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The Effect of Trade Policies on Returns to Rice Research in Sri Lanka: An Analysis

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ABSTRACT. The objective of this paper is to examine the returns to rice research under different trade regimes. A partial equilibrium, static simulation model was used for the analysis. National data on price, quantities demanded and supplied, and research data in 1999 and elasticities of supply and demand were used to calibrate the base equilibrium model. Impacts of three different policy scenarios were assessed using the base equilibrium model. In the first scenario, the impact of research with trade protection was discussed. In this scenario, the Net Annual Research Benefits (NARB), gross return net of expenditure on rice research, was Rs. 58,220 million. In the second scenario, the impact of research impact under free trade was discussed. In this scenario, NARB was Rs. 46,010 million. In the third scenario, the impact of research was discussed under self-sufficiency with free trade. In this scenario, NARB was Rs. 54,393 million. Self-sufficiency in rice could have been achieved by increasing rice research investment up to Rs. 46.56 million (on increase of 37% from Rs. 29.5 million). These results indicate that the impact of rice research was positive and substantial in Sri Lanka despite the trade regime. Similar results were obtained for rice research investment in other countries. It is concluded that the Sri Lankan government had under-invested on rice research and further increase in investment would have resulted in higher benefits.

INTRODUCTION

Returns to research investment

Investments in research and technology development (R and D) have contributed to modern agricultural development through productivity improvements. Beginning with Schultz in 1953 and Griliches in 1958, a large number of research evaluation studies have examined the rate of return to agricultural research investments. Summaries of these studies, which carry rates of return to agricultural research, are reviewed by Norton and Davis (1981), Ruttan (1982), Echeverria (1990) and Alston *et al.* (2000). Rates of return to agricultural R and D in developing countries range from -100 to 1,490 and in developed countries range from -14.9 to 5,645. Rates of return to rice research in different parts of the world range from 11.4 to 466.0. Return to research has shown different results depending on the policy regime, measurement of research benefits, author, commodity, and geographical region of the study. Alston *et al.* (2000) carried out a meta analysis of the return to agricultural R and D and explained reasons for variations in research results. The focus of this paper is on returns to rice research investment in Sri Lanka.

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Research and development in rice sector in Sri Lanka

Rice varieties suitable to different environments were developed through natural selection in the past. In 1902, over 300 rice varieties were being cultivated in the country. However, yields of these varieties were relatively low. This situation led to the initiation of a rice research and development program focussing on increasing productivity through variety improvement. In this program, three main phases can be identified. In Phase I, four different age classes were identified among traditional varieties. In these age classes, pure-line selections were made in the 1940s and of them, five varieties (*Podiwee*, a-8, M-302, VP-28724, PP-2462/11) with a yield potential of 2.0-2.5 mt per ha were released to farmers. In Phase II, a hybridization program was initiated in 1952 at the Central Rice Breeding Station (CRBS), Batalagoda. In 1957, four new varieties known as 'H Series' (H-9, H-4, H-7 and H-10) were released and these were adopted by farmers in a wide range of rice growing environments. This group of rice varieties was identified as the Old Improved Varieties (OIVs). In Phase III, with the influence of the International Rice Research Institute (IRRI), 'Bg' rice varieties were released in the 1970s. These varieties, called the New Improved Varieties (NIVs), have intermediate plant height, erect leaves and adequate resistance to bacterial leaf blight. Several 4-4.5 month varieties (Bg 90-2, Bg 400-1, Bg 379-2 and Bg 380) and 3.5 month varieties (Bg 94-1, Bg 94-2 and Bg 350) with a yield potential of 10 mt per ha were released to farmers. In the early 1980s, a high yielding short-aged variety, Bg 750 was released. Varieties of Bg 407 and Bg 745 with a better quality and higher yield potential were released in the late 1980s. However, some of these Bg varieties gave relatively lower yields than even some of the traditional varieties under some soil conditions (*e.g.*, in saline soils). After recognizing this limitation, rice improvement programs were initiated at the Bombuwela Research Station and in the other satellite stations situated in stressed environments during the 1970s. New varieties performing well in saline soils were released from Bombuwela. They were referred to as the Bw series. Improved cultivation practices have also been introduced from time to time. Altogether about 21 High Yielding Varieties (HYVs) are being cultivated by about 85% of the farmers in the country (Weerasinghe, 1994; Dhanapala, 2000). A hybrid rice program is the next major introduction to the Sri Lankan rice sector. This program was initiated for the first time in the early 1980s and then carried further in 1994 by scientists at the Rice Research Development Institute (RRDI), Batalagoda in collaboration with a team of Chinese scientists from the University of Sichuan (Jayaratne, 2000). Niranjan *et al.* (2000) evaluated the impact of rice research investments on rice production in Sri Lanka. It was found that a 1% increase in investment has increased rice production by 0.3%.

