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# The Economic Impact of Public Rice Research in Thailand

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## Abstract

This study provides a measure of the current state of technical knowledge determined in part by current and past public investment in rice research. With respect to the technical knowledge, rice production function is estimated. The result reveals that the improvement of technical knowledge enhances the land productivity and also leads to the changes in rice production structure. Since rice planted areas are expanded along with the employment of agricultural manual workers, the cost is no doubt increased. The public rice research represents a crucial driving force for encouraging the growth of production. Further, the social welfare deriving from public investment in rice research is estimated by using Marshallian concept. The result reveals that the cumulative economic surplus is quite high. As a consequence, the B/C ratio implies that those investments generate a benefit of 6.92, 6.25 and 5.68 Baht for every Baht spent by 5, 10 and 15% discount rate, respectively.

**Keywords:** Public Investment, Rice Research, Technical Knowledge, Rice Production, Economic Surplus

# 1. Introduction

Agricultural research is treated as an economic activity. The resources that are allocated to various research enterprises are readily observed and measured. Nevertheless, the value of the knowledge that is produced by these enterprises is always difficult to be determined (Schultz, 1984). The principal resources consist of scientific personnel, laboratory facilities, test plots, etc. The knowledge may come in more applied forms such as higher yielding varieties of crops. It may come in forms that would be directly utilized by farmers such as knowledge about the nutrient requirement of livestock (Adulavidhaya *et al.,* 1987). Moreover, the knowledge resulted from research is typically endowed with the attributes of the public good: nonrivalness and nonexcludability. Given such attributes of the knowledge, a socially optimum level of investment in research would hardly be expected if it were left to private firms. The public support is still required in order to correct the failure of market mechanism (Akino and Hayami, 1975).

According to Thailand's agricultural research, the largest share of government budget was for crop research with relatively small budgets for livestock, forestry and fisheries (Fan *et al.,* 2004). Of these crop researches, the rice research continuously received the highest priority. From 1960 to 2000, Rice Research Institute[3] was the most funded government agency for rice research with an average budget of 111.20 million Baht at 1988 price or 35.74% of all agricultural

[3] From 1960 to 2000, Rice Research Agency was mainly restructured twice. In 1972, Department of Rice within Ministry of Agriculture was adjusted to be Rice Section within Department of Agriculture. In 1982, it was changed to be Rice Research Institute within Department of Agriculture. Finally, in 2006, it has been restructured to be Bureau of Research and Development within Department of Rice.

research budgets (Table 1). These budgets funding several research activities lead to technological development in rice production. The historical background of rice research is reviewed as follows.

The first rice research station was established in 1916. Head selections and variety yield trails were started, with emphasis on grain quality and yield. Rice breeding work began on intensive scale in 1950. Initial work involved with the identification of superior types from the existing material collected from the fields. In 1954, a big boost to rice research occurred with the Rice Department was established from an agency under the governance of the Ministry of Agriculture. During the period, hybridization breeding and mutation breeding were both particularly initiated. Research of soil fertility, plant protection and mechanization were also started or intensified during this period (Welsch and Tongpan, 1972).

During the 1960s, the Green Revolution that developed in Asia had a dramatic and pervasive impact on the tropical Asian rice economy. The major source of growth shifted from the crop area expansion to the increase in yields per hectare. Those yield increases were made possible by the widespread adoption of fertilizer-responsive, high-yielding modern rice varieties introduced in 1966 (David and Otsuka, 1994). The year of 1966 was a turning point for rice improvement in Thailand, when a Thai breeder crossed the line IR-8-288-3 from International Rice Research Institute (IRRI) with a local tall variety. Later, the first two non-glutinous, semi-dwarf, non-photoperiod sensitive and high yielding varieties were released. They were named RD1 and RD3. Although their yields were not as high as IR8, the grain qualities were far better. Because the short-stem rice was not appropriate enough for the lowland flooding area, i.e. the Central Plain, the breeding of deep-water rice has been emphasized since 1974. The RD varieties that were progeny lines of the cross between IR and local varieties were RD1, RD2, RD3, RD7, RD11, RD17, RD19, RD23 and RD25 (Pochanukul, 1986).

Therefore, the first question of how the public investment for rice research affects production is examined. Furthermore, the returns of these investments to society have been intuitively quite high. Nevertheless, Thailand's rice research has been quantitatively known little of these benefits. It consigns this article to the second question of how much the public investment in rice research benefits to social welfare.

**Table 1** Agricultural and Rice Research Budget

(Value: Million Baht at 1988 price)

| Year | (1) Agricultural Research Budget | (2) Rice Research Budget | (2)/(1) |
|---|---|---|---|
| 1960-1969 | 189.69 | 54.40 | 28.68% |
| 1970-1979 | 285.39 | 91.96 | 32.22% |
| 1980-1989 | 271.85 | 106.00 | 38.99% |
| 1990-2000 | 446.80 | 192.45 | 43.07% |
| 1960-2000 | 298.43 | 111.20 | 35.74% |

*Note*: The figures are represented as the average value during the concerning period.

