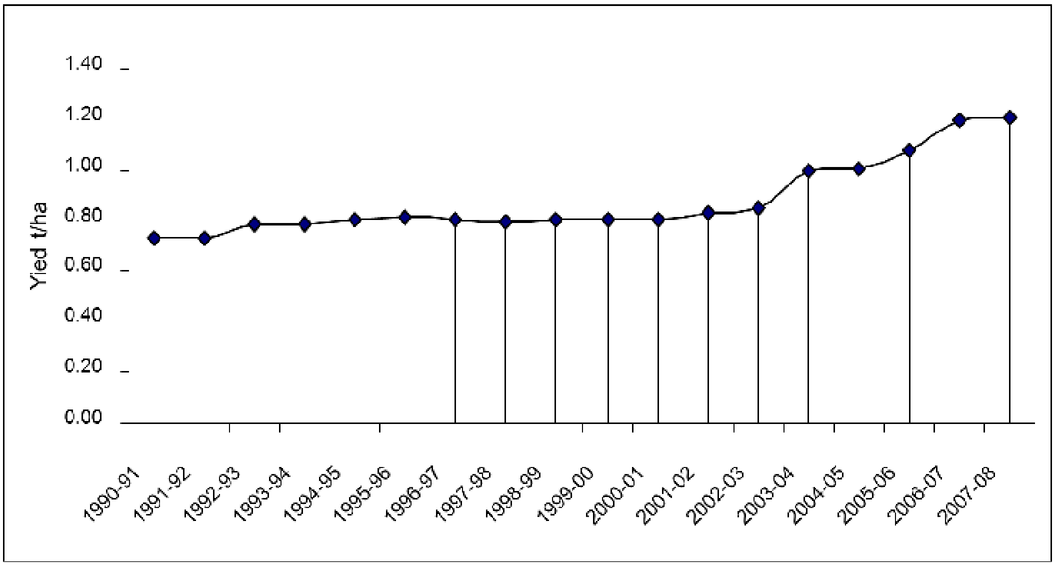
INTRODUCTION

Chili, an important spice crop in Bangladesh is widely grown both in the winter and summer seasons. Area under chili cultivation was 141,300 hectares producing about 154 thousand tons in 2007–2008. Production of winter chili is about 84.38 percent of total chili production (BBS 2011).

Chili is used in its green and dried forms. It is especially liked for its pungency, spicy taste, and the appealing color it adds to the food (Mathukrishnan, Thangaraj, and Chatterjee 1993). Chili is used as pickles, in sauces, and extract of chilies is used for ginger beer and other beverages (Purseglove et al. 1991). It is a principal ingredient in the Bangladeshi kitchen as curry powder and paste. It has medicinal values also. In 1999–2000, just before the development and introduction of the improved variety (BARI Chilli-1) in Bangladesh, the national yield per hectare was very low at only 0.82 tons per hectare. The reasons behind such low yield were lack of improved variety and practice of unimproved cultural methods. Productivity increased after 2002–2003 (Figure 1). National productivity of chili started to increase since 2003–2004, and it stood at 1.26 tons per hectare in 2007–2008 due to the development and dissemination of improved varieties (BBS 2010). National productivity (yield) will be further increased with the widespread adoption of BARI Chilli-1.

Due to increasing population, demand for cereal food increased significantly. To mitigate this demand, the land area of chili crop was diverted to cereal food crop cultivation. On the other hand, there are now many spice processing industries (e.g., Square, BD Foods, Pran, Archu, Advanced Chemical Industries (ACI), Amrita, Dekho, etc.), which have been established in Bangladesh to export chili powder as a finished product. Due to that, demands for chili as raw material of these industries are increasing at an incremental rate, which has resulted in a big gap observed between present production and demand. To close this gap, the country had to spend a huge amount of foreign currency every year to import chili from abroad.

