DISSERTATION

IMPACTS OF GOVERNMENT SPENDING ON THAILAND'S AGRICULTURAL SECTOR

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THESIS

IMPACTS OF GOVERNMENT SPENDING ON THAILAND'S AGRICULTURAL SECTOR

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The thesis consisted of two parts in line with the theme of forward linkage between government spending and agriculture. As a macro level, how much the public consumption spending benefits to agriculture is examined in the first part. As a micro level, how much the public investment in rice research contributes to productivity and social welfare is analyzed in the second part.

The first part begins with the estimation of parameters in the structural model. It reveals that the government consumption spending has impact on interest rate, exchange rate, price index and GDP. These variables link government spending to the agricultural sector. The estimated parameters are utilized for policy simulation. As simulation results, when the government increases the consumption spending by 5, 10 and 15%, its impacts on agricultural sector are concluded in terms of percentage change from baseline value as follows. Food consumption raises to 1.04, 2.08 and 3.12%. Food export raises to 0.05 0.10 and 0.15%. Meanwhile, food import raises to 1.06, 2.12 and 3.19%. Consequently, surplus of trade balance for food worsens to 0.22, 0.43 and 0.65%. In addition, employment in agricultural sector raises to 0.01, 0.03 and 0.05%. Capital stock in agricultural sector also raises to 0.05, 0.09 and 0.14%. Gross domestic production in agricultural sector subsequently raises to 0.16, 0.31 and 0.47%. Therefore, Thailand's agricultural sector is affected not only by the spending specifically designed for it but also by the government consumption spending.

The second part provides a measure of the current state of technical knowledge determined in part by current and past public investment in rice research. According 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 rather high. Consequently, the B/C ratio implies that those investments generate a benefit of 2.83, 2.55 and 2.32 Baht for every Baht spent by 5, 10 and 15% discount rate, respectively.

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INTRODUCTION

Problem Statement

The main impetus of Thailand's economic growth in the 1960s and the 1970s has been the growth of agriculture. However, the momentum of agricultural growth was lost in the late 1970s as the land frontier was exhausted and the relative importance of agriculture in production declined (Warr, 1993). In the late 1970s, the annual growth rate of agricultural GDP declined to 4.14 per cent. During the late 1980s and 1990s, the growth rate of agricultural sector further shrank to less than 4 per cent per year. Consequently, the agricultural GDP as a share of GDP quickly decreased. The contribution of agriculture in GDP subsequently dropped to 10 per cent in the early 2000s (Table 1). During the present time, it is strongly stated that the agricultural sector is less significant sector in the way of Thailand's economic growth.

The share of Thailand's labor force in the agricultural sector has decreased since the year of 1972. This was also accompanied by growing migration from agriculture to the cities. The share of the total active population in agriculture was 59.62 per cent in 1992 and declined to 46.02 per cent in 2001. However, it can be declared that the agricultural sector remains the important source of employment (Table 2). Further, the poorest citizens are disproportionately concentrated in the agricultural sector (Warr, 1993). Although the poverty incidence in the whole kingdom measuring as the percentage of the population living below the poverty line dramatically dropped, the rural poverty rate was approximately 20.12 per cent with relatively small poverty rate for urban in 2000 (Table 3). Accordingly, the agricultural sector until to now has remained significant sector in the way of Thailand's economic development.

Table 1 GDP and agricultural GDP, 1976-2004

(Unit: million baht at 1988 price)

Year	GDP		Agricultural GDP[1]		
	Value	Growth rate (%)	Value	Growth rate (%)	% of GDP
1976-1980	809,145	7.96	175,173	4.14	21.76
1981-1985	1,078,649	5.45	209,200	4.26	19.42
1986-1990	1,577,830	10.34	249,812	3.17	16.05
1991-1995	2,500,010	8.62	289,610	1.15	11.75
1996-2000	2,963,604	0.64	291,481	2.35	9.85
2001-2004	3,363,464	5.17	335,764	2.64	10.00

Note: [1]Agricultural GDP is represented as gross domestic product originating from agriculture, hunting, forestry and fishing.

Figures are shown as the average value of concerning period.

Source: Office of the National Economic and Social Development Board (NESDB)

Table 2 Labor force in Thailand, 1972-2001

Year	Agricultural sector (%)	Non-agricultural sector (%)	Total (%)
1972	69.45	30.55	100.00
1977	65.70	34.30	100.00
1982	62.84	37.16	100.00
1987	60.81	39.19	100.00
1992	59.62	40.38	100.00
1996	57.98	42.02	100.00
2001	46.02	53.98	100.00

Source: Charoensuk (2003)

Table 3 Poverty in Thailand, 1976-2000

Year	Urban poverty (%)	Rural poverty (%)
1976	22.45	44.48
1981	18.25	39.11
1986	22.47	53.25
1992	10.02	32.13
1998	4.72	15.97
1999	5.65	19.89
2000	5.81	20.12

Source: Fan *et al*. (2004)

With respect to the sense of economic development, Thailand's agricultural sector has been strongly brought up by the government through various programs. With no doubt, the program that is a so-called agricultural policy has intended impacts on the agricultural sector according to the microeconomics school. Nonetheless, Schuh (1976) succinctly stated that the agricultural economists have to give greater attention to monetary and fiscal policy if they want to understand developments in the agricultural sector. Moreover, Stamoulis *et al*. (1995) pointed out that the agricultural sector's performance is affected not only by policies specifically designed for it but also, and often more deeply, by policies affecting the overall macroeconomic environment, e.g. public sector deficits, inflation, interest rate and exchange rate. Apart from this, the research of agricultural economics in aspect of macroeconomics school rarely revealed in Thailand. It is begun by asking that how macroeconomics policies linkage to agriculture.

According to the macroeconomic policies, the fiscal policy played an important role for stimulating economy growth. Further, Loha-Unchit (1985) stated that in order to encourage the growth through the demand side, the tool of expenditure was more effective and efficient than tax revenue. Furthermore, based on the balance sheet of national income reported by NESDB, from 1976 to 2004, the average

government consumption expenditure was approximately 187,682 million Baht at 1988 price and its growth rate was accounted for 5.88 per cent per year. As a consequence, the government expenditure as percent of GDP was roughly accounted for 10.00 per cent per year (Table 4). It led this study to find out how much the government consumption spending benefits to Thailand's agricultural sector.

Table 4 General government consumption spending, 1976-2004

(Unit: million baht at 1988 Price)

Year	Government consumption spending[1]		Value of GDP	% of GDP
	Value	Growth rate (%)		
1976-1980	90,585	12.24	809,145	11.14
1981-1985	134,222	7.27	1,078,649	12.44
1986-1990	158,064	2.63	1,577,830	10.19
1991-1995	206,894	6.22	2,500,010	8.31
1996-2000	264,939	3.69	2,963,604	8.96
2001-2004	292,313	2.56	3,363,464	8.71
1976-2004	187,682	5.88	2,003,450	10.00

Note: [1]According to balance sheet of national income, general government consumption expenditure = compensation of employees (wages & salaries and pay & allowance of members of the armed forces) + purchases from enterprises and abroad (military and civilian purposes) - purchases by households and enterprises.

Figures are shown as the average value of concerning period.

Source: Office of the National Economics and Social Development Board (NESDB)

Objective

This study aims to analyze the impacts of government consumption spending on Thailand's agricultural sector.

Organization of Part I

The rest of Part I is organized as follows. The next section reviews several related literatures. It is separated into the effects of macroeconomic variable on agriculture and the effects of macroeconomic policy on agriculture. Within the latter category, the simulation result in structural and CGE model is respectively reviewed. Tracking down the related literatures, the conceptual framework is outlined in the section of research methodology. This framework is developed in two structural models. The first one is for estimating the impact of government spending on macroeconomic variables. The second one is for estimating the impacts of transmission variables on agricultural variable. The method and procedure consisted of three steps: estimation of model, formulation of complete model and policy simulation.

The overview of Thailand's government spending from 1970 to 2004 is documented. According to the National Economic and Development Plan (Plans One to Eight), the overview of Thailand's agriculture is also reviewed. As descriptive evidence, the major economic indicators of agricultural sector are analyzed. In the result section, the estimated behavioral equations are analyzed that whether there is a consistent in the economics theories. Then the estimated elasticities for long run relationships are interpreted. With respect to the formulation of whole model, it should be assessed the simulation errors. It follows that the policy simulation is performed under the alternative scenarios in order to analyze impacts of government consumption spending on agricultural sector. In the last section, the summary and final remark is presented. The summary is firstly documented. And then the recommendations are drawn from the estimation results. The limitation of this study and directions of future study are presented in the last section.

REVIEW OF LITERATURE

As the classical journals, Schuh (1974), (1976) and (1979) rekindled the new macroeconomics of agriculture. It is briefly stated that the macroeconomics of U.S. agriculture should be cast in the context of opened economy rather than rapid technological change and agricultural transformation. This is because in March 1973 the U.S. has adopted to flexible exchange rates and a well-developed international capital market. Afterwards, numerous literatures in line with this theme have been released. The macroeconomics of agriculture may be broadly classified under two headings. Firstly, according to the partial perspective, the way to deal with this heading is that the macroeconomics variables are treated as exogenous variable affecting to agricultural variables. Secondly, according to the general equilibrium perspective, the effects of macroeconomic policy on agriculture are investigated.

Effects of Macroeconomic Variable on Agriculture

The previous studies on the relationship between macroeconomic variable and agriculture indicated that the vital variables consisted of exchange rate, inflation and interest rate. These studies also reflected that over the past 20 years, the agricultural economist paid more attention to the role of exchange rate in export of agricultural products. On the one hand, the linkage between inflation and agricultural price has been rarely found in particular the impacts of interest rate on agricultural input. This may be because these issues are not suitable to analyze via partial perspective.

I. Exchange rate and agricultural export

In late 1970s and 1980s, most of literatures used the static econometric model in order to estimate the marginal effect of exchange rate on agricultural export. As an illustrative instance, Batten and Belongia (1986) estimated U.S. agricultural export equation where foreign real income, U.S. real agricultural prices and the real trade-weighted exchange rate are the explanatory variables. The estimated elasticity of real agricultural exports with respect to the real exchange rate is equal to -0.72.

To set up the explanatory variables of Batten and Belongia (1986) is more trivial. On the other hand, the other literatures attempt to extend the theoretical model as follows. Firstly, Johnson *et al*. (1977) revealed that the domestic price of wheat in U.S. was affected by dollar devaluation with respect to Europe and Japan, higher export taxes by Canada & Australia and U.S. transport policy, which raised shipping costs between U.S. and Japan & Europe. The dollar devaluation was of lesser importance for the U.S. domestic price than foreign commercial policy. Secondly, Collins *et al*. (1980) criticized that the exchange rate analyses relying on theoretical models limited to free trade or two countries were misleading. The exchange rate effects on real U.S. commodity prices were smallest under free trade.

Thirdly, Grigsby and Arnade (1986) proposed that the analysis should concern with consequences of exchange rate policies of a competitor country. To the extent that exchange rates are used as protectionism devices by many countries, and the disequilibrium exchange-rate systems in developing countries, these alternative exchange rate arrangements were important to U.S. agricultural trade. Lastly, Schwartz (1986) analyzed the effects differ in a competitive market versus a noncompetitive market framework. Under simple competitive market the more the exchange rate fluctuates, the more variable was the short-run changes in domestic prices and trade shares *ceteris paribus*. If the U.S. and Canada, conversely, cooperate only occasionally, that is under incompetitive circumstance, then the swings in shares and prices might actually exceed the competitive case.

Nonetheless, the four last studies remain the static approach. Saying in other word, they are in the line with the long run perspective regardless of the short run perspective. Hence, in 1990s the literatures developed the econometric model into dynamic econometric model, which is a so-called Error Correction Model (ECM). As an illustrative instance, Saunder *et al*. (1999) investigated the long- and short-run relationships between variations in the exchange rate and U.S. agricultural exports. A long-run analysis was undertaken within the confines of a cointegration testing framework. ECMs were used to analyze the short-run dynamics departures from the long-run equilibrium relation under investigation. Agricultural exports and the real

exchange rate were found to be cointegrated. The ECM estimates indicated that the existence of a unidirectional causal flow from the real exchange rate to the volume of U.S. agricultural exports. Consequently, the appreciation of the real exchange rate would reduce the volume of U.S. agricultural exports in the short run.

II. Inflation and agricultural price

As the empirical evidence, Starleaf (1982) revealed that if the macroeconomic polices have had at least a short-run impact on real output of the U.S. macroeconomy (nonfarm business), it appeared that they have also had a short-run effect on the agricultural sector, particularly the agricultural output prices level. Moreover, Starleaf *et al*. (1985) did not conclude that agricultural output prices relative to nonagricultural prices were increased by higher rates of inflation, but rather that they were benefited by unanticipated increases in the rate of inflation.

Therefore, the farmers may realize inflation to be useful in the short run because of higher agricultural commodity price. Nonetheless, the weakness point of those literatures is that the inflation is treated as exogenous variable regardless of important factor affecting the general price level, i.e. monetary policy.

III. Interest rate and agricultural input

Notwithstanding this heading has not been appeared in the way of empirical evidence, the linkage between interest rate and agricultural input is briefly stated in several articles. This relationship would be described as follows.

Interest rate closely and inextricably linked the U.S. agriculture to national financial markets in a number of ways. Interest rates would influence variable production costs by raising or lowering the payments required for short-run planting-to-harvest borrowing. Meanwhile, the interest rates affected the cost of long-term capital investments (Orden and Niles, 2003). Apart from this, the indirect effects of real interest rate on agricultural sector through the exchange rate as well as the price

level. The farmland prices also varied inversely with interest rates (Snell *et al*., 1997). Nevertheless, the interest rate linkage has been argued as important in the U.S. to high land prices in the 1970s period of loose monetary policy, and falling land prices in the 1980s period of tight monetary policy (Ardeni and Freebairn, 2002).

Effects of Macroeconomic Policy on Agriculture

There are basically two schools of though namely structural and computable general equilibrium (CGE) model in order to investigate the effects of monetary and fiscal policy on agricultural sector. The former view is derived from the first welfare theorem in the line of microeconomics theory. Its quantitative analysis is also in the form of non-parametric model. The latter view is come from the general equilibrium in the way of macroeconomics theory. Quantitatively, the parametric model, which is a so-called econometric model, is also employed.

I. Survey of literature: Structural model

The procedures of these researches are comprised of three steps: consideration of macroeconomic school (Keynesian, Neo classical and Neo Keynesian), structure of theoretical model and estimation & policy simulation.

Firstly, the implications each of the macroeconomic schools of thought for linkages between general economy and agriculture were quite different. According to Keynesian view, the policies had impacts on real agricultural variables but the direction of their effects remained controversial. On the other hand, Neoclassical view indicated that those policies would not have any real impacts on agriculture variables. This is because all of macroeconomic variables and agricultural price response to a policy shock by the same proportion. For the Neo-Keynesian, the policies had real impacts on agriculture in the short run. The impacts of policies would disappear as prices of nonagricultural goods rise to their long run equilibrium over time (Choe, 1989).

Secondly, the framework of macroeconomic developed into the structural model. The model builders adapt two strategies to capture the interaction between macroeconomy and agricultural sector. The first one is that a satellite model is separated from the macroeconomics model in the sense of providing no estimates of endogenous variables but depended on the forecasts of variables created by the macroeconomics model. The second one is that the model considers agriculture as an industrial sector (Roop and Zeitner, 1977). Finally, the econometric theories are employed for estimation and replication. Theoretically, they consisted of static and dynamic macroeconometric model.

The rest of this part devoted to the survey of empirical evidences. Beginning with the case of U.S. agriculture, in the early 1980s the agricultural economist paid more attention on the effects of macroeconomic policy on agriculture. This is because the international markets have experienced a severe cyclical downturn. In addition, the important structural changes have taken placed in the world economy if one compares the early 1980s to 1960s. Meanwhile, during such time a restricted monetary policy and an expansionary fiscal policy contributed strongly to the severe downturn in agriculture. The literatures, which are in line with this theme, are Paarlberg *et al*. (1984); Kitchen *et al*. (1987), and Just (1990).

Paarlberg *et al*. (1984) is in the form of Keynesian school, structural modeling in the way of satellite model and using static macroeconometric model. They demonstrated alternative scenario, the acceleration in U.S. money growth between mid 1982 and early 1984, and the increase in the federal deficit. As the simulation results, the increase in U.S. income and the rising value of the dollar have raised U.S. import demand and, as a result, foreign exports and income increase. This increase in income has had a positive impact on demand for agricultural goods that had at least partly offset the dampening effect of the highly valued dollar.