*Source*: Bureau of Budget

## 2. Conceptual Framework and Theoretical Model

To answer two questions of this study, the conceptual framework was formulated (Figure 1). The rice research budget would stand for the research inputs, i.e. scientific personnel, material, etc. in order to produce the technical knowledge, i.e. higher yielding varieties, modern techniques, etc. Technical knowledge would show the increase in rice production. With this hypothesis, it would result in the rice supply. Using Marshallian concept of social welfare, the shift in rice supply schedule would be viewed as beneficial to the economic surplus. To evaluate the contribution of public investment in rice research to social benefit, the economic surplus was compared with the budget of rice research.

Such framework developed two theoretical models. The model of estimating production with consideration of the technical knowledge is illustrated in the section 2.1). The model of estimating social welfare is described in the section 2.2).

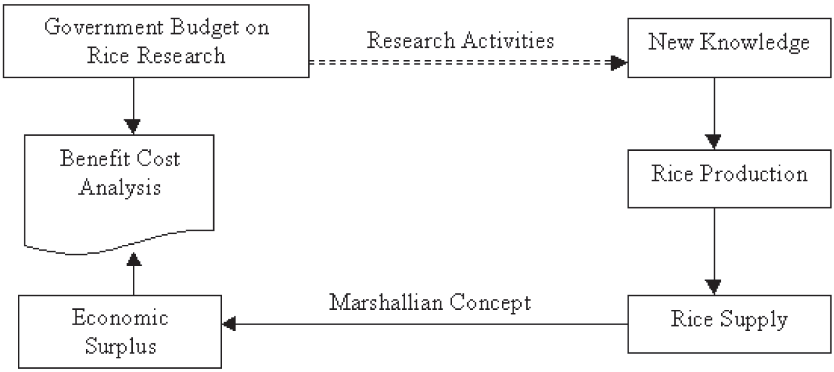



**Figure 1** Conceptual Framework

### 2.1 Model of Production with Consideration of Rice Research

According to Griliches (1979), let Y = F(X, K, u) be the production function connecting some measure of output or productivity, Y, to the input X, K and u, where X stand for an index of conventional inputs, K is a measure of the current state of technical knowledge determined in part by current and past research expenditure and u stand for all other unmeasured determinants of output. Let us also assume that there exists a relationship between K, the current level of technical knowledge, and W(B)R, an index of current and past levels of research investment, where W(B) is a lag polynomial, describing the relative contribution of past and current research and development levels to K. B is the lag (backward shift) operator. Thus,

$$K = G[W(B)R, v] \qquad ...(1),$$

where v is other set of unmeasured influenced on the accumulated level of knowledge and

$$\begin{aligned} W(B)R &= (W_0 + W_1B + W_2B^2 + ...)R_t \\ &= W_0R_t + W_1R_{t-1} + W_2R_{t-2} + ... \qquad ...(2). \end{aligned}$$

Based on the above theoretical model, the econometric models of estimating rice production are formulated. Before going on, the current state of technical knowledge is computed first. In the way of econometrics, the equation (1) and (2) imply that the polynomial distributed lag model should be employed in order to compute the current state of technical knowledge. Nevertheless, Pochanukul (1992 cited in Oungsawat, 1995) has revealed that in case of Thailand's rice production, the polynomial distributed lag model failed to accept in the statistical sense. Thus, Pochanukul utilized a direct search method for the measure of technical knowledge (G). Ultimately, it is determined by the government expenditure on rice research in real term. Let $X_4$ be the variable of current state of technical knowledge. The formula can be expressed as follows:

$$X_{4,t} = 0.2G_{t-1}+0.4G_{t-2}+0.6G_{t-3}+0.8G_{t-4}+1.0G_{t-5}+0.9G_{t-6}+0.8\,G_{t-7} +0.7G_{t-8}+ \ldots +0.1G_{t-14} \quad \ldots(3).$$

Attention now turns to be the model specification of rice production. A Cobb Douglas function has been employed in this study. With the assumption of constant return technology, the logarithm transformation is specified. Furthermore, Log-Log model is separated into two types. The first one utilizes the land productivity, paddy quantity per unit of the planted area, as the dependent variable. It has been expressed as follows:

$$Ln[(Y/X_1)_t] = \beta_0 + \beta_1 Ln[(X_2/X_1)_t]+ \beta_2\, Ln[(X_3/X_1)_t] + \beta_3 Ln(X_{4,t}) + u_t \quad \ldots(4),$$

where Y = the total production of paddy in million tons. The variable of $X_1$, $X_2$, and $X_3$ is played a role of the conventional inputs in production, where $X_1$ = the planted area in million rais, $X_2$ = the weather variable, the ratio of harvested area to planted area is a proxy of this variable according to Pochanukul (1986). The variable of $X_3$ is the utilization of chemical fertilizers in million tons. With respect to the shift variable of the production function, $X_4$ = the current state of technical knowledge as previously seen. The uncorrelated random error terms (u) are assumed to be zero mean and constant variance. The $\beta_1$, $\beta_2$ and $\beta_3$ is expected to be greater than zero.