Figure 1. Yield trend of chili



Realizing the importance of chili, the Bangladesh government started chili research through the Spices Research Centre (SRC) of the Bangladesh Agricultural Research Institute (BARI) in 1994-1995 to increase chili production. As a result, BARI has already released an improved chili variety, named BARI Chilli-1, which has been cultivated in farmers' fields since its release. The Bangladesh Agricultural Research Council (BARC) and the Department of Agricultural Extension (DAE), to a great extent have contributed to disseminate this improved chili variety among farmers. Therefore, the contribution of BARC and DAE in the R&D of chili in Bangladesh are greatly associated with BARI.

The present analysis thus took into account the benefits from past chili research and its farm level extension in the country. This study seeks to provide information for policy makers, donors, researchers, extension workers, and the public on the contribution and the rate of return of investment in chili R&D in Bangladesh.

METHODOLOGY

Sources of Data

Data were collected from both published and unpublished reports and informal interviews with scientists. The area, production, and yield of BARI Chilli-1 were collected from the SRC; adoption rates were collected through informal interviews with scientists; harvest price and consumer price index (CPI) were collected from various issues of statistical yearbooks (1994–2008) published by the Bangladesh Bureau of Statistics (BBS). The supply elasticity was taken from the study conducted by Dey and Norton (1993). SRC is the organization mainly responsible for chili research in Bangladesh; extension and promotion activities were done by DAE; BARC mainly provided the administrative costs. On-farm yield data of BARI Chilli-1 were collected from SRC. Data on the input costs change was calculated by the researcher through analyzing increased production which claimed higher labor costs for harvesting, transporting, seeds, and used slightly more fertilizers per hectare for improved variety than for traditional varieties.

Analytical Procedure

The collected data were analyzed using the following statistical techniques.

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 chili research and extension. The analysis was done under a small open-economy market[1] situation which uses domestically produced chili and imports to cover production shortfalls of chili in Bangladesh. The theoretical concept of ESM is illustrated in Figure 2.

The concept of economic surplus was used to measure economic welfare and the changes in economic welfare from policy and other interventions (Alston, Norton, and Pardey 1995; Currie, Murphy, and Schmitz 1971). Usually, the economic surplus concept is used 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

1 A small-economy market is one where the amount of exports or imports is small relative to total trade in the commodity. Thus, there is little or no effect of individual behaviors of a country on the world price of the commodity (called the small country assumption).

curve D_1), consumer surplus is depicted as area P_oP_nb in Figure 2. This is the surplus or benefit to consumers because of a functioning market. Consumer surplus is that area beneath the demand curve minus 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 2. The area P_nbO in the surplus left to the farmers after they have paid for the total costs of production, area ObQ_n (Alston, Norton, and Pardey 1995).The adoption by farmers of an intervention such as an improved variety usually means one of two things: (1) a farmer can supply more of the commodity using the same level of resources (i.e., same land area and other inputs), or (2) a farmer can supply the same level of commodity output but do it with less resources. In either case, this is depicted by a shift to the right of the supply curve as shown in Figure 2 (the shift is from S_1 to S_2). The shift in 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.

Given a shift in the supply curve S_1 to S_2, the change in consumer surplus is depicted in Figure 2 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 Figure 2 as Area Oac − Area P_nbaP_0. Area Oac represents the decrease in the cost of producing 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 2), which is a loss in farmers' income. Farmers can recover some of this loss since they can sell more quantity (Q_n to Q_0 in Figure 2) 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 intervention.

For a closed economy model, the estimated price elasticity of demand is used in the above formulas. For a small open-economy model, where the elasticity of demand is perfectly elastic, a sufficiently large number of η (Nagy and Alam 2000) is used. 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 the commodity does not change with the shift in the supply curve. For this study, the Bangladesh chili market is modelled as a small open-economy market.