Trade liberalization in Sri Lanka

Sri Lanka along with the rest of the world is moving towards the gradual removal of restrictions on trade. Developing countries are expected to reduce their tariffs by 26% over the period 1995-2005 under the Uruguay Round of General Agreement on Tariffs and Trade (GATT) negotiations (Sandaratne, 1995; Meemeduma, 1995). The South Asian Preferential Trading Agreement (SAPTA) came into force in December 1995 and it was proposed to convert SAPTA into SAFTA (South Asian Free Trade Area) by the year 2001 promoting free trade (Perera, 2000; Somaratne, 2000). The Indo-Lanka Free Trade Agreement, would further liberalize trade between Sri Lanka and India (Alwis, 2000; Samarappuli, 2000). Currently rice is in Sri Lanka's negative list, in the trade agreements written so far, and hence the rice market is not presently affected by trade agreements. Tariff rate on rice imports during 1999 was around 35% which was raised to 49% after imposing an additional 14% surcharge in the year 2001.

Objective of the study

As indicated earlier the type of trade regime is one of the factors determining returns to research investment. The objective of this study is to simulate changes in returns to rice research under different trade regimes in Sri Lanka.

METHODS

The conceptual model

A partial-equilibrium static simulation model of an open economy is used in the analysis. The conventional commodity market model is assumed, with adjustments for market distortions arising from government interventions in the rice market. It is recognised that other factors such as environmental externalities of supply and the nature of the research induced supply shift also affect research benefits. Not all of these are taken into account in this exercise. A log-log supply function is selected and adjustments made for market distortions by way of trade protection. Graphical representation of the model employed to estimate social returns to research investments in a small importing country with protection is depicted in Fig. 1 (Alston *et al.*, 1995).

In Fig. 1, S_0 represents the supply curve in the absence of research investments. When this situation is considered under free trade, supply is Q_1. In the absence of research investments but with the enforcement of a protection on imports, supply increases to Q_2. S_1 represents the research-induced shift in the supply function. When this situation is considered under free trade, supply increases to Q_3. In the presence of research investments and a protection on imports, then supply increases to Q_4. S_2 represents the supply curve given a self-sufficiency situation in free trade, then supply increases to Q_5. The net annual research benefits (NARB) which is the change in producer surplus net of research investment expenditure, to rice research investments are discussed under three different trade policy scenarios. In the first scenario, the actual position, as of 1999 where a Nominal Protection Rate (NPR) of 16% is estimated, is calculated. In the second scenario, the potential NARB under a free trade regime is simulated. In the third scenario, NARB to research investments to achieve self-sufficiency under free trade is simulated. The basic assumption in the third scenario is that the objective of research investments is to achieve self-sufficiency in rice and estimate the level of investments required to achieve such self-sufficiency.

Producer surplus is measured by the area above the supply curve and below the price line. Gross Annual Research Benefits (GARB) is measured and discussed under three scenarios. In the first scenario, GARB is equal to the area AEO minus area ACO (area OCE) in Fig. 1. In the second scenario, GARB is equal to the area BFO minus area BDO (area ODF). In the third scenario, GARB is equal to the area BGO minus area BDO (area

ODG). NARB is equal to the GARB minus research investments in each scenario. Benefit Cost Ratio (BCR) is equal to the GARB divided by research investment.