The second model employs the paddy quantity as the dependent variable. Since the effect of technical knowledge on the rice planted area expansion should be test first, the model is specified in the recursive system as follows:

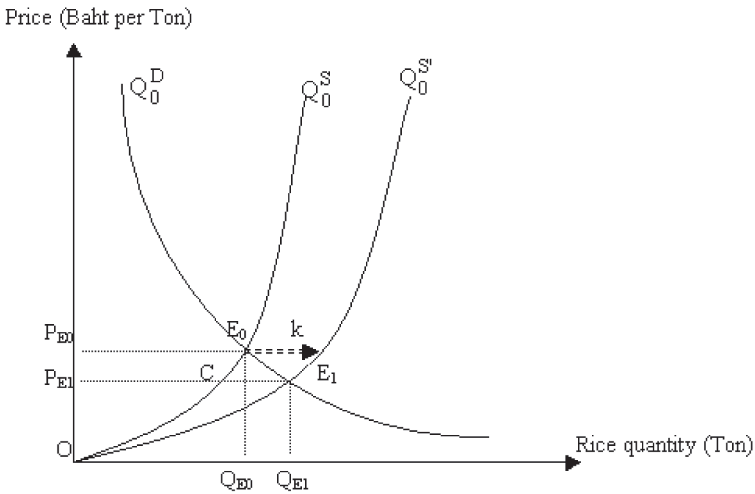
$$Ln(X_{1,t}) = \alpha_{1,0} + \alpha_{1,1}Ln(X_{4,t}) + u_{1t} \quad ...(5),$$

$$Ln(Y_t) = \alpha_{2,0} + \alpha_{2,1}Ln(X_{1,t}) + \alpha_{2,2}Ln(X_{2,t}) + \alpha_{2,3}Ln(X_{3,t}) + u_{2t} \quad ...(6),$$

where the disturbances ($u_1$ and $u_2$) are assumed to be zero contemporaneous correlation. The $\alpha_{1,1}$, $\alpha_{2,1}$, $\alpha_{2,2}$ and $\alpha_{2,3}$ is expected to be greater than zero.

## 2.2 Model of Estimating Social Welfare

With such hypothesis, the improvement of technical knowledge deriving from rice research is shown to increase rice production and results in the supply of rice, which in turn increases social welfare. The model of estimating social welfare is based on Akino and Hayami (1975). Using the Marshallian concepts of social return and cost, social returns to rice research are measured in terms of changes in economic surpluses, which result from the shift in the rice supply curve corresponding to a shift in the production function. This relation is shown in Figure 2 in which $Q_0^D$ and $Q_0^S$ is repectively the market demand and supply curves, whereas $Q_0^{S'}$ represents the supply curve that will exist if the current state of rice technical knowledge develops. At the retail level, assuming competitive market equilibrium, no rice import, no government intervention, the shift in the supply curve from $Q_0^S$ to $Q_0^{S'}$ increases economic surplus by area $OCE_1$ + area $E_0E_1C$.




*Source*: Based on Akino and Hayami (1975)

**Figure 2** Impacts of Rice Research on Demand-Supply Model

For quantitative estimation, the first step in estimating the changes in economic surpluses is the specification of the demand and supply curve. In this study a constant elasticity demand is assumed as $Q_0^D = aP^{-\eta}$, where $Q_0^D$ and P is respectively the quantity and the retail price of rice, and $\eta$ is the retail price elasticity of demand. Similarly, a constant elasticity supply function is assumed as $Q_0^S = bP^{\alpha}$, where $\alpha$ is the retail price elasticity of demand. Moreover, a hypothetical supply curve is assumed to be exiting in the case of full use of current state of technical knowledge as $Q_0^{S'} = (1+k)bP^{\alpha}$, where k represents the rate of shift in the supply function due to improved rice knowledge. Using integral technique, the following formulas held in equilibrium:

$$\text{area } E_0E_1C = \left\{\frac{a^{\frac{\alpha+1}{\eta+\alpha}}\, b^{\frac{\eta-1}{\eta+\alpha}}}{1-\eta}\left(1-\left(\frac{1}{1+k}\right)^{\frac{1-\eta}{\eta+\alpha}}\right)\right\} - \left\{\frac{a^{\frac{\alpha+1}{\eta+\alpha}}\, b^{\frac{\eta-1}{\eta+\alpha}}}{\alpha+1}\left(1-\left(\frac{1}{1+k}\right)^{\frac{\alpha+1}{\alpha+\eta}}\right)\right\} \quad ...(7),$$

and area $OCE_1 = a^{\frac{\alpha+1}{\eta+\alpha}} b^{\frac{\eta-1}{\eta+\alpha}} \left(\frac{k}{\alpha+1}\right)\left(\frac{1}{1+k}\right)^{\frac{\alpha+1}{\eta+\alpha}}$ ...(8).