The change in economic surplus for a small open-economy market that is mostly domestically produced, but allows imports to cover shortfall (i.e., the Bangladesh chili market) is depicted in Figure 3. 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 chili when faced by the pre-research supply curve S_1. Chili imports are equal to QT_n. When faced by the research-induced supply curve S_2 (the supply curve that exists because farmers have adopted new high-yielding varieties). Chili producers increased production to quantity Q_n and increased Q_nQ_0. Chili imports are decreased by the same amount as the increase in production

Figure 2. Economic surplus model (closed economy)

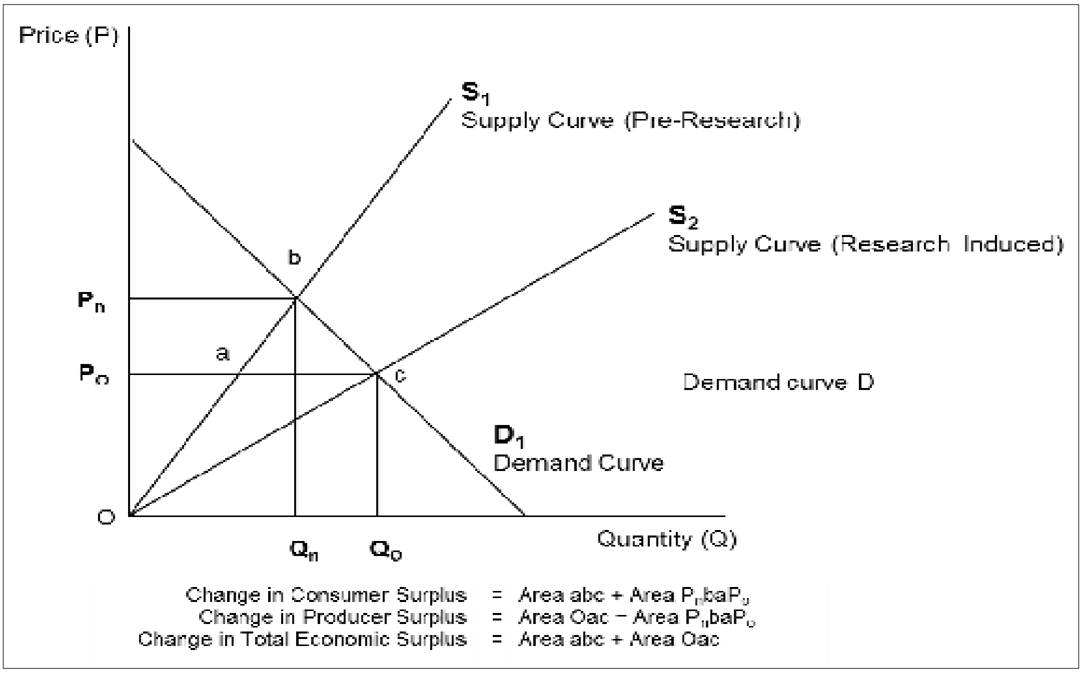
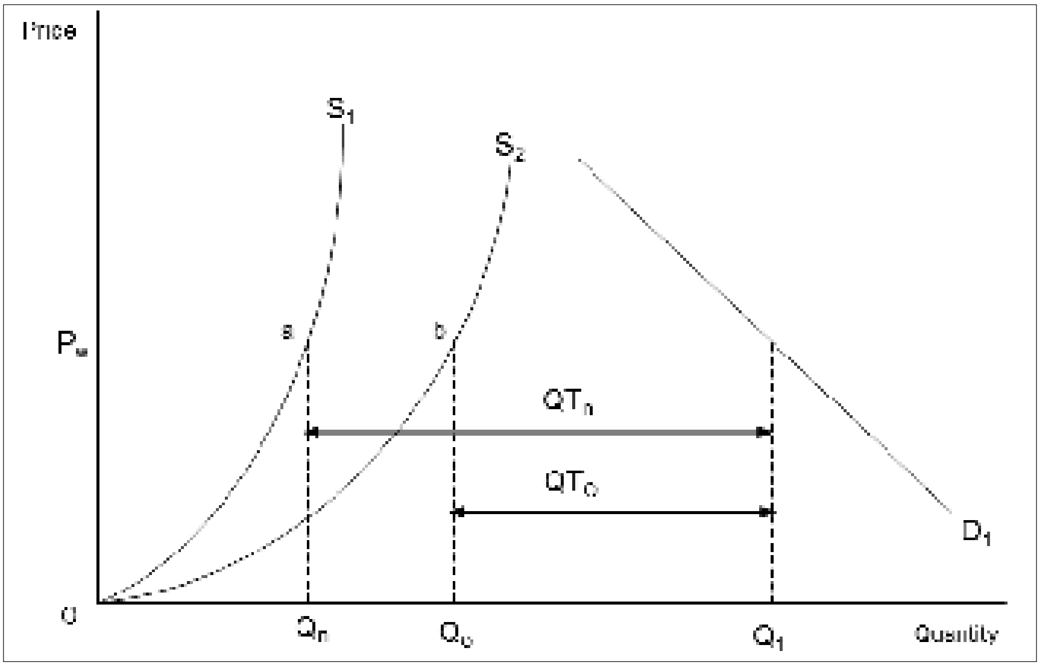