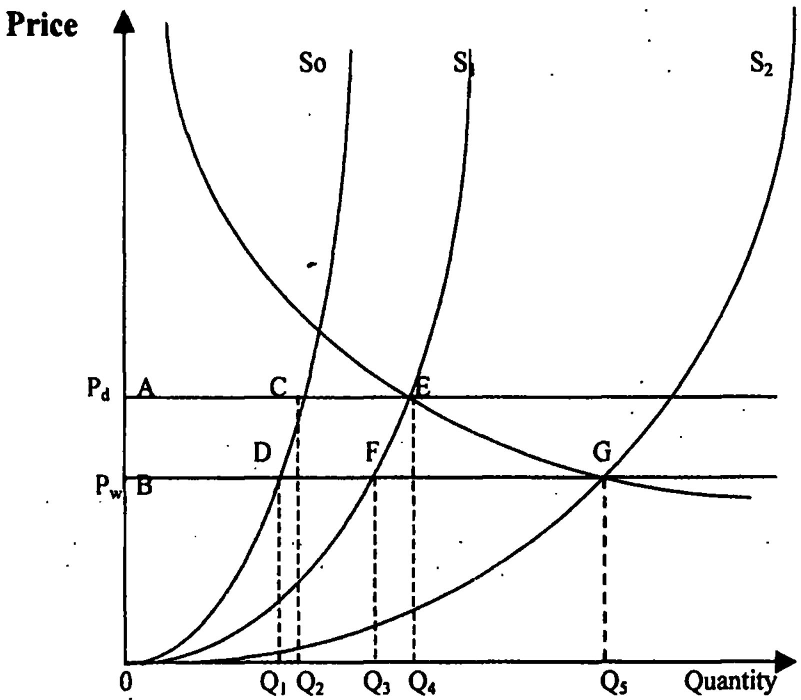

Fig. 1: Partial equilibrium model of estimating benefits to rice research in a small importing country with a trade protection.

The algebraic model used in this study based on this conceptual model is shown below.

$$S = e^{\alpha} P_d^{\beta} R^{\delta} \quad \ldots\ldots\ldots 1$$

$$P_d = P_w (1 + NPR) \quad \ldots\ldots\ldots 2$$

$$PS = e^{\alpha} R^{\delta} \frac{P_d^{(\beta+1)}}{(\beta+1)} \quad \ldots\ldots\ldots 3$$

$$NARB = PS - R \quad \ldots\ldots\ldots 4$$

Endogenous variables = S, P_d, PS, NARB
Exogeneous variables = R, P_w, NPR

S	=	Supply
R	=	Research investment expenditure
P_d	=	Domestic price of rice
P_s	=	Producer surplus
NPR	=	Normal Protection Rate
NARB	=	Net Annual Research Benefit
e	=	Natural log
α	=	Intercept term of the supply function
β	=	Price elasticity of supply
δ	=	Research elasticity of supply

The empirical model and data

In previous research benefit evaluation studies in the world, supply and demand functions are assumed to be either linear or non-linear. The supply shift is assumed to be either parallel or non-parallel. Research benefits occurring with linear parallel and linear non-parallel shifts have been compared by Lindner and Jarrett (1978), Rose (1980), Wise and Fell (1980) and, Norton and Davis (1981). The linear pivotal supply shift framework can be found in Lindner and Jarrett (1978) and Rose (1980). The GARB in linear-parallel supply shift is higher than that of linear non-parallel pivotal and proportional supply shifts, but lower than that of linear convergent supply shift. Peterson (1967), Ayer and Schuh (1972), Akino and Hayami (1975), Flores-Moya *et al.* (1978) and, Nagy and Furtan (1978) have adopted the non-linear constant elasticity pivotal supply shift framework among, others (Table 1). A comparison of research benefits from linear and non-linear specifications of the demand and supply curves was evaluated by Voon and Edwards (1991). The key point described by Voon and Edwards is that if a particular model specification is a better description of reality, then use of the alternative model specification can cause overestimation (or underestimation) of returns to research. Niranjan *et al.* (2000) in their analysis estimated and explained that the non-linear specification of the supply function describes data better than the other form for the Sri Lankan rice sector. In order to simulate the benefits, price elasticity of rice supply (0.59) and research elasticity of rice supply (0.37) are taken from Niranjan *et al.* (2000).

Table 1. Type of supply curve shifts, functional form and their measurements.