In order to assess the contribution of public investment in rice research to social welfare, the social benefits are compared with the expenditure of rice research by computing the benefit cost ratio (B/C Ratio) as the following formula.

$$\text{B/C Ratio} = \sum_{t=1}^{n} \frac{B_t}{(1+r)^t} \Big/ \sum_{t=1}^{n} \frac{C_t}{(1+r)^t} \quad ...(9),$$

where $B_t$ = the economic surplus in year t, $C_t$ = the government budget on rice research in year t and r = the discount rate.

## 3. Result and Discussion

### 3.1 Impacts of Public Rice Research on Productivity

The rice research conducted by the government agency, Rice Research Institute, was focused on this study. The scope of current state of technical knowledge in the equation (3) was based on data from 1974 until 2000 because the complete data set for rice research budget was available from Bureau of Budget. In addition, the data set for production of paddy, the planted area, the harvested area and the usage of chemical fertilizer on paddy were drawn from Office of Agricultural Economics. The models of estimating production were estimated by the ordinary least squares method.

The estimation result is reported in Table 2. The estimated coefficients are consistent with the expectation of sign. Although some coefficients are statistically insignificant, it would be acceptable in the econometric sense because this problem is only derived from high correlation between two independent variables. Further, since the adjusted $R^2$ and three diagnostic tests for econometric problems, both of the estimated models perform well. The discussion of main results is dividing into two parts; first, the role of technical knowledge in land productivity is illustrated, second, the effect of technical knowledge on the expansion of rice planted area is described and then technical knowledge reflects the changes in rice production structure.

**Table 2** Rice Production Function with Consideration of Technical Knowledge

**Model 1: Land productivity function**

$$Ln[(Y/X_1)_t] = 3.88 + 0.19Ln[(X_2/X_1)_t] + 0.02Ln[(X_3/X_1)_t] + 0.41Ln(X_{4,t})$$

t-statistic (2.34)** (0.89)$^{NS}$ (0.28)$^{NS}$ (2.89)**

Adjusted $R^2$ = 0.79, LM test = 1.13(0.29), ARCH test = 0.20(0.66), RESET test = 2.26 (0.15)

$r_{Ln(X_2/X_1),Ln(X_3/X_1)} = -0.72$, $r_{Ln(X_3/X_1),Ln(X_4)} = 0.95$

**Model 2**

**Effect of technical knowledge on rice planted area expansion**

$$Ln(X_{1,t}) = 3.25 + 0.13Ln(X_{4,t}) + [AR(1) = 0.35]$$

t-statistic (11.35)** (3.06)**

Adjusted $R^2$ = 0.55, LM test = 0.10(0.75), ARCH test = 0.32(0.57), RESET test = 0.06(0.81)

**Rice production function**

$$Ln(Y_t) = 1.50 + 2.06Ln(X_{1,t}) + 1.18Ln(X_{2,t}) + 0.12Ln(X_{3,t}) + [AR(1) = -0.69, AR(2) = -0.48]$$

t-statistic (0.63)$^{NS}$(3.61)** (3.39)** (3.59)**

Adjusted $R^2$ = 0.86, LM test = 1.05(0.31), ARCH test = 0.05(0.83), RESET test = 1.01(0.33)

*Note*: An asterisk ** denoted statistical significance at the 0.05 level.
An asterisk $^{NS}$ denoted non-statistical significance at the 0.05 level.
LM test: The probability of accepting the null hypothesis implies that the residuals are not autocorrelated at the level of confidence interval as mentioned by p-values in parenthesis.
ARCH test: The probability of accepting the null hypothesis implies the residuals are homoscadastic at the level of confidence interval as mentioned by p-values in parenthesis.
RESET test: The probability of accepting the null hypothesis implies that the model is correctly specified at the level of confidence interval as mentioned by p-values in parenthesis.
$r_{X1,X2}$ = Correlation between $X_1$ and $X_2$. AR (n) = Autoregressive order n.

## *Role of Technical Knowledge in Land Productivity*

According to the first model in Table 2, the improvement of current state of technical knowledge significantly enhanced the land productivity. It is succinctly stated that the public investment in rice research is viewed as beneficial to yield per rai. This inference conformed to the findings of Pochanukul (1986) and Isvilanonda *et al*. (1997). In order to support this argument, the following descriptive evidence is illustrated. The technical knowledge that was provided by Rice Research Institute mainly would come in the form of recommended varieties. One of them is represented as the modern rice varieties (MVs) that are non-photoperiod sensitive varieties, e.g. Chainart1, Pratoomtanee1 and Supanbulee60, 90 etc. Since the yields of MVs are normally higher than those of local varieties (LVs), the substitution of MVs for LVs raises paddy output per planted area over the past several years.