Kitchen *et al*. (1987) simulated the relationship between macroeconomic policy and U.S. agriculture by linking two econometric models: a macroeconomic model and an agricultural model called Food and Agricultural Policy Simulator

(FAPSIM). It is annual model including wheat, corn, sorghum, barley, oats, soybeans, soybean meal, soybean oil, cotton, rice, beef, chicken, eggs, turkeys and dairy. Under the alternative scenario of higher money growth and lower budget deficits, the main simulation results were summarized as follows. Agricultural demand increased. Consumer food expenditures increased. Meanwhile, agricultural production, net farm income and farmland values increased.

Just (1990) formulated a model of the U.S. corn, sorghum and soybeans that included the role of U.S. agricultural policies and related livestock markets. Meanwhile, The macroeconomic effects of monetary and fiscal policy are estimating using the FAIRMODEL model of the U.S. macroeconomy. The specification of these equations bases macroeconomic phenomena on microeconomic foundations. The main results revealed that an increase in government expenditures had a positive effect on most agricultural prices immediately but that the effect could turn negative for some commodities in the second year.

Owing to the initiated literature, the procedures of Paarlberg *et al*. (1984) are straightforward. The scope of this analysis also remains the concept of aggregate agriculture instead of commodity aspect. On the one hand, the frameworks of Kitchen *et al*. (1987) and Just (1990) are rather sophisticated. The simulation results of these literatures are also reliable in the way of various agricultural products. Nevertheless, Kitchen *et al*. (1987) and Just (1990) may have two weakness points as follows. Firstly, their empirical evidences are based on the annual time series data despite the action of monetary policies basically needed to use the quarterly simulation results. Therefore, these literatures may not perform well for macroeconomic policy makers. Secondly, with respect to the dynamic approach, their econometric model having no beneficial use in the concept of impulse response. In fact, the impacts of monetary policies are theoretically taken for a longer quarter. Hence, Vector Autoregression model (VAR) may be suitable rather than ordinary regression model.

Apart from this, the review of previous literature in the case of developing countries is presented as follows. In the case of Tanzania and Malawi, Lopez *et al*.

(1991) formulated a simple structural model to provide insights about the quantitative importance of the various channels by which government policies had affected the agricultural exportable sector. Their simulation result indicated that fiscal policies were not neutral with respect to the structural of agricultural production. Although their results support to the Keynesian's proposition, the theoretical model of this study is deficient in the macroeconomic theory. The variable of government spending only represents as a fiscal policy.

Wongsak (2001) developed a small-scale macroeconomic model for Thailand. The simulation results indicated that the demand for labor and GDP in agricultural sector increase owing to the fiscal policy as well as monetary policy. According to the theoretical model, this study is derived from Keynesian perspective. The model also considers the agriculture as the industrial sector. This way rather differs from the previous literature, i.e. Paarlberg *et al*. (1984); Kitchen *et al*. (1987), and Just (1990). Nonetheless, this study concentrated on only two agricultural variables so that the other variables, i.e. food export and consumption are questionable.

II. Survey of literature: CGE model

The procedures of CGE model consisted of four steps: set up the theoretical model, construction of database, calibration of model and simulation. The first step is to set up the theoretical model according to the first welfare theorem. The merit of such model is that the researchers obviously see the interrelation among various sectors, i.e. agricultural, industrial and financial sector. Moreover, each sector would be disaggregated into various types of products. That is the agricultural sector would be separated into crop, livestock, and fishery products.

The second step needs the database, which is a so-called Social Accounting Matrix (SAM). A SAM is a matrix representation of the circular flow of income. SAMs respect the difference between goods and factors (Gibsun, 2003). SAM is not merely database for CGE model, but also tools for analysis of the economic impacts of public policy called SAM multiplier. It describes the behaviors of the different

actors and their interactions across markets. These assume that each actor whose account is given in the SAM behaves according to fixed coefficients. While the motivation for this work was not to analyze macro equilibrium, SAM multipliers look very much like the simple Keynesian model. (Robinson and Hans, 2005).

According to the previous literature, the empirical evidence of SAM multiplier has been released in many countries including Thailand. As an illustrative instance, Susangkarn & Tinnakorn (1999) and Saebae (2003) constructed SAM multiplier model in order to investigate the economic effect of government spending on various sectors in Thailand. The pro of such model is that the theoretical model is not sophisticated. The quantitative analysis also needs only Excel Program rather than the complicated software program. On the one hand, the con of such model is that the construction of SAM database is not convenient. This is because it derived from different database of government agencies. Furthermore, the databases of Thailand are reported in the sense of time lag. The SAM multiplier model also assumes the fixed price. Therefore, the results may not accordance with the real incident.

The third step is calibration of empirical model or parameterization. Most of parameters are drawn from the related researches. This step is more inconvenient for developing countries because it is not easy to seek some parameters, i.e. elasticity of substitution between traded and nontraded goods. Nonetheless, these parameters will be adjusted in the way of sensitivity analysis. The last step is policy simulation that normally needs to utilize the mathematical software program, i.e. MATLAB and GAMS. Certainly, these software programs are not convenient for beginner.

The rest of this part devoted to the review of CGE study. Beginning with Güzel and Kulshreshtha (1995), a static CGE model for the Canada indicated overall the agricultural sectors would gain from a devaluation, but the effects on various sectors of the economy would be quite different. It is also found that revaluation of the Canadian dollar would harm the agricultural households through decreased prices, outputs, and incomes. These results indicate that exchange rate and macroeconomic policy changes may be one of the causes of agricultural price and income instability in Canada.

Owing to the severe problem of public budget deficit in Zimbabwe, Bautista *et al*. (2002) and Fagernäs (2004) attempted to analyze the economic impacts of such policy on agriculture. Bautista *et al*. (2002) created the CGE model, which deals only with the current fiscal account. The simulation results revealed that a reduction in government consumption expenditure to remove the current fiscal deficit was shown to lead to a slight decline in GDP and to increases in agricultural production and rural incomes. In addition, the model simulation result indicated that the fiscal policy in Zimbabwe had an anti-agriculture bias in benchmark year and that doing away with the current fiscal deficit would have required only a small tradeoff in GDP but would have had a favorable equity effect. Interestingly, the simulation result of this literature reflected the controversy over economic development and economic growth. In other word, the policy makers have to tradeoff between equity and economic growth with respect to the fiscal policies.

Additionally, Fagernäs (2004) indicated for expenditure reduction to generate a reasonable outcome, it needs to be combined with devaluation. Furthermore, CGE model's results imply that a fall in government consumption (combined with devaluation) seems favors agriculture more than a rise in income tax rate. The result of this literature may support to the proposition that is the tool of expenditure is more effective and efficient than tax revenue according to the fiscal policy.

Because the public spending played as a vital role in stimulating Thailand's economy, Chainakul (2002) and Charoensook (2003) created CGE model to analyze this issue. The former model is assumed that in order to finance the budget deficit, the government issues bond to Bank of Thailand. The latter model is assumed that in order to finance the budget deficit, the government borrows from foreign countries. Both of them employ the input-output table of the year 1998 to built SAM. Broadly speaking, their results revealed that the expansion of government spending has positive impacts on Thailand's economy. Nonetheless, when the economic impacts of sector are considered, the details of result are different due to different assumption. It should be noticed that their analysis employed the outmoded database. Therefore, these simulation results may be appropriated for the national planning rather than economic forecasting.

As seen previously, the theoretical models remain the concept of static CGE. Currently, CGE model would be developed into the concept of dynamic. That is the household agent sought an optimal consumption plan over an infinite time horizon. At the same time, the firm agent's behavior was determined by the maximization of representative profit function. The agent found the optimal production plan over an infinite horizontal time. However, the way to deal with the theoretical model is rather tough.

METHODOLOGY

Conceptual Framework

Tracking down the previous literatures, the framework was outlined in Figure 1. It was schematically represented the linkages underlying the effects of government consumption expenditure on agricultural sector. Let agricultural sector be a satellite of mroecoeconomy. Accordingly, the framework was separated into two blocks. The first block depicted the forward linkage between government consumption spending and macroeconomic variables. Based on the traditional Keynesian school, the government was also treated as an exogenous variable. Keynesian view briefly stated that the government spending affected GDP, price level and interest rate *ceteris paribus*. They further affected the value of domestic currency. These variables, which is a so-called "transmission variable" transferred from the first block to the second block.

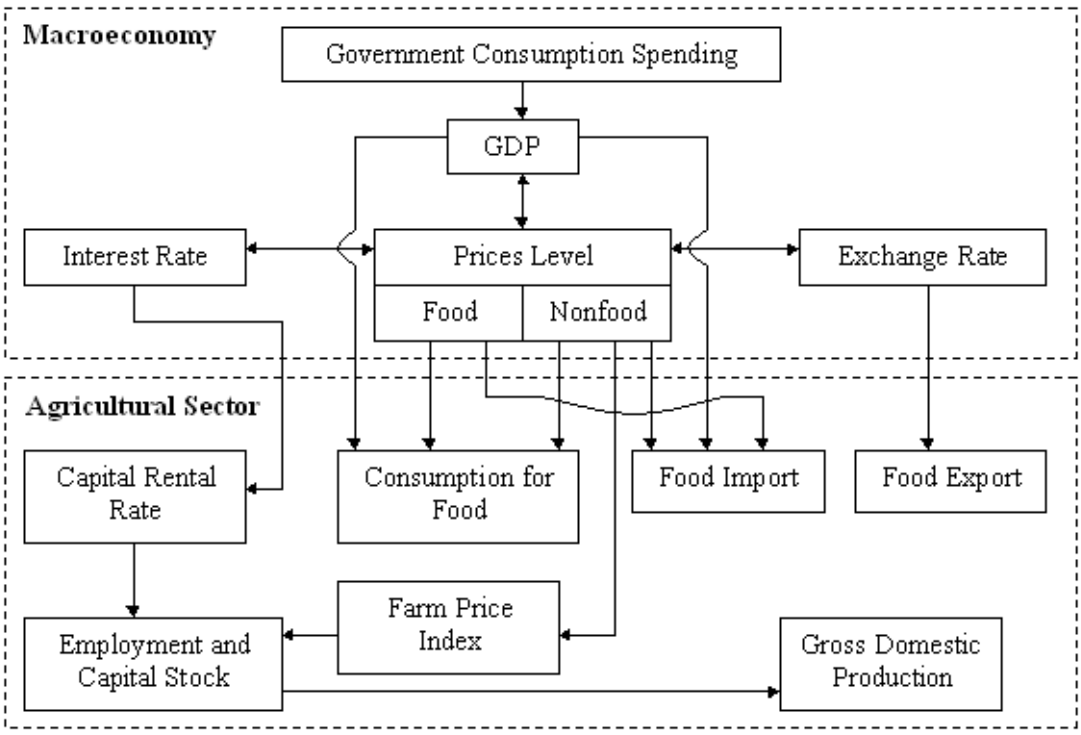

Figure 1 Conceptual framework

The second block presented the relationship between transmission variables and main aggregate variables in agricultural sector. These agricultural variables were comprised of food consumption, food export & import, employment & capital stock and gross domestic production in agricultural sector. The relationship between transmission variable and agricultural variable is presented as follows.

i) GDP would have positive impact on the food consumption and import.

ii) Price level would affect the food consumption and import via CPI for food and nonfood.

iii) Exchange rate would affect the food export.

iv) Interest rate would relate to the capital stock and employment in agricultural sector via a capital rental rate.

v) Price level would relate to the capital stock and employment in the agricultural sector via a farm price index.

vi) Interest rate and price level would relate to gross domestic production in the agricultural sector via labor and capital stock.

Theoretical Model

Such framework developed two theoretical models. First block developed the structural model of estimating impacts of government consumption spending on macroeconomics variables is illustrated in Part I. Second block developed the structural model of estimating impacts of transmission variable on aggregate variable in agricultural sector is described in Part II.

I. Model for estimating impacts of government spending on macroeconomics variables

A. Real sector (Froyen, 1995)

It was firstly assumed the fixed price expectation. A central notion in the model was that for a level of output to be an equilibrium level required that "output" be equal to "aggregate demand". In the simple model, this condition for equilibrium was expressed as Y = E where Y was equal to total output (GDP) and E equaled aggregate demand. The aggregate expenditure was comprised of four components: household consumption (C), desired national investment demand (I), government consumption expenditure (G) and current account (Ex-Z). Current accounts were exports minus imports. The condition for equilibrium output in the open economy was then Y = C + I + G + Ex – Z. To find an expression for equilibrium GDP in the open economy model, this study took government spending as exogenous. Consumption was given by the consumption function, C = f(Yd); $0 < (dC/dYd) < 1$, where Yd was represented as disposable income. It was incomes minus taxes, Yd = Y – T. Tax revenue function was expressed as T = f(Y); $(dT/dY) > 0$.

Rising real interest rate retarded national investment demand. Following the macroeconomic model of Bank of Thailand, the expanded GDP had positive impact on investment. Accordingly, the investment function was written as I = f(R, Y); $(\partial I/\partial R) < 0$ and $(\partial I/\partial Y) > 0$. Furthermore, the decrease effective exchange rate (E) induced to increase export demand. The rising in the foreign national income (Yf) also increased export demand. The export function was expressed as Ex = f(E, Yf); $(\partial EX/\partial E) < 0$ and $(\partial EX/\partial Yf) > 0$. Beside, following the macroeconomic model of Bank of Thailand, the crucial factor affecting to import was that GDP, export and import price index (Pimp). The import function was then written as Z = f(Y, EX, Pimp); $(\partial Z/\partial Y) > 0$, $(\partial Z/\partial EX) > 0$ and $(\partial Z/\partial Pimp) < 0$.

The price determination is described as follows. Let P = WnaPna + WaPa be the identity equation of prices index (P) with the condition of Wna + Wa = 1, where Wna, Pna, Wa and Pa was respectively stood for weight of nonfood item, nonfood prices index, weight of food item and food prices index. The reduced form of

nonfood prices index would be written as Pna = f(R, Pimp, Y); $(\partial \text{Pna}/\partial \text{R}) < 0$, $(\partial \text{Pna}/\partial \text{Pimp}) > 0$ and $(\partial \text{Pna}/\partial \text{Y}) > 0$. It was conceptually derived from the context of cost side and demand side. The import price index and real interest rate was played as a proxy variable of cost side. Meanwhile, real GDP was played as a proxy variable of demand side. Apart from this, based on Starleaf (1982), the nonfood price index had a short run impact upon the food price index. Furthermore, as a small country, the food price function would include the world agricultural price index as another explanatory variable. Therefore, the food price model was defined as Pa = f(Paw, Pna); $(\partial \text{Pa}/\partial \text{Paw}) > 0$ $(\partial \text{Pa}/\partial \text{Pna}) > 0$.

B. Money sector: Interest rate reaction function

According to Keynesian perspective, the real money supply (Ms = M/P) is treated as the exogenous factor. Meanwhile, the money demand (Md) function can be written as $\text{Md} = \text{f}(\text{Y}, \text{Rn})$; $(\partial \text{Md}/\partial \text{Y}) > 0$ and $(\partial \text{Md}/\partial \text{Rn}) < 0$. If the equilibrium in money market exists, then it will be have Md = Ms.

With respect to money market equilibrium, the money supply (Ms) and GDP played an important role in determining interest rate. Additionally, the interbank overnight lending rate (Rninb) has significant impacts on the interest rate regarding Charoenkittayawut (2001). Thus, the reduced form of interest rate was expressed as Rn = f(Rninb, Ms, Y); $(\partial \text{Rn}/\partial \text{Rninb}) > 0$, $(\partial \text{Rn}/\partial \text{Ms}) < 0$ and $(\partial \text{Rn}/\partial \text{Y}) > 0$.

C. Foreign exchange sector: Real exchange rate reaction function

Thailand has adopted the managed-float exchange rate regime since July 2, 1997. Nonetheless, the central bank would intervene in the market only when necessary, in order to prevent excessive fluctuations and achieve economic policy goals. It would be stated that under this system, the market forces determine exchange rate. In other word, these exchange rates are determined by the interaction of forces affecting the demand and supply for currencies on the foreign exchange market.

Theoretically speaking, the determinants causing the demand for foreign currencies to increase would cause the home currencies (Baht in this study) to depreciate relative to the foreign currencies. The demand for foreign currencies is derived from the desire of home country's consumers and business agencies to import foreign goods & services, to invest in the other countries, to repay debts owed outside home country, and for transfer payments made to foreigners. The foreign currencies are bidden on foreign markets in settlement of these legal obligations of residents and government. This increases the demand for foreign currency resulting in the depreciation of the foreign currency's value relative to home currencies.

On one hand, any force resulting in an increase in the supply of foreign currencies would cause the home currencies to appreciate. The supply of foreign results from the domestic country exports of goods & services, and income received from foreign investment and investments in home countries by foreign entities. As the U.S. consumers purchase Thai agricultural product, for instance, the conversion of the U.S. dollar currencies into the baht drives up the supply for the U.S. dollar causing the rate of exchange (Baht per U.S. dollar) to appreciate.