Figure 3. Small open-economy importer economic surplus model



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 change in economic surplus from the adoption of new chili varieties is thus a change in producer surplus only and is identified by area Oab in Figure 3 (corresponds to area Oac in Figure 2). The amount of foreign exchange saved by the adoption of improved varieties is equal to Pw × Q_nQ_0.

Empirical Approach

The Akino and Hayami (1975) approximation formulas for calculating changes to producer and consumer economic surplus are described below. The formulas for calculating the change in economic surplus for a closed economy analysis (Figure 2) is as follows:

$$\text{Area A (abc)} = 0.5\, P_O Q_O \left(\frac{\left(k(1+\gamma)\right)^2}{(\gamma+\eta)} \right) \quad (1)$$

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

$$\text{Area C } (P_n b a P_O) = \left(P_O Q_O k \left(\frac{1+\gamma}{\gamma+\eta} \right) \right) \times \left(1 - \left(\frac{0.5k(1+\gamma)\eta}{\gamma+\eta} \right) - 0.5k(1+\gamma) \right) \quad (3)$$

where:

P_O = Price of chili (BDT/ton) (existing market price)

Q_O = Production of BARI Chilli-1 (ton) (existing production)

P_n = Quantity price that would exist in the absence of research

Q_n = Quantity of chili produced that would exist in the absence of research

k = Horizontal supply shifter

γ = Price elasticity of chili supply

η = Absolute price elasticity of the demand for the commodity.

The Supply Shifter (k)

The supply shifter *k* is the overall yield advantage of improved varieties of chili over the local variety weighed by the area sown to the improved variety of chili. 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 2 (Gardiner, Sanders, and Barker 1986; Nagy and Furtan 1978). The supply shifter *k* is calculated as follows:

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

where:

Y_{it} = yield of the improved varieties of chili in year *t*

Y_t = yield of a base (or average yield of local variety chili) that has been grown in the past and that would still be grown if no new varieties had been developed

A_{it} = proportion of the total area sown to the improved variety of chili in year *t*

n = number of improved chili varieties.

Estimation of Net Present Value

The amount of total funds returned from the investment in research is called net present value (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 = cost of research and extension in year *t*

r = discount rate.

Internal Rate of Return

The internal rate of return (IRR) was calculated relating to the total social benefit (TSB) minus an input cost change, if any, in each year, to the research expenditure (C) 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).