**Table 3** Average Land Productivity

(Unit: kilogram per rai)

| | Whole Kingdom | Region[a] North | Northeast | Central | South |
|---|---|---|---|---|---|
| Total | 504.54 | 549.88 | 364.93 | 578.01 | 382.44 |
| 1. Major Rice Crop (1989-2005) | | | | | |
| 1.1) Local Varieties | 324.26 | 334.21 | 264.79 | 316.83 | 312.87 |
| 1.2) Modern Rice Varieties | 506.73 | 486.44 | 335.60 | 573.85 | 390.08 |
| 2. Second Rice Crop (1991-2005) | | | | | |
| 2.1) Modern Rice Varieties | 619.47 | 658.80 | 449.62 | 693.21 | 436.49 |

*Note*: [a] The data set in 1998 is not available.

The figures are represented as the average value during the concerning period.

*Source*: Office of Agricultural Economic

Based on the rice crop survey report from 1989 to 2005, Office of Agricultural Economics revealed that the major rice yields of LVs was only 324 kilograms per rai despite those of MVs was approximately 507 kilograms per rai. Meanwhile, from 1991 to 2005 the second rice yields of MVs was roughly 619 kilograms per rai. Particularly in the Central Region, the major and second rice yield of MVs was roughly 574 and 693 kilogram per rai, respectively (Table 3). Nevertheless, the rice production can broadly be defined depending upon the production environment: irrigated and rainfed environment. Farmers in the rainfed environment still grow the local varieties and only one crop per year, which yield very low amount per rai in relative to MVs. On the other hand, the modern RD varieties have gained acceptance among Thai farmers in irrigated areas, especially in the Central Plain. An important acceptance factor is that they are not photoperiod-sensitive, which enables farmers to increase cropping intensity as well as yield (Isvilanonda and Wattanutchariya, 1994).

## *Role of Technical Knowledge in Production Structure*

Regarding to the second model in Table 2, the improvement of knowledge deriving from the rice research had significant impacts on the expansion of rice planted area and then it resulted in the paddy output. As the estimated production function, not surprisingly, the planted area elasticity of production is still comparatively high. It is further stated that the public investment in rice research benefits to increase in paddy output. In order to support this proposition, the following descriptive evidence of changing in rice production structure from 1989 to 2005 is reviewed. The illustration is based on the set of time series data for the planted area that is surveyed by Office of Agricultural Economics.

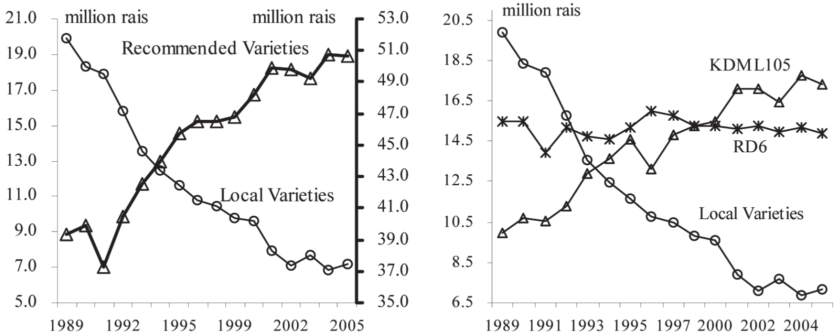



**Figure 3** Planted Area of Major Rice Crop

The largest share of the planted area was for a major rice crop (about 90%) with relatively quite small planted area for a second rice crop (about 10%). The major rice crop planted area of local varieties shrunk from 19.90 million rais in 1989 to 7.15 million rais in 2005 (Figure 3). On the average, the planted area of local varieties was only 20% of total planted area of major rice crop (Table 4). Attention now turns to the planted area expansion of the recommended varieties derived from the rice research. For the major rice crop, the planted area of the recommended varieties expanded from 39.29 million rais in the year 1989 to 50.62 million rais in the year 2005, or roughly 80% of total planted area of major rice crop (Table 4).