Type	Supply curve shift	Type of supply curve	Reference
Parallel	-	Linear	Griliches (1958)
Proportional	Proportional change	General specification	Peterson (1967)
Parallel	Horizontal shifter	Linear	Hertford and Schmitz (1977)
Pivotal	Production function	Constant elasticity	Akino and Hayami (1975)
Four shifts	Vertical shifter	Linear	Lindner and Jarrett (1978)
-	Vertical shifter	Linear kinked supply curve	Rose (1980)

Source: Norton and Davis. 1981.

In the supply function, price of seed paddy (Rs. per bushel) and proxy for weather (the ratio of rice area harvested to total rice area cultivated) are also shown as significant variables. However, their effects were added into the intercept term in the simulation exercise. The supply function used for policy simulation is given below:

$$lQs_t = 7.67 + 0.59 lP_{t-1} + 0.37\, lRES$$

where, at time t, lQs is the log of the quantity of paddy supplied (mt), lP_{t-1} is the log of the average nominal retail price of rice lagged by one year (Rs per kg) and lRES is the log of weighted average research investment (Rs.) on rice (nominal) lagged over 8 years and distributed as a polynomial for 5 years.

The research investment on rice was considered as a lag variable. Hence, nominal research investments from 1987-1991 (five years) were weighted by using the annual research elasticities calculated for that period and then compounded each using a 12% rate (the rate which is used by the World Bank for publicly funded research). The total compounded weighted research investment (nominal) calculated using the procedure above was Rs. 29.5 million and it was considered as the base-year (1999) value in the analysis. Price of rice was also considered as a one-year lag variable in the estimation. Hence, world price of rice in 1998 was compounded using the same rate (12%) and then adjusted to suit the base-year 1999. The compounded world market price of rice was considered as the nominal retail price and it was Rs. 27.93 per kg in 1999. Demand for rice to be achieved at the self-sufficiency level under free trade scenario is calculated at -0.1 price elasticity of rice demand (Appendix 1).

Table 2. Base-year, 1999 data set.

Variable	Value
Compounded world price (retail) of rice (Rs. per kg) (P_w)	27.93
Domestic rice supply (million kg) (S)	2,855
Compounded weighted total rice research investment (million Rs.) (R)	29.5
NPR	16%
Compound rate	12%
Price elasticity of rice demand	-0.1

The NPC on traded output is estimated using the following formula (Monke and Pearson, 1994).

$$NPC = \frac{Private\ (market)\ price}{Social\ (world)\ price}$$

The calculation of NPC for rice in 1999 is done taking the rice wholesale market as the point of reference. Then;

$$NPC\ for\ rice = \frac{Average\ wholesale\ price\ for\ domestic\ rice\ (Rs/kg)}{Average\ wholesale\ price\ for\ imported\ rice\ (Rs/kg)}$$

$$NPC\ for\ rice\ during\ 1999 = \frac{25.78}{22.31} = 1.16$$

$$NPR = 100\,(NPC - 1) = 16\%$$

NPC of 1.16 shows that due to government policies market price of rice was maintained at a level 16% higher than the world price.

Base year data set is presented in Table 2. The TSP (Time Series Package) was used to simulate the NARB in this analysis.

RESULTS AND DISCUSSION

The equilibrium values of the simulation exercise are shown in Table 3. Rice research impact under three different trade regimes is shown in Table 4.

Scenario 1: Research impact with trade protection

The Sri Lankan rice sector with research investments as of 1987-1991 and current protection level is considered as the basis for the analysis. With rice research investments of Rs. 29.5 million and a NPR of 16%, retail price of rice was Rs. 32.40 per kg and domestic supply was 2.855 million mt GARB was Rs. 58,249 million. GARB is calculated by subtracting the equilibrium Producer Surplus (PS) in the absence of research with protection from the PS in the presence of research under protection. NARB was Rs. 58,220 million, and BCR was 1975.

Table 3. Equilibrium values of the simulation exercise.