RESULTS AND DISCUSSION

Adoption Status and Yield Advantages of BARI Chilli-1

The adoption of an improved crop variety is a very important factor by which the volume of change in economic surplus is determined. The higher the adoption rate of an improved variety over a traditional one, the higher the change in surplus. Apart from this, it gives us feedback as to why and how well a technology is being accepted by the farmers. There was no chili varietal adoption survey conducted in Bangladesh. The existing variety survey information along with the considerable field experience of the scientists are used to sketch out the percentage area sown by variety grouping which are presented in Table 1.

Table 1. Area of traditional variety replaced by BARI Chilli-1

Year	Total Chili Area		Area of LVs		Area Grown to BARI Chili -1	
	Hectare	%	Hectare	%	Hectare	%
1994–95	66427	100	66427	100	0	0.00
1995–96	66302	100	66302	100	0	0.00
1996–97	66235	100	66235	100	0	0.00
1997–98	66320	100	66320	100	0	0.00
1998–99	175231	100	175231	100	0	0.00
1999–00	175275	100	175275	100	0	0.00
2000–01	174935	100	174935	100	0	0.00
2001–02	169915	100	169575	99.80	340	0.20
2002–03	169937	100	169088	99.50	850	0.50
2003–04	162154	100	160532	99.00	1622	1.00
2004–05	154812	100	152490	98.50	2322	1.50
2005–06	142466	100	139616	98.00	2849	2.00
2006–07	141296	100	136350	96.50	4945	3.50
2007–08	93522	100	88846	95.00	4676	5.00

Note: LVs = local varieties; 0 values indicate no improved variety was released.

BARI Chilli-1 was released in 2000–2001. The area grown to BARI Chilli-1 was 0.20 percent in 2001–2002, which gradually increased to 5 percent in 2007–2008 (Table 1). The annual rate of adoption of BARI Chilli-1 was 0.67 percent.

Supply shifter k

The supply shifter *k* identifies the amount of production that can be attributed to varietal improvement research in each year (i.e., the shift in the supply curve). The higher the value of the supply shifter, the more is the shift in the supply curve, resulting in higher benefit to society. The supply shifter is the outcome of the simultaneous force of adoption percentage and yield advantage. Table 2 shows each year's adoption percentage and supply shifter of chili. It was found that the rate of shift gradually increased. The shifter accounted for the yield advantage of BARI Chilli-1 over the traditional variety. The supply shifter of chili was found to be 0.027 for the year 2007–2008, meaning that about 3 percent more chili production was made available during 2007–2008 because of farmers' adoption of BARI Chilli-1.

Table 2. Calculation of the supply shifter (k) of BARI Chilli-1 over traditional variety

Year	% Area of BARI Chilli-1, replacing LVs	Supply shifter K
1994–95	0	0.000
1995–96	0	0.000
1996–97	0	0.000
1997–98	0	0.000
1998–99	0	0.000
1999–00	0	0.000
2000–01	0	0.000
2001–02	0.2	0.007
2002–03	0.5	0.016
2003–04	1.0	0.023
2004–05	1.5	0.019
2005–06	2.0	0.018
2006–07	3.5	0.028
2007–08	5.0	0.027

Yield Advantage

This is a very important factor to determine 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—on-station yield trial data and on-farm yield data. The on-station yield trial 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 the on-farm situation. Another argument placed by different authors (Hertford and Schmitz 1971; Ayer and Schuh 1972; Akino et al. 1975; Scobie and Posada 1977; Nagy and Furtan 1978) 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 was determined by estimating production functions of yield as a function of new varieties and other inputs. This process requires 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. The yield advantages have been calculated for this study following Gardiner, Sanders, and Barker 1986 (1986), Nagy and Furtan (1978), and Nagy (1991). BARI Chilli-1 replaced the traditional varieties starting in 2001-2002.

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 chili. Per hectare average yield of improved variety of BARI Chilli-1 was found to be 2.60 tons. In the case of traditional variety, it was only 0.72 tons. Therefore, the yield advantage of BARI Chilli-1 over traditional variety was found to be 72 percent (Table 3).