**Table 4** Planted Area

(Unit: million rais)

| | Whole | Region | | | |
|---|---|---|---|---|---|
| | **Kingdom** | **North** | **Northeast** | **Central** | **South** |
| Total | 64.09 | 14.79 | 32.44 | 14.04 | 2.81 |
| 1. Major Rice Crop (1989-2005)[a] | 57.16 | 12.58 | 31.90 | 10.05 | 2.64 |
| | (100%) | (100%) | (100%) | (100%) | (100%) |
| 1.1) Local Varieties | 11.69 | 3.53 | 3.54 | 2.65 | 1.97 |
| | (20%) | (28%) | (11%) | (26%) | (74%) |
| 1.2) Recommended Varieties | 45.47 | 9.05 | 28.36 | 7.39 | 0.66 |
| | (80%) | (72%) | (89%) | (74%) | (26%) |
| (1) Modern Rice Varieties | 8.75 | 3.31 | 0.86 | 4.21 | 0.37 |
| (2) Photoperiod Sensitive Varieties | 36.72 | 5.74 | 27.49 | 3.18 | 0.30 |
| -KDML105 | 14.25 | 1.24 | 12.05 | 0.92 | 0.05 |
| -RD6 | 15.14 | 2.18 | 12.92 | 0.04 | 0.00 |
| -Others | 7.32 | 2.32 | 2.52 | 2.23 | 0.25 |
| 2. Second Rice Crop (1991-2005)[b] | 6.93 | 2.21 | 0.54 | 3.98 | 0.16 |

*Note*: [a] In 1998, the data set is not available.

[b] In 1992 and 1993, the data set is not available.

The figures are represented as the average value during the concerning period.

*Source*: Office of Agricultural Economic

Moreover, the recommended varieties are broadly separated into photosensitive and non-photosensitive varieties. Two of the most important types in the photosensitive varieties are KDML105 (non-glutinous rice) and RD6 (glutinous rice) because of their quality. Mostly, they are cultivated in the northeastern and some areas of upper northern region. Their expansion of the planted area is motivated by the higher price. In the northeastern region, the farmers are increasingly growing KDML105 because it yields a relatively higher price and easy to penetrate the market As a consequence, the planted area for growing KDML105 expanded from 9.95 million rais in the year 1989 to 17.29 million rais in the year 2005. While during that period, the RD6 planted area remained rather unchanged (Figure 3). On the average, the planted area of RD6 and KDML105 accounted for 33 and 31% respectively of the rice planted area of recommended varieties (Table 4).

Therefore, over the last two decades, the rice planted areas of recommended varieties replaced for those of local varieties. This reflects the increase in paddy output is mainly due to the allocation of land for growing the recommended varieties. In other words, the increase in paddy output results from the changes in rice production structure. In short, it affirms the argument taking from the estimated recursive model: the improvement of technical knowledge deriving from the stock of public investment in rice research would be beneficial to paddy output.

## 3.2 Impacts of Public Rice Research on Social Welfare

Since the improvement of technical knowledge increases paddy output as seen in earlier section, it results in increasing social welfare through supply perspective. Based on the equation (7) and (8) in the section 2.2), the economic surplus was computed by substituting several estimated parameters. Most of them were drawn from the related literatures (Table appendix a.). The scope was analyzed over the past 15 years: 1986 to 2000.

The result reveals that the accumulation of economic surplus is estimated to have been approximately 19,399.52 million Baht at 1988 price (Table 5). This result is consistent with the findings of Setboonsarng *et al*. (1991) and Oungsawat (1996) in the way that the public investment in rice research is shown to increase Thailand's social welfare. In order to evaluate this benefit, B/C ratios are basically calculated by selected discount rate. As the results, the public investment in rice research generated a benefit of 6.92, 6.25 and 5.68 Baht for every Baht spent by 5, 10 and 15 percent discount rate, respectively (Table 5). This result conforms to the findings of Adulavidhaya *et al*. (1986), Areekul *et al*. (2000) and Isvilanonda *et al*. (2000) in the way that the public investment in rice research yields similarly high returns.

With regard to the sensitivity analysis, the different cases about the elasticities of demand (η) & supply (α) and about the rates of shift in supply curve (k) resulted in the different estimates of cumulative economic surplus and benefit cost ratio. The results of analysis reveal that their estimates are sensitive to the rates of shift in supply. On the other hand, they are rather insensitive to their respective price elasticities (Table 6). Since the rates of shift in supply curve (k) are directly estimated in this paper even though the elasticities of demand (η) and supply (α) are drawn from the related literature, the estimates of economic surplus and benefit cost ratio are still acceptable by conventional standards.

**Table 5** Economic Surplus and Rice Research Expenditure

(Unit: Million Baht at 1988 price)

| Year | Economic Surplus | Rice Research Expenditure |
|---|---|---|
| 1986-1990 | 336.51 | 112.79 |
| 1991-1995 | 964.46 | 182.36 |
| 1996-2000 | 2,578.94 | 211.56 |
| 1986-2000 | 1,293.30 | 168.90 |
| Accumulation Value | 19,399.52 | 2,533.57 |
| B/C Ratio | Net Present Value at r = 5% | |
| 6.92 | 11,514.77 | 1,663.58 |
| B/C Ratio | Net Present Value at r = 10% | |
| 6.25 | 7,233.54 | 1,156.53 |
| B/C Ratio | Net Present Value at r = 15% | |
| 5.68 | 4,805.07 | 845.65 |

*Note*: The figures in four first rows are represented as the average value during the concerning period.