In the foreign exchange markets, the demand and supply of any particular currency conceptually determines the prices. With respect to the demand for foreign currency increases, its price, or the baht per unit of foreign currency, depreciate. As the supply of foreign currency increases, the baht per unit of foreign currency appreciates. These results are assumed that other determinants affecting the exchange rate hold unchanged.

To verify such hypothesis the exchange rate reaction function contains the current account and difference between domestic and foreign interest rate as the explanatory variable. The model would be express as follows:

$$E = f((R-Rf), (EX-Z)); \ (\partial E/\partial(R - Rf)) > 0 \ \text{and} \ (\partial E/\partial(EX - Z)) > 0 .$$

II. Model of estimating impacts of transmission variables on agricultural variables

Given the following features, it was expected that macroeconomic variables affected the agricultural sector. The agricultural sector was characterized by product homogeneity, a pre-condition for the absence of imperfect competition. Also, agricultural prices were subject to seasonal variations. Moreover, farming activities were often carried on by large fractions of the population and very dispersed on the territory. Finally, production of commodity relied on an irreproducible factor of production--land--whose availability was finite and whose productivity could not be individually infinitely increased (Ardeni and Freebairn, 2002). In addition, this study was focused on forward linkages--from the macroeconomic variables to aggregate variables of agriculture regardless of agricultural-nonagricultural interaction.

The variables transferred from model of estimating impacts of government spending on transmission variables consisted of GDP (Y), price level (P), interest rate (R) and effective exchange rate (E). In this study the aggregate variables of agriculture consisted of food consumption, food export & import, employment & capital stock, and gross domestic production in agricultural sector. The model of estimating impacts of transmission variable on agriculture was described as follows.

A. Model of estimating impacts of GDP and price level on food consumption and import (In and Mount, 1994)

It was firstly assumed that no explicit analysis of behavior under the uncertainty was included. In the consumption sector, household agent sought an optimal consumption plan over an infinite time horizon. Theoretically, optimal demand conditions for four different commodities--domestic food products (Ca), world food products (Cfa), domestic nonfood products (Cna) and world nonfood products (Cfna)--were derived. Further optimal demand conditions for financial asset (B) and optimal level of leisure (l) were established. The objective function would be defined as

$$V = \int_0^{\infty} e^{-s(t)} U(l, Ca, Cna, Cfa, Cfna, B/P)\, dt .$$

To define the budget constraint, first it was assumed that, agent spent current expenditures on consumption goods given domestic prices (P_i) and foreign prices (Pfi), where the i subscript corresponds to a (food) or na (nonfood). Second, two sources of income for agent were current wage income (WaL) from exogenously determined wages (Wa), where L was hours of work by households, and interest earnings on holdings of domestic asset (RB). Financial market was assumed perfect, so households might save or borrow at an exogenously given domestic market rate of interest. In addition, to define the time constraint, notice that the leisure time (l) and hours of work (L) exhaust the total available time in each period (l + L = 24hours). The budget constraint for every period would be written as PaCa + PnaCna + PfaCfa + PfnaCfna + $\dot{B}$ = waL + RB.

Based on the separability assumption of utility, the Hamiltonian approach was used to derive optimal equilibrium condition.

$$MaxV = \int_0^{\infty} e^{-s(t)} U(\bullet)\, dt + \lambda\{wN + RB - \dot{B} - (PaCa + PnaCna + PfaCfa + PfnaCfna)\}$$

The first order conditions at each point in time are

$$\frac{\partial V}{\partial N}: \quad e^{-s(t)}\left[-\left(\frac{\partial U}{\partial N}\right) + \lambda w\right] = 0 \Rightarrow \frac{\partial U}{\partial N} = \lambda w$$

$$\frac{\partial V}{\partial Ca}: \quad e^{-s(t)}\left[-\left(\frac{\partial U}{\partial Ca}\right) - \lambda Pa\right] = 0 \Rightarrow \frac{\partial U}{\partial Ca} = \lambda Pa$$

$$\frac{\partial V}{\partial Cna}: \quad e^{-s(t)}\left[-\left(\frac{\partial U}{\partial Cna}\right) - \lambda Pna\right] = 0 \Rightarrow \frac{\partial U}{\partial Cna} = \lambda Pna$$

$$\frac{\partial V}{\partial Cfa}: \quad e^{-s(t)}\left[-\left(\frac{\partial U}{\partial Cfa}\right)-\lambda Pfa\right] \quad =0\Rightarrow \frac{\partial U}{\partial Cfa} \quad =\lambda Pfa$$

$$\frac{\partial V}{\partial Cfna}: \quad e^{-s(t)}\left[-\left(\frac{\partial U}{\partial Cfna}\right)-\lambda Pfna\right] \quad =0\Rightarrow \frac{\partial U}{\partial Cfna} \quad =\lambda Pfna$$

$$\frac{\partial V}{\partial B}: \quad e^{-s(t)}\left[\frac{1}{P}\left(\frac{\partial U}{\partial (B/P)}\right)+R\lambda\right]-\left[\frac{d\left(e^{-s(t)}(-\lambda)\right)}{dt}\right]=0\Rightarrow \frac{\partial U}{\partial (B/P)}=\left(s-\left(\frac{\dot{\lambda}}{\lambda}\right)-R\right)P\lambda$$

The implications of the above optimality conditions would be summarized as $\partial U(\bullet)/\partial Xi = \lambda Pi$ where X_i is any argument of $U(\bullet)$ and might include leisure, consumption goods and financial asset in each period. P_i is the corresponding price for X_i, and λ is the marginal value of the budget constraint. Nonetheless, this paper is focused on demand for agricultural products. Thus, the optimal demand conditions for leisure, non-agricultural products and financial asset would be ignored here.

Based on the separability assumption of utility, the optimal demand conditions for commodities are expressed as functions of each group's price terms and expenditures for consumption (X), $X = PaCa + PnaCna + PfaCfa + PfnaCfna$. Since this research was concentrated on demand for food products, the optimal demand conditions for leisure, nonfood products and financial asset would be ignored here. The optimal demand conditions for commodities would be expressed as functions of each group's price terms and expenditures for consumption. Thus, the consumption function for food and import function for food was respectively written as

Ca = f(Pa, Y, Pfa, Pna, Pfna); $(\partial Ca/\partial Pa) < 0$, $(\partial Ca/\partial Y) > 0$, $(\partial Ca/\partial Pfa) > 0$ and

Cfa = f(Pfa, Y, Pa, Pna, Pfna); $(\partial Cfa/\partial Pfa) < 0$, $(\partial Cfa/\partial Y) > 0$ and $(\partial Cfa/\partial Pa) > 0$.

B. Model of estimating impacts of exchange rate on food Export

According to Schuh (1974), Batten and Belongia (1986) and Saunder *et al*. (1999), it was stated that exchange rate was a key factor to determine the competition of agricultural products in the international markets. This was because the weakened domestic currency was conceptually decreased the price of agricultural product in the trading partner countries. Moreover, because the exchange rate regime in Thailand has adopted the managed-float exchange rate regime since July 2, 1997, it should be then concerned on the effect of effective exchange rate on food export. Thus, the food export model (Exa) was written as Exa = f(E, Yf); $\left(\partial \text{Exa}/\partial \text{E}\right) < 0$, $\left(\partial \text{Exa}/\partial \text{Yf}\right) > 0$.

C. Model of estimating impacts of price index and interest rate on employment and capital stock in agricultural sector (In and Mount, 1994)

The maximization of representative profit function determined the farm agent's behavior. The farmers found the optimal production plan over an infinite horizontal time. They were also assumed to be price taker in two input markets. The objective of farm was to maximize its present value, which was simply the discounted value of its net cash flow.

$$Z = \int_{o}^{\infty} e^{-R(t)} \left[\text{PfarmF}(\text{Ka}, \text{Na}) - \text{WaNa} - \text{Pka}\left(\dot{\text{K}}\text{a} + \delta \text{Ka}\right) \right] dt ,$$

where $R(t) = \int_{o}^{t} R(s)\, ds$. PfarmF(Ka, Na) was farm revenue, where Pfarm was farm price and F(Ka, Na) was the production function. WaNa was cost of labor, where Wa was wage rate in agricultural sector. Pka($\dot{\text{K}}\text{a} + \delta$Ka), was agricultural sector's current expenditure on capital input, where Pka was the price of capital and δ was rate of physical depreciation of capital. The capital expense was PkaδKa to maintain the capital stock intact and Pka$\dot{\text{K}}\text{a}$ to add to capital stock at the rate $\dot{\text{K}}\text{a}$ per unit of time. In addition, it was assumed that bonds and equities were perfect substitutes from the

viewpoint of wealth-holders, implying that the nominal interest rate on bond R was the appropriate rate for discounting the farm's cash flow.

The expression of farm objective function is of the form

$$G(y, x, \dot{x}, t) = \int_0^{\infty} f(y, x, \dot{x}, t)dt$$

Note that the Euler equation for this form would be obtained as

$$\frac{\partial f}{\partial y} = 0, \quad t \in [0,\infty); \quad \frac{\partial f}{\partial x} - \frac{d}{dt}\left(\frac{\partial f}{\partial \dot{x}}\right) = 0, \quad t \in [0,\infty);$$

For expression to obtain a maximum, at each point in time, by using the above conditions, it is required that

$$\frac{\partial f}{\partial y}: \quad e^{-R(t)}\left[Pfarm\left(\frac{\partial f}{\partial Na}\right) - Wa\right] = 0 \Rightarrow \frac{\partial f}{\partial Na} = \frac{Wa}{Pfarm}$$

$$\frac{\partial f}{\partial x}: \quad e^{-R(t)}\left[Pfarm\left(\frac{\partial f}{\partial Na}\right) - Pka\delta\right], \quad \frac{\partial f}{\partial \dot{x}}: \quad e^{-R(t)}(-Pka)$$

$$\frac{d}{dt}\left(\frac{\partial f}{\partial \dot{x}}\right): \quad -\dot{P}kae^{-R(t)} + Pkae^{-R(t)}R$$

Thus, $$\frac{\partial f}{\partial x} - \frac{d}{dt}\left(\frac{\partial f}{\partial \dot{x}}\right) = e^{-R(t)}\left[Pfarm\left(\frac{\partial f}{\partial Na}\right) - Pka\delta\right] - \left(-\dot{P}kae^{-R(t)} + Pkae^{-R(t)}R\right)$$

$$= 0 \Rightarrow \frac{\partial f}{\partial Ka} = \frac{Pka}{Pfarm}\left[R + \delta - \left(\frac{\dot{P}ka}{Pka}\right)\right].$$

The condition implies that the marginal product of labor is equal to real wages and the marginal product of capital is equal to the real rental cost of capital, e.g. $(\partial F/\partial L) = Wa/Pfarm$, $(\partial F/\partial Ka) = \frac{Pka}{Pfarm}\left[R + \delta - \left(\frac{\dot{P}ka}{Pka}\right)\right]$. Then, a farm's analyzed profits are expressed as $\Pi = PfarmF(Ka, Na) - WaNa - PtilKa$, where $Ptil = Pka\left[R + \delta - \left(\frac{\dot{P}ka}{Pka}\right)\right]$. When solving this problem, the optimal demand for labor and capital stock in agricultural sector are respectively expressed as Na = f(Wa/Pfarm, Ptil/Pfarm, Pfarm), Ka = f(Wa/Pfarm, Ptil/Pfarm, Pfarm).

Let us also assumed fixed supply of input. Therefore, the function of employment in agricultural sector was written as

Na = f(Wa/Pfarm, Pfarm, Ptil/Pfarm); $(\partial Na/\partial(Wa/Pfarm)) < 0$, $(\partial Na/\partial Pfarm) > 0$ and $(\partial Na/\partial(Ptil/Pfarm)) > 0$.

The function of capital stock in agriculture was written as

Ka = f(Ptil/Pfarm, Wa/Pfarm, Pfarm); $(\partial Ka/\partial(Ptil/Pfarm)) < 0$, $(\partial Ka/\partial(Wa/Pfarm)) > 0$ and $(\partial Ka/\partial Pfarm) > 0$.

In addition, based on Starleaf (1982), it was stated that the nonfood price index had a short run impact upon the farm price index. Furthermore, as a small country, the farm price function would include the world agricultural price index as another explanatory variable. Thus, the farm price function was expressed as

Pfarm = f(Paw, Pna); $(\partial Pfarm/\partial Paw) > 0$ and $(\partial Pfarm/\partial Pna) > 0$.

D. Model of estimating impacts of price index and interest rate on gross domestic production (In and Mount, 1994)

In agricultural sector, gross domestic production was characterized by well-behaved production function (Ya). It was also assumed to exhibit the constant return to scale technology. It was expressed as

$$Ya = f(Na, Ka);\ (\partial Ya/\partial Ka) > 0 \text{ and } (\partial Ya/\partial Na) > 0.$$

As previously seen, it was stated that the price level and interest rate would have the effects on gross domestic production via channel of capital stock and employment.

Method and Procedure

This study is comprised of three steps: estimations of equations, formulation of complete model and policy simulation.

Step1: Estimations of equations. The simultaneous equations (Eq.(1) to Eq. (7)) were estimated by two-stage least squares method. The endogenous variables consisted of Y, C, Yd, T, I, Ex and Z. The exogenous variable consisted of G, Sd, E, R, Yf and Pimp. Other behavioral equations were estimated by ordinary least squares method (Table 5). The scope of this analysis was based on time series data during the first quarter of 1997 to the third quarter of 2004. The main sources of data sets were Bank of Thailand and Office of the National Economics and Social Development Board (Table 6).

Step 2: Formulation of complete model. The whole model consisted of 6 identity equations (Eq.(1), (3), (7), (12), (17), (19)) and 16 behavioral equations. It also contained 22 endogenous (Y, C, Yd, T, I, Ex, Z, P, Pna, Pa, Rn, R, E, Ca, Cfa, Exa, Ta, Pfarm, Ptil, Na, Ka, Ya) and 13 exogenous variables (G, Sd, Yf, Pimp, Rninb, Rf, Ms, Paw, Pfa, Pfna, Pka, δ, Wa). The baseline was solved by Gauss-Seidel algorithm for the entire period. The model was evaluated by simulation errors.

Table 5 Macroeconomic-agricultural linkage model

Structural model	Equation
Macroeconomic Model	
$Y_t = C_t + I_t + G_t + Ex_t - Z_t + Sd_t$	…(1)
$C_t = f(Yd_t)$	…(2)
$Yd_t = Y_t - T_t$	…(3)
$T_t = f(Y_t)$	…(4)
$I_t = f(R_t, Y_t)$	…(5)
$Ex_t = f(E_t, Yf_t)$	…(6)
$Z_t = f(Y_t, Pimp_t, Ex_t)$	…(7)
$P_t = 0.6394Pna_t + 0.3606Pa_t$	…(8)[1]
$Pna_t = f(R_t, Pimp_t, Y_t)$	…(9)
$Pa_t = f(Paw_t, Pna_t)$	…(10)
$Rn_t = f(Rninb_t, Ms_t, Y_t)$	…(11)
$R_t = Rn_t - (P_t - P_{t-4})/P_{t-4}$	…(12)
$E_t = f((R_t-Rf_t), (Ex_t-Z_t))$	…(13)
Agricultural Sector Model	
$Ca_t = f(Pa_t, Y_t, Pfa_t, Pna_t, Pfna_t,)$	…(14)
$Cfa_t = f(Pfa_t, Y_t, Pfna_t, Pa_t, Pna_t,)$	…(15)
$Exa_t = f(Yf_t, E_t)$	…(16)
$Ta_t = Exa_t - Cfa_t$	…(17)
$Pfarm_t = f(Paw_t , Pna_t)$	…(18)
$Ptil_t = Pka_t\{(R_t + \delta_t - (Pka_t - Pka_{t-4})/Pka_{t-4}) \}$	…(19)
$Na_t = f(Wa_t, Pfarm_t, Ptil_t)$	…(20)
$Ka_t = f(Ptil_t, Pfarm_t, Wa_t)$	…(21)
$Ya_t = f(Na_t, Ka_t)$	…(22)

Note: [1]The coefficient of equation (8) is drawn from Bank of Thailand.

[2]The depreciation rate is assumed to be 10 percent per year.

Variable identification: see Table 6.