Item	With research under protection	No research under protection	No research under free trade	With research under free trade	Self-sufficiency under free trade
Price (Rs./kg)	32.40	32.40	27.93	27.93	27.93
S (mn mt)	2.86	0.005	0.004	2.62	3.09
R (Rs. mn)	29.50	0.00	0.00	29.50	46.56
PS (Rs. mn)	58,356	106.7	84.4	46,,123	54,524

Scenario 2: Research impact in free trade

Given the existing amount of research investments (Rs. 29.50 million) in the context of free trade, the analysis indicates that retail price would fall by 16% from Rs. 32.40 - 27.93 per kg. Supply would decrease by 9% from 2.855 - 2.616 million mt GARB would decrease by 27% from Rs. 58,249 - 46,039 million. In this scenario, GARB is calculated by subtracting the equilibrium PS in the absence of research under free trade, from the PS in the presence of research under free trade. NARB would also decrease by 27% from Rs. 58,220 - 46,010 million. BCR would also decrease by 27% from 1,975 - 1,561.

Table 4. Rice research impact under three different trade regimes in Sri Lanka.

Item	Scenario I Trade protection	Scenario 2 Free trade		Scenario 3 Self-sufficiency under free trade	
Proce (Rs./kg)	32.40	27.93	(-16)	27.93	(-16)
S (mn mt)	2.855	2.616	(-9)	3.086	(8)
R (Rs. mn)	29.50	29.50	(0)	46.56	(37)
GARB (Rs. mn)	58,249	46,039	(-27)	54,440	(-7)
NARB (Rs. mn)	58,220	46,010	(-27)	54,393	(-7)
BCR	1,975	1561	(-27)	1169	(-69)

Figures in parenthesis are percentage change from Scenario 1.

Scenario 3: Research impact when achieving self-sufficiency in free trade

Research investment in rice is the supply shifter considered in this analysis and it is employed here to show how the self-sufficiency conditions are to be met. The compounded weighted total rice research investment in 1999 was Rs. 29.5 million and, increasing that amount by 37% to reach Rs. 46.56 million, would enable Sri Lanka to achieve self-sufficiency in rice production under free trade. In such a situation, domestic price of rice would have been equal to the world market price of Rs. 27.93 per kg (decrease by 16% from Rs. 32.40 kg). Then, the total rice quantity demanded in 1999, that is 3.086 million mt (considered as the demand to achieve the self-sufficiency level under free trade with research investment), would have been met by domestic supply resulting in zero net imports of rice. As a whole, GARB would have been Rs. 54,440 million (decreased by 7% from Rs. 58,249), which would have been distributed among rice producers as their share. In this scenario, GARB is calculated by subtracting the equilibrium PS in the absence of research under free trade, from the PS at the self-sufficiency level under free trade. The NARB would have been Rs. 54,393 million (decreased also by 7% from Rs. 58,220 million). BCR would have been 1,169 (decrease by 69% from 1,975).

CONCLUSIONS

The effects of trade policies on returns to rice research investments are discussed under three different scenarios. In the first scenario, the actual position as of 1999, where a NPR of 16% was imposed, is considered. The Sri Lanka government, invested about Rs. 12,210 million on rice research in 1999 to improve the production of rice farmers. The results of this study show that return to this investment is very high. The results of this study can be compared with early studies, where extraordinarily high returns to rice research were observed and it indicates too little investment in rice research in the past. This situation has been explained as a very serious degree of resource mis-allocation by both national and international policy makers. It can therefore be concluded that the Sri Lankan government had also under-invested on rice research and further increase would have resulted in higher benefits. Research investments under a free trade regime (scenario 2), and increased research investment to achieve self-sufficiency (scenario 3) bring in leaser benefits.

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APPENDICES

Appendix 1. Results of the linear-log demand estimation.

Explanatory variable	Coefficient	t-Statistics
Constant in the demand function	0.24***	4.25
Log of retail price of rice	-0.02*	-1.82
Log of retail price of wheat flour	0.02***	2.67
Log of income proxy	0.004	1.40
Log of one year lag-per capita demand for rice	0.06***	2.74
R^2 = 0.54		
Adjusted R = 0.50		
Durbin-Watson = 2.1		
Auto Correlation Coefficient = -0.29		
Method of estimation: AR1 (Maximum Likelihood Iterative Technique)		
Sample period: 1951-1999		
Number of observation = 49		

* Significant at 10% ** Significant at 5% *** Significant at 1%