**Table 6** Sensitivity Analysis

**a.** Rate of shift in supply curve remained the same (k)

| Price Elasticity Of Demand (η) | Price Elasticity of Supply (α) | Accumulation Value of Economic Surplus at 1988 price (Million Baht) | Benefit Cost Ratio (B/C Ratio) Discount rate 5% | 10% | 15% |
|---|---|---|---|---|---|
| η = 0.986 | α = 0.153 | 19,399.52 | 6.92 | 6.25 | 5.68 |
| η+25%η | α = 0.153 | 19,529.86 | 6.97 | 6.29 | 5.71 |
| η= 0.986 | α +25%α | 18,786.67 | 6.70 | 6.06 | 5.50 |
| η+25%η | α +25%α | 18,930.64 | 6.75 | 6.10 | 5.54 |
| η-25%η | α = 0.153 | 19,347.79 | 6.90 | 6.24 | 5.67 |
| η= 0.986 | α -25%α | 20,057.28 | 7.16 | 6.47 | 5.88 |
| η-25%η | α - 25%α | 19,347.79 | 6.90 | 6.24 | 5.67 |

**b.** Rate of shift in supply curve decreased to 25% (k-25%k)

| | | | | | |
|---|---|---|---|---|---|
| η = 0.986 | α = 0.153 | 14,577.91 | 5.20 | 4.70 | 4.27 |
| η+25%η | α = 0.153 | 14,651.57 | 5.23 | 4.72 | 4.29 |
| η= 0.986 | α +25%α | 14,115.57 | 5.04 | 4.55 | 4.13 |
| η+25%η | α +25%α | 14,196.94 | 5.06 | 4.57 | 4.15 |
| η-25%η | α = 0.153 | 14,548.66 | 5.19 | 4.69 | 4.26 |
| η= 0.986 | α -25%α | 15,073.59 | 5.38 | 4.86 | 4.41 |
| η-25%η | α - 25%α | 15,050.35 | 5.37 | 4.85 | 4.41 |

**c.** Rate of shift in supply curve increased to 25% (k+25%k)

| | | | | | |
|---|---|---|---|---|---|
| η = 0.986 | α = 0.153 | 24,202.56 | 8.64 | 7.80 | 7.09 |
| η+25%η | α = 0.153 | 24,405.26 | 8.71 | 7.86 | 7.14 |
| η= 0.986 | α +25%α | 23,440.96 | 8.36 | 7.56 | 6.87 |
| η+25%η | α +25%α | 23,664.84 | 8.44 | 7.62 | 6.92 |
| η-25%η | α = 0.153 | 24,122.13 | 8.61 | 7.78 | 7.07 |
| η= 0.986 | α -25%α | 25,020.85 | 8.93 | 8.07 | 7.33 |
| η-25%η | α - 25%α | 24,956.95 | 8.91 | 8.05 | 7.32 |

## 4. Conclusion and Implication

According to the public crop researches, the rice research has been continuously received the highest priority. The current and past public expenditures allocated to Rice Research Institute would lead to the development of technical knowledge. It can be measured in the applied forms, particularly, the recommended varieties: photoperiod and non-photoperiod sensitive varieties (modern rice varieties, MVs). Thus, leading to the first question of how the public investment in rice research affects production was examined.

The result of the first model reveals that the improvement of technical knowledge derived from rice research significantly enhances the land productivity. This is because the yields of MVs are conceptually higher than those of local varieties (LVs). When MVs were substituted for LVs over the past several years, the yield per rai enhanced. Meanwhile, the second model reveals that the improvement of technical knowledge affecting the planted area expansion increases paddy output. This is due to the changes in production structure. That is, over the last two decade, the expansion of the recommended varieties, particularly in the Northeastern Plain of KDML105 replaced for the planted area of the local varieties. Therefore, the public rice research had been contributing to production.

The implication of the stated result is briefly described as follows. The expansion of the planted area would physically and economically be limits. At the same time, the citizen in rural zone would temporarily or permanently migrate from agricultural to non-agricultural sector. As a consequence, there would be no doubt that cost of the planted area of rice expansion as well as the employment of agricultural manual workers would be higher. It implies that the public investment in research represents a crucial driving force for stimulating the production growth.

Regarding to the improvement of technical knowledge deriving from rice research, it would result in better social welfare through supply perspective. Furthermore, the social benefit from the government investment in rice research has been intuitively quite high.

Nevertheless, the empirical evidence has been rarely found in a case of Thailand. It consigns this article to the second question of how much the public investment in rice research would be beneficial to welfare. Using Marshallian approach, the result reveals that when the current state of technical knowledge is developed from Rice Research Institute, the cumulative economic surplus is estimated to have been quite high. Consequently, the B/C ratio implies that the investment in rice research is sufficiently attractive. In conclusion, though the model is a static approach, the policy makers are informed of the potential effects of rice research on Thai economy. Apart from this, within the context of allocation of resources to the agricultural research activities, the policy makers would be able to develop the economic model based on this article for research investment in other crops.