Table 6 Variable identification

Variable	Unit	Explanation	Source of data
Y	Million baht	Gross domestic product at 1988 price.	Office of the
C	Million baht	Private consumption expenditure at 1988 price.	National
I	Million baht	National investment at 1988 price.	Economics and
G	Million baht	General government consumption expenditure at 1988 price = compensation of employees (wages & salaries and pay & allowance of members of the armed forces) + purchases from enterprises and abroad (military and civilian purposes) - purchases by households and enterprises.	Social Development Board, www.nesdb.go.th
Ex	Million baht	Exports of goods and services at 1988 price.	www.nesdb.go.th
Z	Million baht	Imports of goods and services at 1988 price.	www.nesdb.go.th
T	Million baht	Taxes revenue at 1988 price. Taxes revenue at current price.	Calculated Bank of Thailand,
E	1994=100	Real effective exchange rate. (Trade-weighted broad-21)	www.bot.or.th
Yf	Billions	Real gross domestic product of the United States of America.	www.economagic.com
Pimp	1995=100	Import price index in terms of baht;	Bank of Thailand, www.bot.or.th
Rn	Per cent per annum	Minimum lending rate. Interest rate as quoted by the 4 largest banks and by the 5 largest commercial banks since January 2000.	Bank of Thailand
Rninb	Per cent per annum	Interbank overnight lending rate.	Bank of Thailand
Ms	Million baht	Narrow money supply at 1988 price. Narrow money supply at current price.	Calculated Bank of Thailand
Rf	Per cent per annum	Real foreign interest rate. (1) Federal funds rate (2) %Change of consumer price index for all urban consumers: all items: index 1982-84 =100: SA	Calculated www.economagic.com

Table 6 (Continued)

Variable	Unit	Explanation	Source of data
P	1988=100	Headline consumer price index.	Rebasing from 2002=100
		Headline consumer price index (2002=100).	Bank of Thailand
Pna	1988=100	CPI for non-food and alcoholic beverages.	Rebasing from 2002=100
		CPI for non-food and alcoholic beverages (2002=100).	Bank of Thailand
Pa	1988=100	CPI for food and non-alcoholic beverages.	Rebasing from 2002=100
		CPI for food and non-alcoholic beverages (2002=100).	Bank of Thailand
Paw	1995=100	World agricultural price index. Comprising rice, shrimp, rubber, sugar, cassava, maize, coffee, soybeans, palm, tobacco, cotton and sorghum.	Bank of Thailand
Pfna	1995=100	Import price indices of nonfood.	Bank of Thailand
Pfa	1995=100	Import price indices of food, beverages & tobacco, animal &vegetable oils and fats.	Bank of Thailand
Pfarm	2002=100	Farm price index.	Bank of Thailand
Pka	2002=100	Producer price index by machinery & equipment, electrical equipment and transport equipment products.	Bank of Thailand
Wa	Baht per month	Average wages were deflated by farm price indices.	Calculated
		Annual data set: 1997 to 1998.	National Statistics Office
		Quarter 1 of 1997 to Quarter 4 of 1998.	Manipulated[1]
		Round 1 (February), Round 2 (May), Round 3 (August), Round 4 (November): 1999-2000.	National Statistics Office
		Quarter 1 of 2001 to Quarter 3 of 2004.	

Table 6 (Continued)

Variable	Unit	Explanation	Source of data
Na	Million	Employment in agricultural sector.	
		Round 1 (February) :1997.	Bank of Thailand
		Round 2 (May) :1997.	Manipulated[2]
		Round 3 (August) :1997.	Bank of Thailand
		Round 4 (November): 1997.	Manipulated[2]
		Round 1 (February), Round 2 (May), Round 3 (August), Round 4 (November): 1998 to 2000.	Bank of Thailand
		Quarter 1 of 2001 to Quarter 3 of 2004.	
Ka	Million Baht	Private capital stock of agricultural sector at 1988 price.	
		Annual data set.	www.nesdb.go.th
		Quarterly data set.	Manipulated[1]
Ca	Million Baht	Private consumption for food (meat, fish, fruit, vegetable, oils and fats)+(dairy products)+(grain mill products, other food products)+(beverages)+(tobacco products) at 1988 price.	www.nesdb.go.th
Ya	Million Baht	Gross domestic product originating from agriculture, hunting, forestry and fishing at 1988 price.	
Exa	Million Baht	Export: (food) +(beverages and tobacco) + (animal and vegetable oils and fats) at 1988 price.	Calculated
		Data set at current market price	www.bot.or.th
Cfa	Million Baht	Import: (food) +(beverages and tobacco) + (animal and vegetable oils and fats) at 1988 price.	Calculated
		Data set at current market price	www.bot.or.th

Note: [1]It was manipulated by Boot Technique; See Appendix A.

[2]It was manipulated by Demographic Techniques; See Appendix A.

Data set is seen in Appendix B.

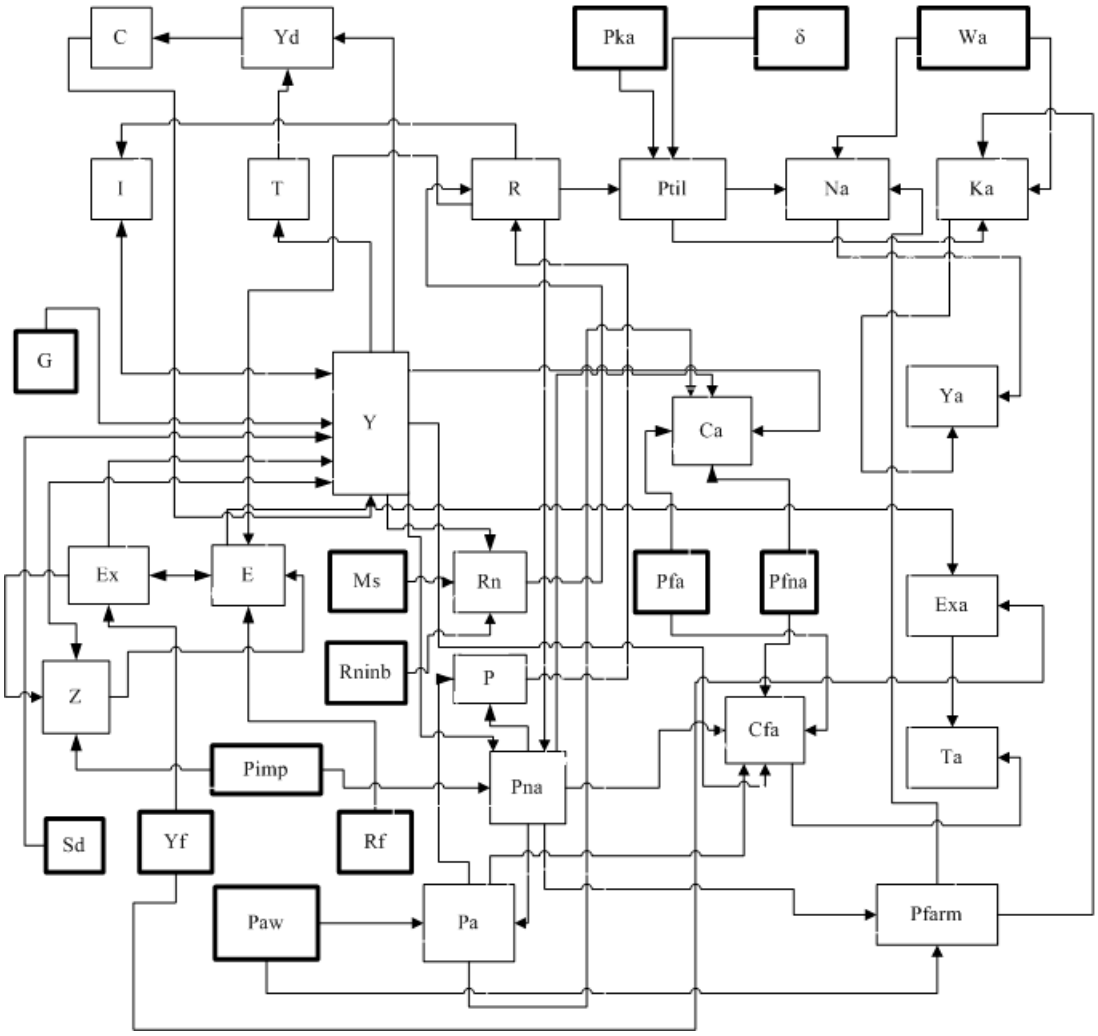

Figure 2 Impacts of shock variable on agricultural variable: Transmission channels
Note: ▭ = Exogenous variable and ▭ = Endogenous variable

Step 3: Policy simulation. Keeping all other things constant, the government consumption spending was played as a shock variable in the alternative scenarios. The effects of shock of government spending on macroeconomic variables diffused from macroeconomic model to agricultural model (Figure 2). Alternative scenarios were solved by Gauss-Seidel algorithm. Fortunately, the procedures were incorporated in EViews software.

AN OVERVIEW OF GOVERNMENT SPENDING AND AGRICULTURE

This section provides an overview of government spending and agriculture in Thailand. It is proceed as follows. The first subsection provides a brief historical background of selected features of government expenditure in two periods: 1970-1988 and 1989-2004. And then the second subsection is classified under two headings. The first heading documents briefly the historical discussion of agriculture from the 1st to 8th National Economic and Development Plan. The second heading presents the major economic indicators of agricultural sector regarding the descriptive evidences. The final part is a conclusion.

Overview of Thailand's Government Spending

This part illustrates changes in the composition of government spending over the period 1970-1988. It looks mainly at changes in the shares of the composition as shown in Table 7 and 8. One way to break down government expenditure is to look at the national income accounts where some items have a direct effect on aggregate output and some do not. The former category can broadly be called purchases of goods and services. The latter category comprises subsidies, transfer payments and interest payments on public debt (Sahasakul, 1993).

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I. During 1970 to 1988 (Sahasakul, 1993)

As shown in Table 7, government purchases (column 1) accounted for an average of 87.8 per cent of government expenditure from 1970-88; interest payments (column 3), 9.5 per cent; and subsidies and transfer payments (column 2), 2.7 per cent. Interestingly, the shares of both subsidies/transfer payments and interest payments have raised steadily over time. An increase in the share of subsidies/transfer payments is partly because of the more emphasis of government on public welfare. On the other hand, an increase in the share of interest payments is because of rapid

expansion of the public debt in the 1980s. At the same time, the interest rates on the public debt were relatively high in the early 1980s.

Looking at the composition of public purchases, government consumption averaged 63.3 per cent of government expenditures over the 1970 to 1987 period with no clear trend (column 4 of Table 7). In fact, the percentage share of government consumption was relatively stable over this period because approximately 60 per cent of government consumption came from the stable item of compensation of employees (column 6 of Table 7). By contrast, the share of public investment in GDP declined in the 1980s. This is partly because the government put a ceiling on public borrowing when revenue was depressed by the slow economy during the early 1980s and government expenditures were constrained. Since the government could not easily cut down its consumption, public investment was cut or deferred.

According to classifying by major function from 1980 to 1988, the defense accounted for the largest share of total government consumption (approximately one-third). When expressed relative to GNP, defense expenditures accounted for only an average of 3.8 per cent (column 9 of Table 8). Of the non-defense consumption (column 3-8 of Table 8), the general administration accounted for approximately a quarter of total government consumption, with a downward trend over the 1970-1987 period. On the other hand, it can be seen for the education and research with an upward trend. The other four items--justice and police, health and special welfare services, transport and communication facilities, and other services--together accounted for an average of approximately 20 per cent. As the increase in subsidies and transfer payments over time discussed above, the share of health and special welfare services rose but the share of transport and communication facilities declined significantly.

Table 7 Expenditures share of the general government, 1970-1987

(Unit: per cent)

Year	Purchases of goods and services (1)	Subsidies and transfers (2)	Interest on public debt (3)	Consumption (4)	Investment (5)	Compensation of employees (6)
1970	93.8	0.7	5.5	63.2	30.6	35.9
1971	92.9	0.9	6.2	61.4	31.5	35.9
1972	91.6	0.4	8.0	60.3	31.3	37.5
1973	90.2	0.8	9.0	62.4	27.8	38.9
1974	89.9	1.5	8.6	65.6	24.4	44.3
1975	90.9	2.2	6.8	61.9	29.1	41.2
1976	91.5	2.5	6.0	59.3	32.2	36.0
1977	90.1	3.1	6.7	59.6	30.5	35.6
1978	90.5	2.5	7.1	64.2	26.2	37.9
1979	89.8	2.4	7.8	66.4	23.4	38.6
1980	87.1	4.8	8.1	60.3	26.8	37.7
1981	86.7	3.4	10.0	65.9	20.7	37.4
1982	85.2	4.1	10.7	63.4	21.8	39.2
1983	82.6	5.7	11.7	64.3	18.3	41.7
1984	84.6	2.2	13.1	65.0	25.3	39.7
1985	82.4	3.7	14.0	65.8	16.5	39.6
1986	81.5	2.6	15.9	63.7	17.8	39.9
1987	79.6	4.3	16.1	66.2	13.4	41.2
1970-87	87.8	2.7	9.5	63.3	24.9	38.8

Note: Theoretically, columns (1)+(2)+(3)=100 per cent, columns (4)+(5)=column (1), and column (6) is part of column (4). However, this may not be exactly the case due to rounding.

Source: Sahasakul (1993)

Table 8 Composition of government consumption classified by major functions, 1970-1987

Year	Share of government consumption (%)								Ratio defense to GNP (%)
	Defense	Non-defense	General administration	Justice and police	Education and research	Health and special welfare services	Transport and communication facilities	Other services	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
1970	30.3	69.7	29.9	8.3	18.8	4.6	7.2	0.9	3.4
1971	30.6	69.4	28.2	8.5	19.8	5.0	7.0	0.9	3.5
1972	29.8	70.2	27.8	8.6	22.0	5.0	5.9	1.0	3.3
1973	31.3	68.7	26.1	8.9	22.2	5.0	5.7	1.0	3.1
1974	29.2	70.8	24.8	9.6	25.2	5.1	4.8	1.2	2.7
1975	26.5	73.5	24.2	9.0	25.5	5.5	8.0	1.3	2.7
1976	29.0	71.0	22.5	8.2	23.9	6.7	8.4	1.3	3.2
1977	33.4	66.6	23.0	8.2	22.9	6.7	4.4	1.3	3.6
1978	34.3	65.7	21.3	8.6	24.4	6.3	3.9	1.2	3.9
1979	36.1	63.9	21.4	7.9	23.7	6.3	3.4	1.2	4.4
1980	32.2	67.8	23.7	7.7	25.5	6.1	3.4	1.4	4.0
1981	34.3	65.7	24.3	7.4	23.4	6.1	3.3	1.2	4.4
1982	31.8	68.2	22.0	8.0	26.8	6.8	3.2	1.4	4.3
1983	31.6	68.4	21.5	8.4	27.2	7.4	2.8	1.2	4.1
1984	32.1	67.9	20.6	8.3	27.8	7.4	2.5	1.4	4.3
1985	33.6	66.4	19.8	8.7	27.1	7.6	2.1	1.1	4.8
1986	31.5	68.5	19.8	8.1	29.0	7.7	2.3	1.7	4.2
1987	31.7	68.3	19.5	7.4	29.3	7.8	2.2	2.1	4.1
1970-87	31.6	68.4	23.4	8.3	24.7	6.3	4.5	1.3	3.8

Notes: Theoretically, columns (1)+(2) = 100 per cent and columns (3)+(4)+(5)+(6)+(7)+(8) = column (2). However, this may not be the case due to rounding.

Source: Sahasakul (1993)

II. During 1989 to 2004

The spending share of the general government from 1988 to 2004 is reported in Table 9. The purchases of goods and services accounted for an average 89.0 per cent of total spending, interest rate payment 5.7 per cent and subsidies & transfer payments 5.3 per cent, respectively. In early 1990s, the share of government purchases of goods and services has raised continuously. Thereafter, it has decreased gradually since July 1997 due to the Asian financial crisis. At the same time, the shares of both subsidies & transfer payments and interest payments have increased steadily over time. This evidence is similar to the pattern of movement during 1970 to 1987.

The composition of government purchases goods & services are reported in Table 9. The government consumption averaged 57.3 per cent of the government purchases over the 1988 to 2004 period (column 4 of Table 9). It is still stable over this period owing to the stable item of compensation employees. On the other hand, the share of public investment expanded from 39.5 of government purchase in 1990 to 53.6 of government purchase in 1997. Nevertheless, owing to the financial crisis, it shrunk to 46.7 per cent of government purchase in 1998 and then this expenditure has declined continuously until to the year 2004.

When the government consumption separated into the major function for 1988 to 2004, the share of education and research accounted for the largest share of 32.4 per cent (Table 10). This is because the eighth National Economic and Social Development was concentrated on the development of human resource. By the contrast, the share of defense become ranked for the second and accounted for an average 22.0 per cent. Moreover, in describing with the ratio to GNP, the defense expenditure decreased from 2.8 per cent in 1990 to 1.6 per cent in 2004. The other four items together accounted for an average of roughly 20 per cent. The share of health and special welfare services raises continuously. On the one hand, the share of transport and communication facilities decreases gradually. This is because the most of big project of transportation and communication are invested by the private sector. From time to time, some transport projects will be invested by foreign loaning.