Estimating Benefits from Chili Research and Extension

Chili research and extension in Bangladesh are conducted by three different organizations: the Bangladesh Agricultural Research Institute (BARI), Bangladesh Agricultural Research Council (BARC), and Department of Agricultural Extension (DAE). The chili research and extension expenditure comprised the yearly expenditure of the three organizations for varietal development and dissemination of the new variety to the farmers (Table 4).

The expenditures of BARI-SRC and BARC were estimated from 1994/95 to 2007/08. The accumulated expenditures of BARI/SRC and BARC were estimated at BDT 88.03 million and BDT 8.10 million (USD 1.12 million and USD 0.10 million), respectively. Extension expenditures and input cost change, which were started since 2001/02, were estimated after the development of the improved variety. The cumulative expenditures of extension and input cost changes, respectively, amounted to BDT 15.77 million and BDT 32.73 million (USD 0.20 million and USD 0.42 million). Over the years, expenditures of BARI/SRC, BARC, DAE, and input cost change was BDT 144.63 million (USD 1.84 million).

For the analysis, the current total expenditures were converted to 2007/08 constant prices using the Bangladesh middle income group CPI Index, which was BDT 181.52 million (USD 2.31 million).

The total change in consumers' and producers' surplus due to chili research and extension were estimated at BDT 12.00 million and BDT 994.64 million (USD 12.65 million). Consumers' surplus was very much lower compared to producers' surplus due to perfect elasticity of demand for chili in the small-open economy market. The estimated total surplus/ total benefits ranged from BDT 70.66 million (USD 0.90 million) in 2001/02 to BDT 33.33 million (USD 0.42 million) in 2007/08, and the total surplus from chili research and extension in Bangladesh was BDT 994.64 million (USD 12.65 million). Furthermore, the total net benefits obtained from chili research and extension was BDT 813.12 million (USD 10.35 million) for the year 1994/95 to 2007/08 (Table 5).

Rate of Return of Chili Research and Extension

The NPV of benefit, external rare of return (ERR), and internal rate of return (IRR) were considered in computing for the rates of return to chili research and extension investments in Bangladesh. To compare the net benefits with the total research costs, present value of research cost (PVRC) was also calculated. All the estimates were calculated at constant (2007/08) prices with 10 percent discount rate.

Table 3. Yield advantages of BARI Chilli-1 over traditional varieties

	Average (weighted) Yield of Improved Variety (t/ha) (dry)	Average Yield of Traditional Variety (t/ha) (dry)	Yield Difference (t/ha)	Yield Advantage
BARI Chilli-1	2.602	0.72	1.88	0.723

Table 4. Chili research and extension expenditures (current BDT) by sources

Year	Total SRC/ BARI Research Expenditures	BARC Administrative Expenditures	Total Extension Expenditures	Input Cost Change	Total Expenditures	Total Expenditures (2007-08 BDT)
1994/95	660,000	225,500	0	0	885,500	1,721,160
1995/96	1,980,000	171,400	0	0	2,151,400	4,005,424
1996/97	7788,000	261,250	0	0	8,049,250	14,723,300
1997/98	8,699,064	675,850	0	0	9,374,914	16,415,928
1998/99	2,882,220	1,181,750	0	0	4,063,970	6,777,341
1999/00	1,728,804	1,221,000	0	0	2,949,804	4,685,034
2000/01	2,132,064	1,114,500	0	0	3,246,564	4,880,802
2001/02	1,985,280	645,000	1,521,812	477,700	4,629,792	6,566,333
2002/03	3,334,320	173,500	1,596,474	1,296,250	6,400,544	8,563,916
2003/04	3,859,020	271,300	1,873,898	2,658,458	8,662,676	10,934,569
2004/05	14,129,808	301,300	2,157,488	4,017,060	20,605,656	24,537,494
2005/06	13,091,496	442,200	2,414,934	5,156,690	21,105,320	23,709,906
2006/07	11,586,960	724,950	3,070,702	9,494,400	24,877,012	26,365,150
2007/08	14,171,520	690,350	3,137,282	9,632,560	27,631,712	27,631,712
Total	88,028,556	8,099,850	15,772,590	32,733,118	144,634,114	181,518,069