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# Appendix

**Table appendix a.** Parameterization

| Parameter | Explanation | Estimated Value | Source of Data |
|---|---|---|---|
| $\eta$ | Rice retail price elasticity of demand in term of absolute value. | 0.986 | Calculated: $\eta = \eta_C\left(\bar{Q}_C^D/\bar{Q}_0^D\right) + [\eta_X\left(\bar{Q}_X^D/\bar{Q}_0^D\right)\left(\bar{P}_r/\bar{P}_X\right)(dP_X/dP_W)(dP_W/dP_r)]$ |
| $\eta_C$ | Rice retail price elasticity of domestic demand in term of absolute value. | 0.486 | Isvilanonda *et al.* (1997) |
| $\eta_X$ | Rice export price elasticity of export demand in term of absolute value. | 1.726 | Patmasiriwat and Sathidsirikul (1990) |
| $\left(\bar{Q}_C^D/\bar{Q}_0^D\right)$ | Average ratio of rice domestic consumption to rice consumption. | 0.618 | Pojean and Wiratpong (2004) |
| $\left(\bar{Q}_X^D/\bar{Q}_0^D\right)$ | Average ratio of rice export to rice consumption. | 0.393 | Pojean and Wiratpong (2004) |
| $\left(\bar{P}_r/\bar{P}_X\right)$ | Average ratio of rice retail price to rice export price in real term. | 1.425 | Pojean and Wiratpong (2004) |
| $(dP_X/dP_W)$ | Reciprocal of slope of price linkage equation. $P_w = f(P_x)$, where $P_w$ = rice wholesale price and $P_x$ = rice export price. | 1.640 | Pojean and Wiratpong (2004) |
| $(dP_W/dP_r)$ | Reciprocal of slope of price linkage equation. $P_r = f(P_w)$, where $P_r$ = rice retail price and $P_w$ = rice wholesale price. | 0.432 | Pojean and Wiratpong (2004) |

**Table appendix a.** Parameterization (continued)

| Parameter | Explanation | Estimated Value | Source of Data |
|---|---|---|---|
| $\alpha$ | Rice retail price elasticity of supply. | 0.153 | Calculated: $\alpha = \alpha_f (\bar{P}_r/\bar{P}_f) [(dP_f/dP_W)(dP_W/dP_r)]$ |
| $\alpha_f$ | Elasticity of rice supply with respect to price received by farmer at mean value. | 0.301 | Itharattana (1999) |
| $(\bar{P}_r/\bar{P}_f)$ | Average ratio of rice retail price to price received by farmer in real terms. | 1.806 | Pojean and Wiratpong (2004) |
| $(dP_f/dP_W)$ | Slope of price linkage equation. $P_f = f(P_w)$, where $P_f$ = price received by farmer and $P_w$ = rice wholesale price. | 0.651 | Pojean and Wiratpong (2004) |
| $(dP_W/dP_r)$ | Reciprocal of slope of price linkage equation. $P_r = f(P_w)$, where $P_r$ = rice retail price and $P_w$ = rice wholesale price. | 0.432 | Pojean and Wiratpong (2004) |
| $k_t$ | Rate of shift in supply schedule deriving from the public rice research. | The numbers distributed in any particular year t. | Calculated: $k_t = \dfrac{\tilde{\beta}_4 \Delta X_{4,t}}{X_{4,t}}$ |
| $X_4$ | Current state of technical knowledge. | The numbers distributed in any | Calculated: See equation (3) in the section 2.1) The data set for |

**Table appendix a.** Parameterization (continued)

| Parameter | Explanation | Estimated Value | Source of Data |
|---|---|---|---|
| | | particular year t. | government budget on rice research was drawn from Bureau of Budget. |
| $\tilde{\beta}_4$ | Elasticity of rice production with respect to the current state of technical knowledge. | 0.268 | Estimated: $\left(\frac{d\ln Y}{d\ln X_1}\right)\left(\frac{d\ln X_1}{d\ln X_4}\right)$ See Model 2 in Table 2 |
| $a_t$, $b_t$ | Parameter of demand function. Parameter of supply function. | The numbers distributed in any particular year t. | Calculated: $a_t = Q_{E0,t}/(P_{E0,t})^{-\eta}$ $b_t = Q_{E0,t}/(P_{E0,t})^{\alpha}$ |
| $Q_{E0,t}$, $P_{E0,t}$ | Rice quantity and retail price without the improvement of technical knowledge in "period t". | The numbers distributed in any particular year t. | Following Oungsawat (1995), the rice quantity and price in "period t-1" was represented as the rice quantity and price without the improvement of technical knowledge in "period t". The data set for rice quantity and retail price was drawn from Pojean and Wiratpong (2004). |