Table 9 Expenditures share of the general government, 1988-2004

(Unit: per cent)

Year	Purchases of goods and services (1)	Subsidies and transfers (2)	Interest on public debt (3)	Consumption (4)	Investment (5)	Compensation of employees (6)
1988	83.51	2.28	14.21	66.57	33.43	64.7
1989	80.58	6.19	13.23	65.36	34.64	66.8
1990	83.94	6.17	9.89	60.51	39.49	67.6
1991	88.58	4.51	6.92	56.09	43.91	67.6
1992	91.14	3.75	5.11	54.94	45.06	68.6
1993	91.26	4.67	4.06	55.85	44.15	69.8
1994	93.29	3.84	2.87	52.82	47.18	67.0
1995	94.53	3.75	1.71	52.75	47.25	71.3
1996	95.55	3.49	0.96	49.94	50.06	67.5
1997	95.71	3.09	1.20	46.42	53.58	71.2
1998	94.14	3.99	1.86	53.40	46.60	72.8
1999	90.46	4.97	4.57	55.33	44.67	72.4
2000	89.15	5.69	5.17	58.10	41.90	72.0
2001	88.22	6.34	5.44	59.43	40.57	72.3
2002	86.42	7.00	6.58	61.53	38.47	74.2
2003	84.13	8.54	7.32	62.15	37.85	74.1
2004	82.89	11.17	5.95	62.45	37.55	74.1
1989-2004	89.03	5.26	5.71	57.27	42.73	70.22

Note: Theoretically, columns (1)+(2)+(3)=100 per cent, columns (4)+(5)=column (1), and column (6) is part of column (4). However, this may not be exactly the case due to rounding.

Source: Office of the National Economic and Social Development Board (NESDB)

Table 10 Composition of government consumption classified by major functions, 1988-2004

Year	Share of government consumption (%)								Ratio defense to GNP (%)
	Defense	Non-defense	General administration	Justice and police	Education and research	Health and special welfare services	Transport and communication facilities	Other services	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
1988	30.95	69.05	19.64	7.48	29.47	8.16	2.37	1.94	3.16
1989	28.39	71.61	20.34	7.72	30.56	8.63	2.36	2.00	2.74
1990	29.29	70.71	20.05	7.49	30.70	8.17	2.31	1.99	2.79
1991	28.95	71.05	20.17	7.82	30.67	8.19	2.10	2.10	2.71
1992	28.11	71.89	20.00	8.18	30.71	8.43	2.21	2.37	2.85
1993	24.86	75.14	20.73	8.40	32.06	9.67	1.85	2.44	2.52
1994	25.51	74.49	21.14	8.25	30.60	9.72	2.21	2.59	2.53
1995	24.41	75.59	18.99	9.54	31.82	10.56	1.81	2.87	2.46
1996	23.49	76.51	21.38	9.30	30.75	10.20	2.00	2.88	2.45
1997	21.75	78.25	20.20	9.49	32.24	11.97	1.95	2.39	2.25
1998	18.74	81.26	20.09	9.33	35.26	12.37	1.96	2.24	2.15
1999	15.10	84.90	25.82	9.11	33.35	12.26	2.19	2.17	1.78
2000	14.57	85.43	25.10	9.56	34.67	12.20	1.72	2.18	1.68
2001	15.58	84.42	24.09	10.32	33.57	12.77	1.75	1.92	1.79
2002	14.92	85.08	23.39	10.33	34.17	12.20	2.69	2.31	1.68
2003	15.43	84.57	23.94	10.66	35.40	11.03	1.45	2.09	1.68
2004	14.29	85.71	25.62	10.85	34.52	10.77	1.83	2.11	1.62
1988-2004	22.02	77.98	21.81	9.05	32.38	10.43	2.04	2.27	2.28

Notes: Theoretically, columns (1)+(2) = 100 per cent and columns (3)+(4)+(5)+(6)+(7)+(8) = column (2). However, this may not be the case due to rounding.

Source: Office of the National Economic and Social Development Board (NESDB)

Overview of Thailand's Agricultural Sector

I. Nation economic development plan: Agriculture aspect (Falvey, 2000)

A. The first and second nation economic development plan, 1961- 1971

The first plan highlighted the limited power of the Office of the Under Secretary to the Prime Minister in coordinating government line agencies. It possibly widened cultural separation and increased rural dependence on urban centers partly through creating off-farm opportunities, which fragmented the social infrastructure of the rural Northeast. Mechanization and upland cash cropping further stimulated rural migration without consideration of longer-term opportunities for displaced persons.

The second plan was based on some analysis of market demand and resources, including manpower. Agriculture was addressed to meet domestic demand for fruit and vegetables while assuming continued mono cropping of rice based on current techniques. Intention to distribute the benefits of economic growth to agricultural producers was predicated on a fall in the proportion of the population engaged in agriculture, and a small improvement in equity occurred. However, the main benefit was for those farmers who exited agriculture to join the much better rewarding non-farm sector. The plan included investment in agricultural research and infrastructure development, and assistance for farmers in politically sensitive areas. State enterprises received less emphasis in favor of private import substitution and industry, which favored the primarily Chinese-Thai ownership of such businesses.

B. The third and forth nation economic development Plan, 1972- 1981

The third plan considered the difficult issues of agricultural land consolidation and allocation, distribution of water to farm level, and issuance of land title deeds, all aimed at introducing Green Revolution technologies. Security of land title was to allow mortgage-backed credit to finance fertilizer and other inputs necessary to obtain the benefits from irrigation and land consolidation. The increased

sophistication in such planing raised expectation of the approach, which was then extended to include social objectives.

The fourth plan used the Division of Agricultural Economics' new national crop model, which was hoped to provide annual modifications and subsequent five-year plans. The crop model was based on incomes from rice and upland crops, under-employment and unemployment, availability of land, utilization of agricultural inputs including fertilizer and new crop varieties, and the allocation of targets for the expansion of upland cropping. The issues considered in designing the agricultural component of the fourth plan included; high population growth, the low average incomes of farmers, rising unemployment among agricultural workers, low agricultural productivity, low rates of technology adoption by farmers, limited availability of agricultural land, and farmer resistance to new technologies. Rural development attracted Royal Projects, foreign aid, a Bangkok Bank community development fund, and army development of irrigation schemes. Poverty alleviation became the national security priority through the fourth plan.

C. The fifth and sixth nation economic development Plan, 1982- 1991

The fifth plan designated the poorest 12,555 villages in the country to receive special development funds. However, national security, not welfare, proved the more powerful motivation. Implementation of the program slowed in proportion to reductions in rural and border insurgency. By 1985, it was estimated that 30 percent of farmers had fallen below the poverty line, compared to 23 percent in 1981, as a result of poor implementation of plan when prices for upland crops declined. Studies of the period indicate that government export taxes stifled rice and rubber production.

The sixth plan, agriculture returned to its national economic role in broader view of the global markets. The plan contained no specific chapter concerning agriculture, discussing it under headings of rural development and natural resources. From this period, the separation of agricultural crops into two categories became standard; products with excess supply and grown for export, including rice, maize, coffee, and cassava. And for which quality improvement appear feasible were

separated from a second group comprised of domestic crops such as garlic, onion, shallot, palm oil, and coconut oil where market improvement, development of agro-industry and import regulations were seen as more important. A third group with insufficient supply such as soy bean meal, fishmeal and cotton were to be promoted through import restrictions. Attempts to introduce water usage fees, notwithstanding a past tradition of contributing both money and labor through the traditional *muang fai* system, confounded government investments and the economic benefit of large scale irrigation schemes. Analyses of such experience informed formulation of the seventh plan.

D. The seventh and eighth nation economic development plan, 1992- 2001

The seventh Plan included productivity enhancement and adding value to primary products. Couched in terms of modern Western agriculture, the plan listed five areas for action; efficient use of natural resources, support for research and development, technology transfer, restructuring production to suit local conditions and market demand, development of agro-processing industries, and improved agricultural cooperative development. Programs or projects specific to each of these were comprised by; Thailand's limited influence on world prices, government's assumed better forecasting ability than farmers', uniform packages which ignored regional and individual variations, miss-orienting subsidy programs to wealthier rather than poorer farmers, and inadequate government services and inputs. Assumed "trickle down" of rural wealth, the 1960s advent of farm labor, and pragmatic farmer responses to unintended incentives led to uneven development as Thailand accepted a price-taking role for exports. By the eighth plan, the farmer debts from government programs, including inedible and unmillable red millet and infertile, expensive, imported cattle had made small holders cynical of government programs.

The eighth National Economic and Social Development, developed before the 1997 economic crisis, sought stable economic growth, social equity, and improved public administration. Agriculture was considered within the development objectives of: improved child education and development; compulsory education to nine years rising to twelve and teacher training; upgrading industrial workers; assisting the

underprivileged; reducing avoidable accidents; reducing the current account deficit and inflation; increasing domestic saving; improving regional and rural infrastructure; reducing poverty; preserving and rehabilitating forest areas; increasing awareness of sustainable alternative agriculture; and promoting investment in rehabilitation and protection of the environment.

II. Key economic indicator of agricultural sector: 1997 to 2004

In this study, the major economic indicators of Thailand's agricultural sector are comprised of agricultural GDP, food consumption, food export, food import, employment and capital stock in agricultural sector. The descriptive evidences are also based on the quarterly time series data in terms of real value from 1997 to 2004. In other word, the overview of agriculture is briefly documented since the financial crisis in Thailand. The growth rates of key economic indicator are reported in Table 11.

A. Agricultural GDP and food consumption

In this research, the agricultural GDP at 1988 price contains the gross value added of agriculture, hunting and forestry of Office of the National Economic and Social Development Board (NESDB). It indicates an overview of agricultural sector development in Thailand. Owing to the economic crisis in 1997, the growth rate of agricultural GDP shrank to –2.52 per cent in 1998. At two later years, the agricultural sector can be a normal state that is its growth rate increased to approximately 4 percent in 2000 and 2001. In the year of 2003, overall of the agricultural sector performed very well. Bank of Thailand (2003) revealed that the crop production increased by 7.8 per cent, attributed mainly to the output of rice and cassava. Meanwhile, crop prices rose by 16.5 percent, led by the increase in the prices of natural rubber and Hom Mali rice in response to continued favorable global demand. Nevertheless, the growth rate of agricultural GDP shrank to -5 per cent in 2004. Bank of Thailand (2004) revealed that the major crop production index declined by 1.2 percent due to lack of rainfall, which adversely affected the production of rice,

sugar cane, and cassava. More precisely, the volatility of quarterly agricultural GDP is in the way of seasonality (Figure 3).

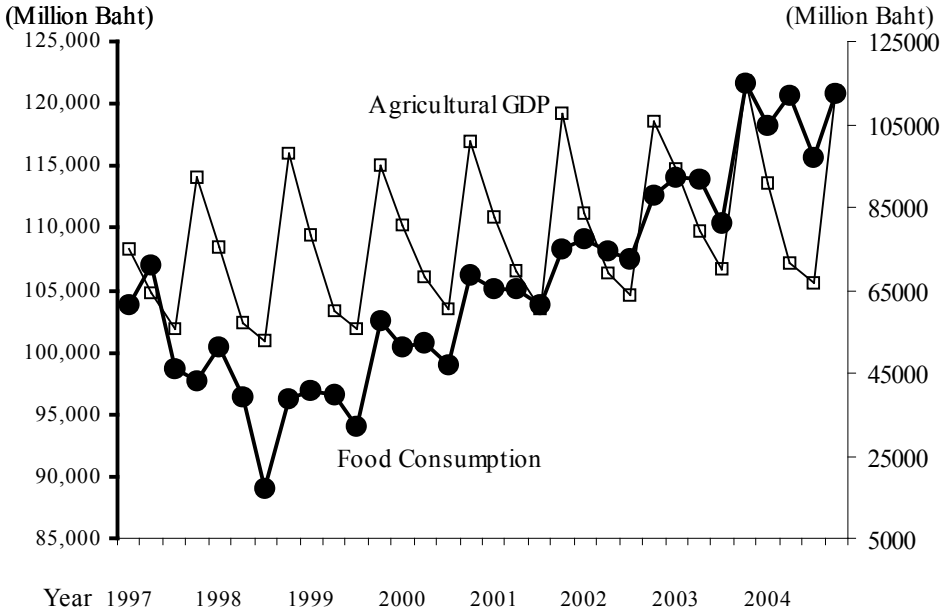

Figure 3 Agricultural GDP and food consumption, 1997-2004
Source: Office of the National Economic and Social Development Board (NESDB)

In this research, the food consumption at 1988 price consists of the expenditure on meat, fish, fruit, vegetable, oils and fats, dairy products, grain mill products, other food products, beverages and tobacco products of NESDB. The growth rate of food consumption shrank to –6.10 per cent in 1998. Meanwhile, Bank of Thailand (1998) revealed that the private consumption expenditure contracted by 14 per cent owing to the following factors. Firstly, the economic contraction reduced households' purchasing power and caused consumers to become more cautious in their spending. The latter was because of higher uncertainty involved in future employment and income stemming from high lay-offs, decreased asset value, and debt overhang. Secondly, the slow pace of resolution of financial institution problems led to lower credit extension, especially consumer credits. However, increases in farm income, export earnings, and workers' remittance benefiting from Baht depreciation helped to prevent a sharper contraction in consumption. Meanwhile, decelerating inflation partly helped to reduce household's expenditure burden. At a later time, the

growth rate of food consumption averaged 4 per cent over the 2002 to 2004 period with seasonal component (Figure 3). Of course, its growth represents a crucial driving force for encouraging the growth of agricultural GDP according to demand perspective.

B. International trade of food

In this research, the food export and import at constant price contains the food, beverages & tobacco and animal & vegetable oils and fats of Bank of Thailand. It can be seen obviously in Figure 4 that Thailand has been the agricultural exporter so far. Therefore, the situation of food import is less significant in the way of trade account during 1997 to 2004. The following explanation is focused on the situation of food export. Interestingly, the growth rate of food export raised to 8.89 percent in 1998. This is mainly because the home currency depreciated heavily during such periods. Moreover, its growth increased significantly to 13.05 and 11.38 in 1999 and 2000, respectively.

Figure 4 Food export and import, 1997-2004
Source: Bank of Thailand

Nonetheless, in 2002 the growth rate of food export severe dropped to –12 per cent particularly in the third quarter. Bank of Thailand (2002) revealed that the volume of rice export declined as a result of an unusually high base volume in the latter part of 2001 when Nigeria accelerated its import of Thai rice in anticipation of a tariff hike. As for tapioca, although its export price rose in 2002 with strong demand from China for tapioca chips and pellets used to produce alcohol, its export value declined as a result of limited domestic supply. In addition, as a result of the rise in tapioca price, livestock producers in the EU turned to use cheaper local grains for feeding instead. The export value of frozen fowl also fell as a result of a continued decline in its export price since May due to intense competition from Brazil, following a production increase and the depreciation of the real exchange rate, and China which had a cost advantage. The decline in price as well as in volume contributed to the fall in frozen fowl exports to the EU. The export value of frozen shrimp declined, owing to both a fall in volume and a fall in price (particularly in the US market, which accounted for over 40 per cent of frozen shrimp exports from Thailand). With more supply coming from China, Vietnam and Brazil, the price of frozen shrimp in the world market was kept low, providing no incentive for Thai producers to expand production. In addition, there were problems concerning the EU's strict examination of antibiotic residues in shrimp.

Subsequently, the growth of food export decreased to approximately 6 per cent in 2004. Bank of Thailand (2004) revealed that it was primarily due to a decline in the export of rubber and frozen fowl. Export volume of rubber to major markets, namely ASEAN, China and Japan, decreased. In particular, China, a major importer, imported more from Indonesia because of lower price. Export volume of frozen fowl decreased by 92.8 percent as a result of avian flu while the reduction in the world supply pushed up the price slightly.

C. Agricultural input

This study is focused on two inputs: labor and capital stock. Beginning with the descriptive evidence of employment in agricultural sector, its growth rate decreased to –5.15 per cent in 1998 regarding to continued sluggish Thai economy. In

2002 the growth rate of employment in agricultural sector raised to approximately 3 per cent. Bank of Thailand (2002) revealed that the overall economic recovered in 2002. At the same time, the government attempts to create jobs, for instance, through the launching of the village funds since mid-2001 and the introduction of the One-Tambon-One-Product projects. Nevertheless, Bank of Thailand (2004) revealed that agricultural employment declined from the previous year by 2 percent as a result of drought and the increased demand for labor in the non-agricultural sectors. In addition, it can be seen obviously in Figure 5 that the time series data of employment in agricultural sector is exactly in the form of seasonality according to the nature of agricultural production.

This study considers only the private capital stock in the 1988 fixed-price of NESDB. It consists of farm buildings, farm structure, animals, plants, agricultural machinery and transportation equipment. Owing to the sluggish Thai economy, the growth rate of capital stock in agricultural sector dropped to -0.62, -0.97 and –0.23 in 1999, 2000 and 2001, respectively. At the later time, it can be seen obviously in Figure 6 that the growth rate of capital stock in agricultural sector averaged 1 per cent over the 2002 to 2004 periods with clear trend.