Note: USD 1 = BDT 78.60

Table 5. Estimation of surplus (BDT) from chili research and extension investments

Year	Change in Consumer Surplus	Change in Producer Surplus	Change in Total Surplus	Total Expenditure (2007–08 BDT)	Net Benefit
A	B	C	D=B+C	E	F=D–E
1994/95	0	0	0	1,721,160	–1,721,160
1995/96	0	0	0	4,005,424	–4,005,424
1996/97	0	0	0	14,723,300	–14,723,300
1997/98	0	0	0	16,415,928	–16,415,928
1998/99	0	0	0	6,777,341	–6,777,341
1999/00	0	0	0	4,685,034	–4,685,034
2000/01	0	0	0	4,880,802	–4,880,802
2001/02	1	70,660,005	70,660,006	6,566,333	64,093,674
2002/03	2	168,226,797	168,226,799	8,563,916	159,662,883
2003/04	3	277,276,422	277,276,425	10,934,569	266,341,856
2004/05	3	228,395,245	228,395,247	24,537,494	203,857,754
2005/06	2	165,741,556	165,741,557	23,709,906	142,031,651
2006/07	1	51,009,750	51,009,751	26,365,150	24,644,601
2007/08	0	33,325,525	33,325,525	27,631,712	5,698,511
Total	12	994,635,300	994,635,310	181,518,069	813,121,941

The NPV, PVRC, ERR, IRR, and benefit cost ratio (BCR) of chili research and extension in a small-open economy condition are shown in Table 6. Under open economy, the producers' benefits were found much higher compared to consumers' benefits since the elasticity of demand for chili was very high.

Table 6 revealed that society benefited substantially from investment in chili research and extension in Bangladesh. The NPV of the benefit indicates the total social benefit for a country; it was negative up to 2000/01, but became positive. This means that the country did not receive any benefit from chili research until 2000/01 (Table 5). After 2000/01, the country as a whole benefited; the trend of which has been increasing up to 2007/08. The NPV was found to be BDT 289.14 million while PVRC over the period was BDT 78.49. The ERR was found to be 502.70 percent. This means that the average taka spent on research and extension in chili earned a return of 10 percent annually from the start of the initial investment (1994/95). It is now paying off at the rate of 502.70 percent annually into perpetuity. In the benefit/cost mode, using 10 percent external interest rate, a BDT 1 investment returned BDT 50.27 over the period. The IRR of 55 percent means that on the average, each taka invested in chili research and extension returned 55 percent annually from the date of the initial investment. It implies that the expenditure on chili research and extension (BDT 78.49 million) could have been borrowed at 55 percent real rate of interest without incurring loss (Table 6).

Table 6. Estimated rates of returns to chili research and extension

NPV (million BDT)	PVRC (million BDT)	ERR (%)	IRR (%)	BCR
289.14	78.49	502.70	55	5.48

Note: USD 1 = BDT 78.60; 2007–08 constant prices

Table 7. Foreign exchange savings from investment in chili research

Year	Import (CIF) Price (2007–08 BDT)	Supply Shifter *k* (%)	Chili Production (ton)	Increase in Production from Research (ton)	Foreign Exchange Savings (2007–08 BDT)
	A	B	C	D=BxC	E=AxD
2001-02	64,156.62	0.007	135,980	905.84	58,115,382
2002-03	62,885.75	0.016	137,325	2,241.18	140,938,324
2003-04	66,026.20	0.023	138,740	3,130.93	206,723,597
2004-05	53,854.09	0.019	185,635	3,607.25	194,265,358
2005-06	53,111.61	0.018	155,430	2,769.56	147,095,808
2006-07	54,262.57	0.028	154,000	4,278.27	232,150,176
2007-08	61,210.59	0.027	118,000	3,189.96	195,259,403
Total			1,174,548,048		

Note: USD 1 = BDT 78.60; CIF = cost, insurance, freight

The BCR was found to be 5.48 for BARI Chilli-1. The IRR and BCR will be increased by increasing the adoption of the improved variety of chili. The value of the parameter indicated that the investment in research and extension of chili in Bangladesh is profitable.