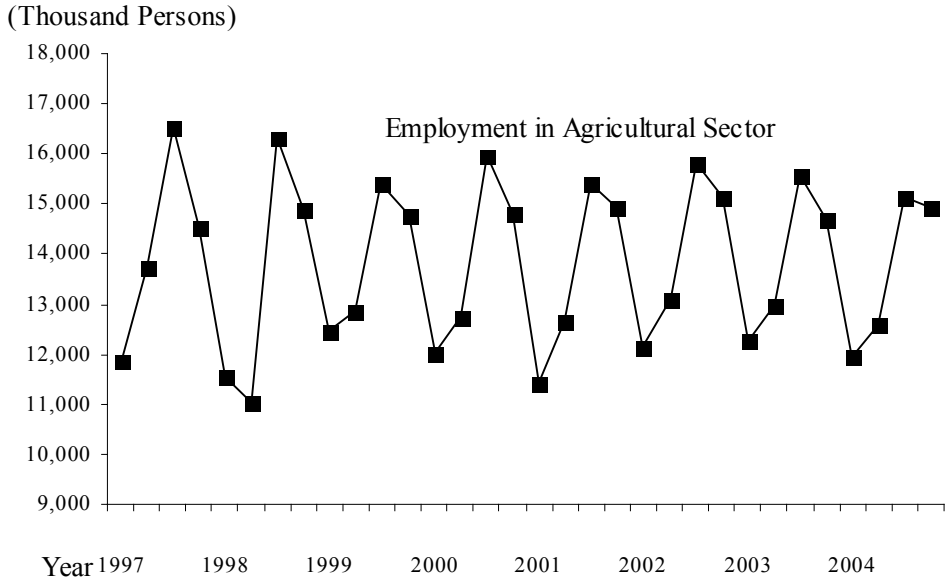

Figure 5 Employment in agricultural sector, 1997-2004

Note: The quarterly data is manipulated by this study. See Appendix A.

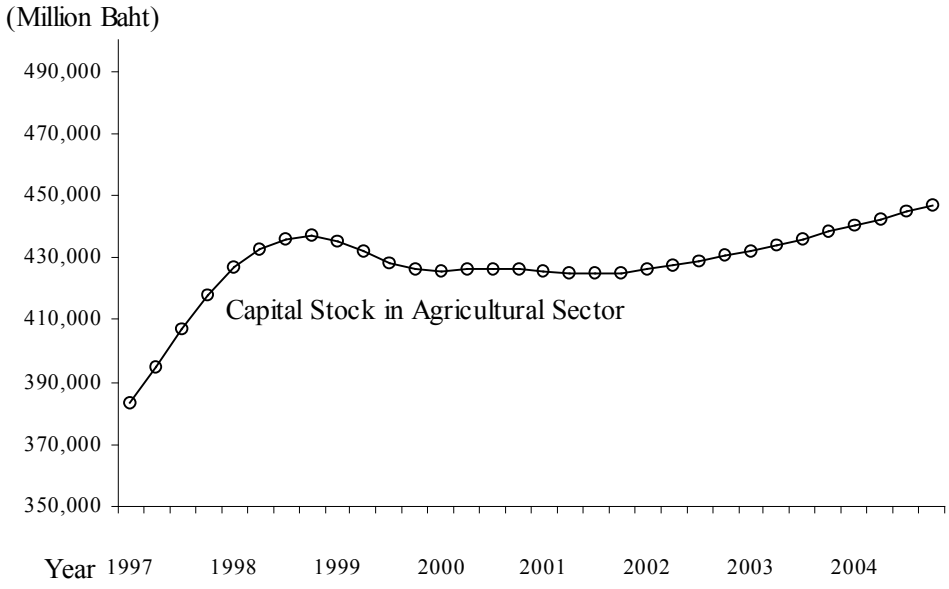

Figure 6 Capital stock in agricultural Sector, 1997-2004
Note: The quarterly data is manipulated by this study. See Appendix A.

Conclusion

Over the past 40 years, the government consumption expenditure averaged approximately 50 per cent of total expenditure. In fact, the percentage share of public consumption was relatively stable over this period because approximately 60 per cent of public consumption came from the stable item of compensation of employees. As concerning on the agricultural sector, the government spends the budget in order to develop this sector according to National Economic and Social Development (Plans One to Eight). Key economic indicators of agricultural sector are also shown as the agricultural sector performance during 1997 to 2004.

According to the composition of public consumption, some items of spending have a direct impact on agriculture and some do not such as defense. However, the theoretical model in earlier section shows that several channels link the government consumption spending to the agricultural sector. Quantitatively, the next section will present the impacts of government consumption spending on agriculture.

Table 11 Key indicator of agricultural sector

Year	Growth Rate (per cent)					
	Agricultural GDP	**Food consumption**	**Food export**	**Food import**	**Employment in agricultural sector[1]**	**Capital Stock in agricultural sector [1]**
1998	-2.52	-6.10	8.89	-0.34	-5.25	8.12
1999	3.17	2.23	13.05	13.71	4.48	-0.62
2000	7.73	4.17	11.38	15.02	-0.10	-0.97
2001						
Q1	2.30	4.69	8.07	25.34	-4.85	-0.01
Q2	1.77	4.25	24.31	37.87	-0.81	-0.23
Q3	0.12	4.98	6.51	23.95	-3.52	-0.41
Q4	6.89	1.98	-1.98	9.97	0.83	-0.27
2002						
Q1	1.64	3.82	-3.66	0.19	6.07	0.08
Q2	-0.65	2.90	-13.40	-15.88	3.66	0.52
Q3	5.03	3.52	-19.74	-21.44	2.54	0.95
Q4	-1.66	3.96	-9.48	7.57	1.15	1.26
2003						
Q1	12.46	4.51	-1.49	0.15	0.97	1.47
Q2	14.66	5.42	9.84	8.41	-0.87	1.62
Q3	10.58	2.77	5.78	8.16	-1.51	1.71
Q4	9.04	8.08	2.11	-9.74	-2.73	1.80
2004						
Q1	-3.35	3.74	-5.70	2.90	-2.58	1.86
Q2	-9.86	5.92	-11.28	-8.75	-3.33	1.92
Q3	-5.48	4.74	-5.68	4.88	-2.87	1.95
Q4	-2.08	-0.66	-1.60	4.93	1.43	1.97
1998-2004	2.68	2.35	4.14	6.86	-0.35	1.51

Note: [1]The quarterly data of capital stock and employment is manipulated by this study. See Appendix A.

Source: NESDB and Bank of Thailand.

RESULTS AND DISCUSSION

The descriptive evidence as mentioned in the preceding section consigns the study to the quantitative evidences in this section. Based on the theoretical model, the result is comprised of two main parts: the estimation of structural parameters and simulation of the macroeconomic-agricultural linkage model. The former is concentrated on the impacts of macroeconomic factors on the key economic indicator of agricultural sector. Since these macroeconomic factors link the government consumption spending to agricultural sector, the latter presents the effects of spending on several agricultural variables.

Result of Estimated Structural Model

The estimation results of behavioral equations are shown in the Table 12. Most of them employ the concept of autoregressive (AR) and moving average (MA) in order to relieve the serial correlation problem. When Lagrange multiplier (LM) test detects the estimated equations, the results reveal to be satisfactory in all of behavioral equations. Additionally, the standard error (S.E.) of regression, which represented a summary measure based on the estimated variance of residuals as well as the adjusted R-squared, which was a measure of goodness of fit were satisfactory. Moreover, the sign of coefficients were consistent with economics theories and previous literatures. Some estimated coefficients might turn out to be close to zero since the level of significance was not clarified. Nonetheless, this problem would be acceptable because this incidence came from the multicollinearity problem (see correlation between two explanatory variables in Table 12). Overall, the estimated regressions performed well.

I. Estimated regressions in macroeconomy

The estimation results of basic Keynesian model are shown as the equation R1 to R13. The concluding remarks are presented as follows.

A. Private consumption and investment

According to the equation R2, the contemporary disposable income has a positive impact on private consumption. Moreover, the short-run marginal propensity to consume is estimated to have been approximately 0.79. This result supports the Keynesian hypothesis that the marginal propensity to consume is greater than zero and less than one. On one hand, the estimated coefficients of the private investment are reported in the equation R5. It revealed that the increase in real interest rate retards significantly the private investment demand *ceteris paribus*. This result conforms to the proposition of Keynesian in the context of crowding-out effect. Meanwhile, the real income has a positive impact on private investment.

Shinnathambu (2001) revealed that the coefficient of real GDP indicated that the accelerator effect of output dominated the private investment behavior in Thailand. It is consistent with the flexible-accelerator family of investment theories. Higher level of output causes the firm to demand a larger stock of capital. This implied that the output expansion is likely to be a necessary condition to maintain a higher investment

B. Price level

With respect to the inflation, the estimation results from equation R8 through R10 indicated that the price level determination is consistent with the concept of cost-push and demand-pull in economic theory. As the cost-push factors, the price level in Thailand is sensitive to the change in the imported price index. On the other hand, as the demand-pull factors, the real interest rate negatively affected the price level owing to decrease in purchasing power of consumer and incentive of business investment. Not surprisingly, the real income lead macroeconomy to increase price level according to increase the aggregate demand. Apart from this, the nonfood price index has significantly positive impact on food price index. This result conforms broadly to the findings of Starleaf (1982).

C. Nominal interest rate

Based on the equation R11, the real GDP has significantly positive impact on nominal interest rate because of stimulating the demand for money. Nonetheless, the level of significance was not clarified. This is because the quite high correlation between the variable of real GDP and money supply. On the other hand, the money supply has significantly negative impacts on the nominal interest rate. These results are consistent with the Keynesian school of thought. In addition, the interbank overnight lending rate, which determined by Bank of Thailand, leads to increase the nominal interest rate when keeping other factors hold unchanged. This result conformed to the finding of Charoenkittayawut (2001).

D. Real effective exchange rate

Based on the equation R13, the difference between domestic and foreign interest rate has a negative impact on the real effective exchange rate. It shows that when the interest rates are high in Thailand relative to the foreign interest rates, the investment in home assets increases. This incidence causes appreciated Thai Baht *ceteris paribus*. Meanwhile, the surplus of current account increases the supply of foreign currencies and then the Baht would appreciate. Notwithstanding the sign of th coefficients are consistent with the expectation, the levels of significance are still questionable. It can be stated that the function of foreign exchange market was not prominently supported by the Thai data during 1997 to 2004.

II. Estimated regressions in agricultural sector

As the transmission variables, the macroeconomic factors have the significant impacts on the agricultural sector (Part b of Table 12). The marginal effect of macroeconomic variable on agricultural variable is utilized for the estimation of elasticity at mean value. Regarding to a concluding remark, the estimated elasticity of food consumption with respect to real GDP is not too low. Therefore, the public policies utilized for stimulating the economic growth significantly affect the food

consumption demand. On one hand, the estimated elasticity of food export with respect to exchange rate is implied that not merely the regulations of international trade but also strengthening the Thai Baht against the U.S. dollar should be a concern of policy makers. The further details of estimation results are discussed as follows.

A. Effect of GDP and price level on food consumption and import

Based on the equation R14 and R15, the estimated income elasticity of food consumption expenditure and food import is respectively equal to 0.78 and 0.70 at mean value. Ardeni and Freebairn (2002) succinctly stated: "…the real income growth increased demand for food and fiber, but the income elasticity was low, perhaps as high as 0.7 to 0.9 for developing countries, but down to 0.4 or lower for developed countries…". Accordingly, Thailand's figure conforms to the findings of developing countries.

The price levels affect food consumption and import via consumer price index for food and nonfood. The estimation result shows that the own-price elasticity of food consumption expenditure is estimated to have been roughly -0.13 at mean value. This result supports the microeconomic theory in the way that the absolute value of own-price elasticity of demand is less than one for the case of necessary commodities. Nonetheless, the interpretation of estimated cross-price elasticity of demand would be ignored here. This is due to the food commodities in home country not perfectly substituting for food produced in foreign countries. Similarly, the food and nonfood commodities also are not clearly substituted products.

B. Effect of exchange rate on food export

According to the equation R16, the marginal effect of real effective exchange rate on food export is significant and is of the expected sign. As a consequence, the food export elasticity with respect to exchange rate is estimated to have been approximately –0.45 at mean value. It is interpreted that holding other things constant, 10% depreciation in the Thai Baht, led on the average about 4.5%

increase in the food export. This result is generally consistent with Batten and Belongia (1986) and Saunder *et al*. (1999) in the way that exchange rate represents a momentous factor to determine the competition of agricultural goods in the international markets.

C. Effect of interest rate and price level on employment and capital stock in agricultural sector

Based on the equation R18 to R21, the real interest rate has a significant impact on two inputs in agricultural sector through the capital rental rate. Based on the estimated coefficient in Eq.R21, the elasticity of labor with respect to capital rental rate is estimated to have been roughly 0.003 at mean value. On one hand, based on the estimated coefficient in Eq.R20, the elasticity of capital stock with respect to capital rental rate is estimated to have been roughly -0.006 at mean value. It was further stated that the employment in agriculture is rather insensitive to the real interest rate. In addition, the price level significantly affects two inputs in the agricultural sector through farm price index. The elasticity of capital stock and labor with respect to farm price index is respectively estimated to have been 0.05 and 0.04 at mean value.

D. Effect of interest rate and price level on gross domestic production in agricultural sector

According to the equation R22, the real interest rate and price level affects gross domestic production in agriculture via the channel of two inputs. The estimated labor elasticity of gross domestic production is equal to 0.62 at mean value. It should be noted that the production elasticity of labor is low. It is of interest to compare the Cobb Douglas production function in logarithmic transformation that is also estimated by Shintani (2003) using gross value added as dependent variable. The result reveals that the estimated labor elasticity of agricultural production is about 0.6. It is stated that Shintani's result confirms the reliability of estimated elasticity in this study.

On one hand, the estimated capital elasticity of gross domestic production is equal to 3.09 at mean value. Comparing with Asian norms, the capital input elasticity of gross domestic production is rather high in Thai Agriculture because Fan *et al*. (1995) revealed that in Asian Agricultural sector the capital input appears to have played a small as its elasticities range from 0.04 through 0.10. Thus, in this study the estimated input elasticity of gross domestic production shows that the assumption of constant return to scale technology is not supported by data set for Thai Agriculture during the study period.

Policy Simulation

The macroeconomic-agricultural linkage model (equation R1 to R22) is evaluated by the simulation errors of system. These errors represent as the comparison between baseline and actual value. The baseline value is solved by Gauss-Seidel algorithm for the first quarter of 1998 through the third quarter of 2004. The root mean square errors of major endogenous variables report in Table 13. It reveals that the values of root mean square errors vary between approximately 1 and 10 per cent. Consequently, Theil Inequality coefficients are less than or equal to 0.057. These errors indicate that the system of complete model is appropriate for policy simulation. To demonstrate a policy replication, increase in government consumption expenditure is set up for three scenarios holding other things constant. The 5, 10 and 15 percent increasing in government expenditure is respectively set up for scenario I, scenario II and scenario III for every quarter over the first quarter of 1998 to the third quarter of 2004. The simulated value of alternative scenario is solved by Gauss-Seidel algorithm.

As the simulation results, the expanded government consumption spending significantly affects the macroeconomic variables. The main simulation results reveal that the real GDP, price level and real interest rate increase, while the real effective exchange rate decrease. And then, these transmission variables affect the endogenous variables in agricultural sector. The impacts of increasing government consumption spending on key economic indicators of agricultural sector are reported in Table 14.

I. Impacts of increase in government consumption expenditure on food consumption expenditure

On the average, although the increase in government consumption spending lead to increase consumer price index for food and real GDP, the food consumption expenditures increase over the three simulation years. This is because the absolute value of own-price elasticity of food consumption is obviously less than the real income elasticity as previously seen in the section of estimation results. Therefore, the damage of food consumption expenditure derived from inflation is not severe.

II. Impacts of increase in government consumption expenditure on food import and export

On the average, the increase in government consumption expenditure leads to increase food import over the simulation years through real GDP as an important transmission variable. At the same time, the expanding government consumption spending lead to increase food export over the simulation years through the transmission variable of real effective exchange rate. Unfortunately, the increased food import has heavy impetus rather than the increased food export that negatively affects the trade account for food. Nevertheless, up to now Thailand has been known as agricultural exporter. Therefore, it has just resulted in the surplus of trade account.

III. Impacts of increase in government consumption expenditure on gross domestic production in agriculture

On the average, the increase in government consumption spending lead to increase farm price index as well as capital rental rate in agricultural sector. Nonetheless, the employment and capital stock in agriculture increase over the simulation years. This is because in term of absolute value the farm price elasticity of input is greater than the capital rental rate elasticity of input as seen in the earlier section. As a consequence, the gross domestic production in agricultural sector

increases through the channel of two inputs. It is further stated that the inflation is advantage for gross domestic production in agricultural sector.

IV. Discussion

Quantitatively, the benefits of Thailand's agricultural sector, which are gained from the government consumption spending, are not prominent (Table 14). The simulation results should be noticed that the food consumption and import impacts of government spending are more benefit rather than gross agricultural production. This is mainly because the macroeconomic-agricultural linkage model is based on the basic Keynesian perspective. This school of thought is strongly believed in the way of demand management in short run instead of the supply management in the long run. That is the government spending has directly impact on food consumption and import through the real GDP. On the other hand, the government spending affects gross domestic production in the agricultural sector through several distant channels.

As comparing with the related literatures, the simulation results of this study are overall consistent with Kitchen *et al*. (1987); Paarlberg *et al*. (1984), and Just (1990) in the way that the macroeconomic policies have significantly unintended effects on the agricultural sector. More specifically, in the case of Thai literature the agricultural GDP impacts of government expenditure conformed to the inference of Wongsak (2001).

On the other hand, the food export impact of government spending seems to be questionable. It should be further discussed as follows. With respect to transmission channel, the real effective exchange rate (REER) links the government consumption spending to the food export. When the government increases the consumption spending, REER decreases or in other word the Thai Baht depreciates. This incident lead to raise the food export. Nevertheless, Thai Baht can be appreciated according to the standard Mundell-Fleming results, which based on Keynesian school of thought.

When the government utilizes expansionary fiscal policy, the real GDP and domestic interest rate raises. Increase real GDP lead to increase import of goods & services and then the current account is worsened *ceteris paribus*. At the same time, increase domestic interest rate lead to increase capital inflow and then the capital account is improved *ceteris paribus*. Owing to these incidences, the domestic currency can be appreciated or depreciated regarding the flexible exchange rate regime. Firstly, if the impetus of worsening current account is less than the force of improving capital account, then the increase demand for foreign currencies will less than the increase supply of foreign currencies. It leads to appreciate the domestic currency in order to the balance of payment account condition. Saying other word, the exchange rate declines according to the equilibrium of foreign exchange market. Secondly, if the impetus of worsening current account is greater than the force of improving capital account, then the increase demand for foreign currencies will greater than the increase supply of foreign currencies. It leads to depreciate the domestic currency in order to the balance of payment account condition. In other word, the exchange rate raises regarding the equilibrium of foreign exchange market.

Notwithstanding the theoretical model indicates that the exchange rate can be increase or decrease, the empirical model of this study has already been investigated. The simulated result of this study can be declared that is consistent with the second case as previously seen.

Table 12 Result of estimated structural model

a. Impacts of government consumption expenditure on macroeconomics variables	$\overline{R}^2$	**S.E. of Regression**	**LM(2) test**
Two-Stage Least Squares Method			
Eq.R1: Expenditure on GDP			
$Ysa_t = Csa_t + Isa_t + Gsa_t + Exsa_t – Zsa_t + Sdsa_t$			
Eq.R2: Private Consumption			
Csa_t = -110,444 + 0.79$Ydsa_t$ + [AR(1)=0.87]	0.998	1,747.236	0.849
(-4.04)*** (21.53)***			(0.654)
Eq.R3: Disposable Income			
$Ydsa_t = Ysa_t – Tsa_t$			
Eq.R4: Tax Revenue			
Tsa_t = -129,018 + 0.30Ysa_t	0.991	1,402.291	0.524
(-2.88)*** (7.34)***			(0.770)
+[AR(1)=0.44,AR(2)=-0.30,AR(3)=0.71, MA(1)=0.82, MA(2)=0.55,BACKCAST=1997:4]			
Eq.R5: National Investment			
Isa_t = -161,454 – 48,909.25R_t + 0.42Ysa_t	0.973	4,460.678	1.681
(-3.30)*** (-0.42) (7.46)***			(0.431)
+ [AR(3)=0.73,AR(4)=-0.35,MA(1)=0.99]			
$r_{R,Ysa}$ = -0.86			
Eq.R6: Export of Goods and Services			
$Exsa_t$ = -590,567 – 3,338.16E_t + 134.73Yf_t	0.988	7,873.011	3.300
(-3.99)*** (-3.26)*** (19.421)***			(0.192)
+ [AR(4)=-0.11,MA(3)=-0.99,BACKCAST=1998:1]			
Eq.R7: Imports of Goods and Services			
Zsa_t = -170,029 + 0.37Ysa_t - 132.47$Pimp_t$ + 0.58$Exsa_t$	0.998	2,870.934	4.320
(-3.78)*** (2.67)*** (-1.41) (3.841)***			(0.115)
+ [AR(1)=0.83,AR(4)=-0.24,MA(4)=-0.97,BACKCAST=1998:2]			
$r_{Pimp, Ysa}$ = 0.68, $r_{Pimp, Exsa}$ = 0.65			

Table 12 (Continued)

a. Impacts of government consumption expenditure on macroeconomics variables	$\overline{R}^2$	**S.E. of Regression**	**LM(2) test**
Ordinary Least Squares Method			
Eq.R8: Consumer Price Index			
$P_t = 0.6394Pna_t + 0.3606Pa_t$			
Eq.R9: CPI for Nonfood and Alcoholic Beverages			
$Pna_t = 144.79 + 0.0082Pimp_t - 85.55R + 2.92\times10^{-5}Ysa_t$	0.988	0.738	1.059
(10.26)*** (0.47) (-3.58)*** (1.68)*			(0.589)
+ [AR(2)=0.47,MA(1)=1.13,MA(2)=0.51,MA(3)=0.51, MA(4)=0.39]			
$r_{Pimp,R} = -0.71$, $r_{Pimp,Ysa} = 0.68$			
Eq.R10: CPI for Food and Nonalcoholic Beverages			
$Pa_t = 91.83 + 0.20Paw_t + 0.60Pna_t$+ [AR(1)=0.88]	0.923	2.337	0.973
(1.40) (1.50)* (1.52)*			(0.615)
Eq.R11: Nominal Interest Rate			
$Ln(Rn_t) = 7.21 + 0.40Ln(Ysa_t) - 1.15Ln(Mssa_t) + 0.16Ln(Rninb_t)$	0.985	0.039	0.435
(1.08) (0.45) (-2.45)*** (5.12)***			(0.804)
+ [AR(1)=0.72,AR(2)=-0.04]			
$r_{Ln(Ysa),Ln(Mssa)} = 0.95$, $r_{Ln(Ysa),Ln(Rinb)} = -0.44$			
Eq.R12: Real Interest Rate			
$R_t = Rn_t - (P_t - P_{t-4})/P_{t-4}$			
Eq.R13: Real Effective Exchange Rate			
$E_t = 72.46 + 77.08(R_t - Rf_t) + 3.32\times10^{-5}(EXsa_t - Zsa_t)$	0.754	2.050	4.087
(5.96)*** (1.53)* (0.34)			(0.130)
+ [AR(1)=0.82,AR(2)=-0.40, MA(4)=0.94,BACKCAST=1997:3]			
$r_{(R-Rf),(EXsa-Zsa)} = 0.45$			

Table 12 (Continued)

b. Impacts of macroeconomic variables on agricultural variables	$\overline{R}^2$	**S.E. of Regression**	**LM(2) test**
Ordinary Least Squares Method			
Eq.R14: Private Consumption for Food			
$Casa_t$ = -19,668 - 67.84Pa_t + 0.11Ysa_t + 54.93Pfa_t + 348.90Pna_t	0.987	803.330	2.452
(-2.25)***(-1.85)** (32.84)*** (2.17)*** (4.30)***			(0.293)
- 30.31Pfna			
(-1.74)**			
Eq.R15: Food Import			
$Cfasa_t$ = -5,345-25.61Pfa_t+0.01Ysa_t+28.68$Pfna_t$- 81.63Pa_t	0.957	545.586	3.715
(-0.58)(-1.23) (1.65)* (2.51)*** (-2.01)**			(0.156)
+ 144.29Pna_t + [AR(1)=0.56,MA(1)=0.997]			
(1.82)**			
$r_{Pfa,Pna}$ = -0.76, $r_{Y,Pna}$ = 0.78, $r_{Y,Pa}$ = 0.71			
Eq.R16: Food Export			
$Exasa_t$ = 48,324 + 4.58Yf_t - 346.49E_t	0.950	1,498.486	3.970
(1.52)* (1.77)** (-2.29)***			(0.137)
+ [AR(3)=0.11,MA(1)=1.60,MA(2)=1.61,MA(3)=0.96,			
BACKCAST=1997:4]			
Eq.R17: Trade Balance of Food			
$Tasa_t$ = $Exasa_t$ – $Cfasa_t$			
Eq.R18: Farm Price Index			
$Pfarm_t$ = -217.21 + 1.31Pwa_t + 1.43Pna_t + [AR(1)=0.49]	0.874	3.893	0.517
(-4.38)*** (7.60)*** (5.41)***			(0.772)
Eq.R19: Capital Rental Rate of Agricultural Sector			
$Ptil_t$ = Pka_t (R_t + δ_t – (Pka_t - Pka_{t-4})/Pka_{t-4})			

Table 12 (Continued)

b. Impacts of macroeconomic variables on agricultural variables	$\overline{R}^2$	**S.E. of Regression**	**LM(2) test**
Ordinary Least Squares Method			
Eq.R20: Employment in Agricultural Sector			
$Nasa_t$ = 13,222 - 0.04$Wasa_t$ + 5.25$Pfarm_t$ + 27.09$Ptil_t$			
(16.78)***(-0.24) (1.59)* (0.95)	0.830	89.272	0.031
+ [AR(1)=0.45,AR(2)=0.26,AR(3)=-0.41,MA(4)=-0.94,			(0.985)
BACKCAST=1997:4]			
$r_{Wasa,Pfarm}$ = -0.51, $r_{Pfarm,Ptil}$ = -0.64			
Eq.R21: Capital Stock in Agricultural Sector			
$Kasa_t$ = 111,620 - 334.39$Ptil_t$ + 206.70$Pfarm_t$ + 0.98$Wasa_t$			
(8.95)*** (-2.276)*** (6.370)*** (1.035)	0.987	1,099.871	1.793
+ 0.69$Kasa_{t-1}$			(0.408)
(31.374)***			
$r_{Wasa,Pfarm}$ = -0.51, $r_{Pfarm,Ptil}$ = -0.64			
Eq.R22: Gross Domestic Production in Agricultural Sector			
$Yasa_t$ = -211,314 + 3.49$Nasa_t$ + 0.56$Kasa_t$			
(-2.097)*** (3.77)*** (2.42)***	0.970	1,085.214	0.444
+ [AR(1)=1.53,AR(2)=-0.70,MA(3)=0.85,BACKCAST=1997:3]			(0.801)

Note: Ysa, Csa, Isa, Gsa, Exsa, Zsa, Sdsa, Tsa, Mssa, Yasa, Casa, Exasa, Cfasa, Nasa, Kasa and Wasa represent as the time series data that smoothly adjusted by four-quarter moving average. Variable Names: See Table 4. Ln is abbreviated for natural logarithm. The asterisk *, ** and *** denote statistical significance at the 0.15, 0.10 and 0.05 level, respectively. AR(n) and MA(n) stand for autoregressive order (n) and moving average order (n), respectively. $r_{X1,X2}$ represents as the correlation coefficient between X1 and X2. $\overline{R}^2$ is represented as the adjusted R-squared. Lagrange Multiplier test (LM test): The Obs*R-squared statistic reports with its p-value. If the reported statistic is insignificant then we will not reject the null hypothesis, which implies the residuals of model is not serial correlation (1 and 2 lagged period) at the level of confidence interval as mentioned by p-values in parenthesis.

Source: Author's Estimation

Table 13 Simulation errors of major endogenous variables

Dynamic-deterministic simulation (1998:QI to 2004:QIII)			
Major endogenous variables	**Mean error (%)**	**RMSE (%)**	**Theil inequality coefficient**
Expenditure on GDP	1.207	2.126	0.011
Private consumption	1.900	2.844	0.014
Nation investment	1.010	4.077	0.019
Export of goods and services	1.415	2.169	0.013
Import of goods and services	1.939	3.613	0.018
Nominal interest rate	-1.533	5.256	0.028
Real effective exchange rate	-2.982	3.744	0.018
Consumer price index	-0.052	0.983	0.005
Consumer price index for nonfood	0.746	1.574	0.008
Consumer price index for food	-1.266	2.207	0.011
Private consumption for food	1.674	2.658	0.013
Food export	4.133	7.769	0.042
Food import	7.653	10.616	0.057
Employment in agricultural sector	-0.112	1.345	0.007
Capital stock in agricultural sector	0.221	0.621	0.003
Gross domestic production in agriculture	4.989	5.874	0.031

Note: Mean error = $\frac{1}{n}\sum_{t=1}^{n}\left(\hat{y}_t - y_t/y_t\right)*100$, RMSE (Root mean square error) = $\sqrt{\frac{1}{n}\sum_{t=1}^{n}\left(\hat{y}_t - y_t/y_t\right)*100}$, Theil inequality coefficient = $\frac{\sqrt{\frac{1}{n}\sum_{t=1}^{n}\left(\hat{y}_t - y_t\right)^2}}{\sqrt{\frac{1}{n}\sum_{t=1}^{n}\hat{y}_t^{\,2}} + \sqrt{\frac{1}{n}\sum_{t=1}^{n}y_t^{\,2}}}$

Table 14 Result of policy simulation

(Unit: million baht at constant price)

Agricultural sector	Baseline value	Simulated value	%Change
a. 5% increase in government consumption expenditure			
Private consumption for food	102,975.43	104,042.86	1.04
Food export	67,548.57	67,582.57	0.05
Food import	14,280.43	14,428.14	1.06
Trade account	53,268.00	53,154.43	-0.22
Employment (thousand persons)	13,835.29	13,837.29	0.01
Capital stock	431,698.71	431,900.43	0.05
Gross domestic production	78,140.14	78,261.29	0.16
CPI for food (1988=100)	199.63	199.77	0.07
b. 10% increase in government consumption expenditure			
Private consumption for food	102,975.43	105,110.14	2.08
Food export	67,548.57	67,616.57	0.10
Food import	14,280.43	14,575.86	2.12
Trade account	53,268.00	53,040.57	-0.43
Employment (thousand persons)	13,835.29	13,839.86	0.03
Capital stock	431,698.71	432,103.43	0.09
Gross domestic production	78,140.14	78,383.29	0.31
CPI for food (1988=100)	199.63	199.93	0.15

Table 14 (Continued)

(Unit: million baht at constant price)

Agricultural Sector	Baseline value	Simulated value	%Change
c. 15% increase in government consumption expenditure			
Private consumption for food	102,975.43	106,178.14	3.12
Food export	67,548.57	67,650.86	0.15
Food import	14,280.43	14,723.86	3.19
Trade account	53,268.00	52,926.86	-0.65
Employment (thousand persons)	13,835.29	13,842.14	0.05
Capital stock	431,698.71	432,307.00	0.14
Gross domestic production	78,140.14	78,505.57	0.47
CPI for food (1988=100)	199.63	200.07	0.22

Note: The figures represent as the average value from the first quarter of 1998 simulation year through the third quarter of 2004.

Source: Author's computation

CONCLUSIONS AND FINAL REMARK

Conclusions

Agricultural sector would affect not only by the spending specifically designed for it but also by the government consumption spending. It consigned this essay to the question of how much this spending benefits to the agricultural sector. Based on the previous literatures, the framework is outlined. It was schematically represented the linkages underlying the effects of government spending on agricultural sector. Let agricultural sector be an outside of macroeconomic model. Therefore, the framework of this study is divided into two blocks. The first block depicts the forward linkage between government spending and macroeconomic variables. Following the basic Keynesian model, the government is also treated as an exogenous variable. It can be concluded that the government spending affected GDP, price level and interest rate *ceteris paribus*. Further, they affected the exchange rate. These variables, which is so-called "transmission variable" transferred from the macroeconomy to agriculture. The second block depicts the relationship between transmission variables and key economic indicators of agriculture. These agricultural variables consisted of food consumption, food export & import, employment & capital stock and gross domestic production in agricultural sector.

The estimation results of behavioral equations consign the complete model to wholly satisfactory results of policy simulation. As simulation results, when the government increases the consumption spending by 5, 10 and 15 per cent, its impacts on agricultural sector are concluded in terms of percentage change from baseline value as follows. Food consumption raises to 1.04, 2.08 and 3.12 per cent. Food export raises to 0.05 0.10 and 0.15 per cent. Meanwhile, food import raises to 1.06, 2.12 and 3.19 per cent. Consequently, surplus of trade balance for food worsens to 0.22, 0.43 and 0.65 per cent. In addition, employment in agricultural sector raises to 0.01, 0.03 and 0.05 per cent. Capital stock in agricultural sector also raises to 0.05, 0.09 and 0.14 per cent. Gross domestic production in agricultural sector subsequently raises to 0.16, 0.31 and 0.47 per cent.