Foreign Exchange Savings

The yearly increase in production due to research save the country's foreign exchange to a remarkable extent. First, the research-induced increase in chili production for each year was calculated by multiplying the country's total chili production by its respective production function shifter *k*. Foreign exchange savings was calculated by multiplying the results by the world chili price.

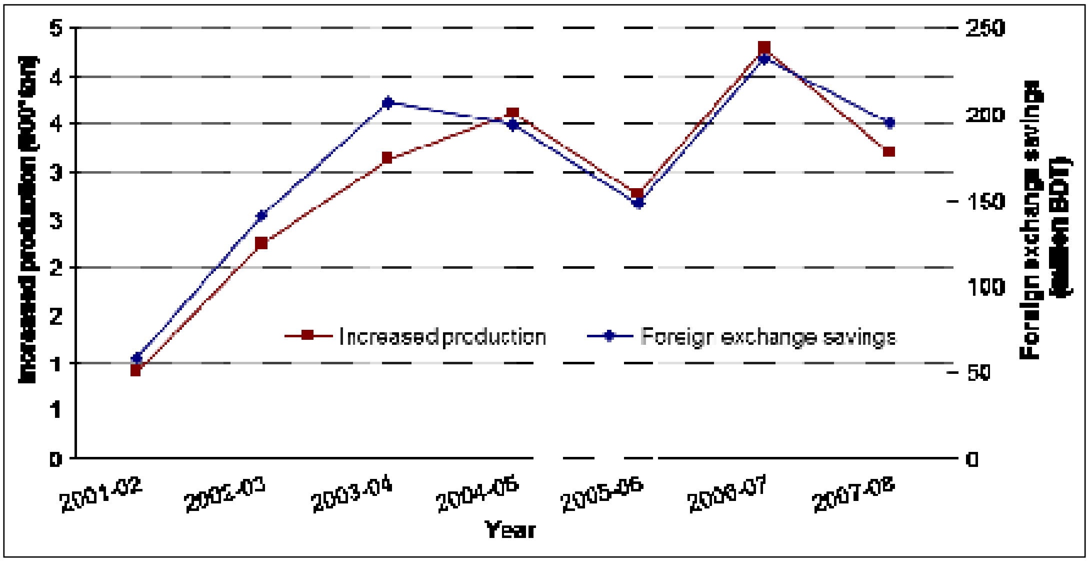
Considerable amounts of chili are imported in Bangladesh every year to meet the demand of the growing population. The imported value of chili was BDT 844.56 million (BBS 2009). In reality, the amount imported is higher due to illegal border trade from neighboring countries. Thus, the increased production attributed to chili improvement resulting from chili research and extension saved foreign exchange amounting to BDT 1174.55 million (USD 14.94 million) (Table 7 and Figure 4).

POLICY IMPLICATIONS

The empirical results indicate that the expenditure on chili research and development paid a favorable rate of return and the society consequently benefited enormously out of it. The IRR to chili research and development expenditure was found to be 55 percent, a good rate of return. The consumer's surplus is found to be very low due to a small open economy. But this situation might not be a good sign for economic prosperity. For the survival of the consumer, price support should be given by government.

The annual adoption rate of BARI Chilli-1 may still be improved because of non-availability of seed. A seed production program should be initiated by the government and non-governmental organizations, so that farmers can get quality seed at a reasonable price.

Figure 4. Foreign exchange savings due to chili research and development over time



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