According to the simulation results, the fiscal policy aspect of expenditure has an unintended effect on agriculture, though the public consumption spending do not directly inject into the agriculture. The simulation results indicate that this spending can flow to the agricultural sector via several channels. Nevertheless, it should be noticed that the agricultural economic impacts of government spending are rather trivial particularly gross production impacts, although the government spends more consumption budget by 15 per cent. This is because these impacts come from several distant channels. Within the economic effects, the food consumption impacts of government spending are relatively outstanding. This is because the theoretical model of this study is based on the Keynesian approach. Of course, this approach is focused on the demand management in the short run periods.

Recommendations

This study implied that the expansion of government consumption spending benefits to the agricultural sector no matter what the composition of public budget by purpose is. Nevertheless, based on the data set that reported by Bureau of Budget over the past 40 years, the government budget on defense & internal security and education is the largest share and approximately accounted for 22 and 19 per cent of total budget, respectively. On the one hand, the government budget on agriculture is just approximately accounted for 9 per cent of total budget. Of these budgets, 2 per cent is devoted to the agricultural research. Accordingly, in order to be more beneficial to agriculture in the long run, the government should give first priority to increase in budget on agricultural research and extension together with encouraging the private investments in agricultural research, i.e. plant breeding. These activities lead the farmers to more chance of improving technological progress. And then the farmers would be able to enhance their productivity. It would eventually increase the growth rate of agricultural GDP. Apart from this, this issue inspires the author to further investigate the economic impacts of agricultural research in the next part of thesis.

Although the estimation results may give support to expectation that the increase in government spending would be able to stimulate the overall economy, its expansion should be performed carefully. This is because it would occasionally

reduce the chance of private capital accumulation. Furthermore, with regard to stabilization of economy, the heavy expansion of government would consign overall economy to unpleasant circumstance, i.e. current account deficit and high inflation.

Limitation of the Study

The shortcoming of this study concerns the modeling approach as follows.

In order to derive the factor inputs demand, the maximization of representative profit function determined the farm agent's behavior. The function of gross domestic production also faced with the constraint of two factor inputs: labor and capital stock. It lead to a shortcoming of this study because the other factor inputs such as rainfall and fertilizer should be considered. Apart from this, the agricultural production is occasionally generated the state of being polluted, especially the contamination of soil, water, or the atmosphere by the discharge of harmful substances. This externality affects negatively the macroeconomy. Hence, the modeling of agricultural production for the future study should be concerned on this problem according to environmental economics.

The supply of labor in agricultural sector is restricted to be inelasticity with respect to the wage. Theoretically speaking, in the consumption sector, the household agent seeks an optimal consumption plan over the infinite time horizon. And then the optimal demand conditions for commodities are derived. Meanwhile, the optimal demand conditions for financial asset and optimal level of leisure are established. In other words, the supply of labor is derived. Nonetheless, the modeling of labor supply is rather sophisticated. It should be further investigation for the future research.

According to the theoretical mocroeconomic model, the modeling approach has to face with the considerable choice of macroeconomic school. The future study may formulate the model regarding the new macroeconomic school of thought. It is conceptually derived from the microfoundation such as New Classical School and New Keynesian School.

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PART II: ECONOMIC IMPACTS OF PUBLIC RICE RESEARCH

INTRODUCTION

Problem Statement

The agricultural research is treated as an economic activity. The resources that are allocated to 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 high 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). Further, the new knowledge resulted from agricultural 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).

The agricultural research in Thailand has been based on sustainability of agriculture. Technology is investigated, studied and developed to facilitate the ability to produce at the household and community level as well as the export, substitution for import and agro-industry level (Panityothai, 1999). The agricultural research was supported by a number of government ministries and agencies. The Ministry of Agriculture and Agricultural Cooperatives is the largest performer of agricultural research (Pray and Fuglie, 2001). Nevertheless, the agricultural budgets are mainly allocated to administrative activities over the past 40 years. On the other hand, the budget on agricultural research was only accounted for 1.56 per cent of total (Table 1). It can be declared that the public support has been still concerned on Thailand's agricultural research up to the present period.

Tables 1 Government budget on agriculture, agricultural research and rice research, 1960-2000

(Unit: million baht at 1988 price)

Year	Budget on agriculture (1)	Budget on agricultural research (2)	Budget on rice research[1] (3)	(2)/(1)	(3)/(2)
1960-1969	4,438.58	189.69	54.40	4.27%	28.68%
1970-1979	10,516.99	285.39	91.96	2.71%	32.22%
1980-1989	17,490.21	271.85	106.00	1.55%	38.99%
1990-2000	44,094.79	446.80	192.45	1.01%	43.07%
1960-2000	19,135.14	298.43	111.20	1.56%	35.74%

Note: [1]From 1960 to 2000, the 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. Figures are shown as the average value of concerning period.

Source: Bureau of Budget

Within Thailand's agricultural research, the largest share of government budgets 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 was the most funded government agency for rice research with an average budget of 111.20 million baht at 1988 price or 35.74 per cent of all agricultural research budgets (Table 1). Of the research budget on rice research, 50 per cent was roughly spent on salary & permanent wage and temporary wage. It reflected that the manpower was the most crucial factor in the rice research production over the past 40 years. On the other hand, the share of budget on land and building materials was decreased from 13 per cent of total budget in 1960s to 4 per cent of total budget in early 1980s (Table 2). Furthermore, from 1984 to 2000, the investment in land and building materials has not been appeared in the rice research budget because the new experimental station

was not established over such periods. As far as research inputs are concerned, the budgets funding several research activities lead to technological development in rice production. The improvement of technology may come in the forms of high yielding varieties of rice or modern rice varieties according to rice breeding program.

During the 1960s, the Green Revolution that developed in Asia had a dramatic and pervasive impact on the tropical Asian rice economy (David and Otsuka, 1994). The establishment of International Rice Research Institute (IRRI) in the year 1960 is deemed the first important step for rice research. Moreover, it was stated that 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 IRRI with a local tall variety. Afterwards, the first two non-glutinous, semi-dwarf, non-photosensitive and high yielding varieties were released. They were named RD1 and RD3 (Pochanukul, 1986). Until the present period, the rice breeding has been on going continuously creating certified rice varieties, recommended rice varieties and general varieties for the farmers to be able to grow in different geological systems. These varieties are lowland rice, upland rice, floating rice, deepwater rice and other varieties totaling 84 varieties (Department of Agriculture, 2003). Theoretically speaking, these varieties lead to enhance the yield per rai. It consigns this study to the question of how the public investment in rice research affects productivity? In addition to productivity impacts, the returns of research investments to society have been intuitively quite high. Nevertheless, the empirical evidence has been rarely found in a case of Thailand. It leads study to the second question of how much rice research investment has been beneficial for social welfare?

Table 2 Government budget on rice research classified by function, 1960-2000

(Unit: million baht at 1988 price)

Department of Rice,1960-1971 and Division of Rice, 1972							
Year	**Total**	**Salary and permanent wage**	**Temporary wage and compensation**	**Ordinary**	**Materials**	**Structures**	**Land and building materials**
1960-1969	54.40	24.72	7.48	4.37	6.94	4.61	7.03
	(100.00%)	(45.45%)	(13.74%)	(8.03%)	(12.76%)	(8.47%)	(12.92%)
1970-1972	91.90	38.61	12.07	9.78	13.21	5.69	12.56
	(100.00%)	(42.01%)	(13.13%)	(10.64%)	(14.37%)	(6.19%)	(13.66%)
1960-1972	73.15	31.66	9.77	7.07	10.07	5.15	9.79
	(100.00%)	(43.73%)	(13.44%)	(9.33%)	(13.57%)	(7.33%)	(13.29%)

Division of Rice, 1973-1979						
Year	**Total**	**Salary and permanent wage**	**Temporary wage**	**Compensation and ordinary**	**Materials**	**Structures, land and building materials**
1973-1979	91.99	42.65	12.84	10.13	13.26	13.11
	(100.00%)	(46.36%)	(13.96%)	(11.01%)	(14.41%)	(14.26%)

Table 2 (Continued)

(Unit: million Baht at 1988 price)

Division of Rice, 1980-1981 and Rice Research Institute, 1982-1983								
Year	**Total**	**Salary and permanent wage**	**Temporary wage**	**Compensation, ordinary and materials**	**Structures**	**Public utility**	**Subsidy and others**	**Land and building materials**
1980-1983	109.36	54.48	16.59	23.08	2.08	2.10	8.49	4.65
	(100.00%)	(49.82%)	(15.17%)	(21.11%)	(1.91%)	(1.92%)	(7.76%)	(4.26%)

Rice Research Institute, 1984-2000						
Year	**Total**	**Salary and permanent wage**	**Temporary wage**	**Compensation, ordinary and materials**	**Structures**	**Subsidy and others**
1984-1993	128.32	76.57	17.59	27.86	5.47	1.37
	(100.00%)	(59.67%)	(13.71%)	(21.71%)	(4.26%)	(1.06%)
1994-2000	208.04	126.46	37.10	36.39	8.10	0.00
	(100.00%)	(60.78%)	(17.83%)	(17.49%)	(3.89%)	(0.00%)
1984-2000	168.18	101.51	27.35	32.13	6.78	1.37
	(100.00%)	(60.23%)	(15.77%)	(19.60%)	(4.08%)	(1.06%)

Source: Bureau of Budget

Objective

The objectives of this study are to analyze the role of public rice research in production and to evaluate the social welfare impacts of rice research investment.

Organization of Part II

The rest of Part II is organized as follows. The next section revises several related literatures. Firstly, the role of public agricultural research in agricultural production is reviewed. Secondly, the evidences on returns to expenditure on agricultural research are reviewed. Tracking down several previous literatures, the conceptual framework is outlined in the first part of research methodology and then developed this framework in two theoretical models. The first one is for estimating production with consideration of the current state of technical knowledge. The second is was for estimating social welfare. The source of data and method of estimation is illustrated in the section of method and procedure.

In the section of overview, the historical background of agricultural research and rice research is documented. The development of rice breeding program in Thailand is also summarized. As the quantitative evidence, in the section of results and discussion, the contribution of public investment in rice research to production and social welfare is respectively documented. The summary and final remark is presented in the last section. The summary is documented and then the policy implications are drawn from the estimation results. The limitation of the study and direction for future study is suggested.

REVIEW OF LITERATURE

The agricultural economists have raised various questions, which are engaged the interest of the linkages between pubic research investment and agriculture up to the present period. A vital question is about the study on assessing contributions of agricultural research to either production or social return or some combination of the two. Hence, the first heading of this section presents literatures review in line with the theme of the role of public agricultural research in production. Afterwards, the second heading of this section shows the evidences on returns to investment in agricultural research.

Role of Public Agricultural Research in Productivity

Broadly speaking, there are two ways to deal with this heading. The first way is that the accumulation of public budget on agricultural research leads to improve the current state of technical knowledge. The combination between technical knowledge and conventional inputs such as land, labor, rainfall, weather index and fertilizer etc. would enhance the agricultural productivity according to the production function. Nonetheless, as an explanatory variable, the government expenditure on research is occasionally plugged into the production function regardless of the accumulation process of public budget. The second way is focused on several factors affecting the agricultural productivity function regardless of combination of conventional inputs. It is mainly because this way believed that the conventional inputs would be high correlated with time trend. This incident may cause insignificant coefficients for these variables. In stead of the conventional inputs, the factors affecting productivity are comprised of the agricultural research stock variables generated from past public budget on agricultural research & development, average years of schooling of the rural population, length of rural roads, number of rural telephone sets and rural electricity consumption.

I. Technical knowledge and agricultural productivity

Conceptually, in an attempt to identify the productivity enhancing effects of public spending, a measure of the current state of technical knowledge, determined in part by current and past research and development expenditures (Griliches, 1979). In other word, the accumulation of research and development expenditure implied to the improvement of current technical knowledge. According to the knowledge, Evenson and Kislev (1975); Kahlon *et al*. (1977), and Evenson *et al*. (1999) revealed that the agricultural research did made a positive and substantial contribution to agricultural productivity in the case of India. Pochanukul (1986) also employed the distributed lag structure of Indian agricultural research in order to formulate the current state of technical knowledge in the case of Thailand. The results revealed that the rice research had positive impacts on the land productivity and farm household productivity of main rice crop. Additionally, Fan and Pardey (1995) formed ad hoc to address the issue of cumulative research expenditure in the case of Asian agriculture. It revealed that additional government spending on agricultural research had the largest impact on agricultural productivity growth.

Notwithstanding the main results of those literatures are consistent with the expectations, the conceptual model and collecting data would not be clarified. As an illustrative, Pochanukul (1986) and Fan & Pardey (1995), the formulation of technical knowledge may be not satisfied in the sense of econometric owing to the lack of the distributed lag model. According to the collecting data, the secondary data in different states or provinces is not occasionally complete for analysis, particularly in the case of developing country. Thus, the data is manipulated under some serious assumptions of the researcher, i.e. Kahlon *et al*. (1977) and Pochanukul (1986).

Apart from this, Isvilanonda *et al*. (1997) treated the public investment in rice research as an explanatory variable regardless of concerning on the lag structure. The main results revealed that when investment in rice research per worker increased 1 Baht per worker, labor productivity increased respectively 0.016 and 0.023 tons per worker in case of ordinary least squares and weighted least squares method.

II. Factors affecting agricultural productivity

Theoretically speaking, the agricultural productivity is affected not only the government investment in agricultural research but also the public expenditure in infrastructure, education and health. Siamwalla *et al*. (1988), contrary to general belief, had not found that for expenditures in irrigation and road had led to striking increases in productivity, although they do played some role in preventing the expansion of land under cultivation. It appeared that irrigation played a role in increasing labor productivity only in conjunction with expenditure on research, although the result was still clouded by some uncertainty. Apart from this, a weakness point of this literature is the formulation of research variable. That is the research variable should be in terms of stock variable rather than flow variable.

Fan *et al*. (1999); Fan & Rao (2003), and Fan *et al*. (2004) in order to study on the effects of public investment on agricultural productivity in the case of India, region (Africa, Asia & Latin America) and Thailand, respectively formulate the same conceptual framework. According to the theoretical model, the independent variables are a set of technology, infrastructure, and education variables that are used to capture their impact on labor productivity growth. Once the lengths of lags are determined, the simultaneous equation system can be estimated with the polynomial distributed lags and appropriate lag length for each investment. The main results revealed that additional government spending on agricultural research and extension has the largest impact on agricultural productivity.

As the tool for estimation, Fan *et al*. (1999); Fan & Rao (2003), and Fan *et al*. (2004) are good enough in the sense of econometric theory. On the other hand, they may face with the problem of complete data set. Particularly, the data set has to be in term of pooling data owing to disaggregating into states or regions. When the analysis is concentrated on the regions, the contributions of public investment in agricultural research and development in a region can diffuse throughout the country, which is a so-called “spillover effect”. Nonetheless, Siamwalla *et al*. (1988); Fan *et al*. (1999), Fan & Rao (2003), and Fan *et al*. (2004) paid less attention on this problem.

Evidences on Returns to Investment in Agricultural Research

There are two basic methods for evaluation returns to spending on research: statistical and imputation method. The computation treated research expenditure as an investment. The statistical method estimated a rate of return to an additional or marginal dollar of research spending. They generally employed a production function that was estimated utilizing data on production, inputs, and research program. The variables of research have to be specified carefully as to their timing and spatial dimensions. The imputation method attempted to measure the costs and benefits to a particular program of research conducted over the time periods indicated. Different methods and data were utilized to measure benefits. Sometimes statistical procedures were used; in other cases data comparing production using old and new technology were used. These studies reported what might be termed average rates of return--that was, rates of return that hold for the entire research investment (Evenson, 1984).

A frequently used measure a benefit was the economic surplus method that provided a relatively simple, flexible approach to specifying the value of research, by comparing the situations with and without it. In order to turn agronomic data into the economic values, the surplus approach utilized the concepts of supply, demand and equilibrium. Supply represented producers' production costs, and demand represented consumers' consumption values. Some equilibrium quantity and price resulted from the interaction of these two forces. Economic welfare depended not only on the equilibrium price and quantity, but also on the producers' production costs and consumers' consumption values (Masters *et al.*, 1996).

Table 3 summarized a number of studies of agricultural research programs. Quantitatively, these studies revealed that the return of research expenditure has been quite high. It was further stated that the investment in agricultural research was sufficiently attractive. Meanwhile, Evenson (2001) concluded that in almost all categories of agricultural research studies, median estimated rates of return were high, (often exceeding 40%) but the range of estimates was also high. It was additionally concluded most of the estimates were consistent with actual economic growth experiences.

Table 3 Summary studies of returns to investment in agricultural research

Study	Country	Commodity	Time period	Return
Imputation Method				
Griliches (1958)	USA	Hybrid corn	1940-55	IRR = 35-40%
Barkley (1997)	USA	Wheat	1979-94	B/C = 12
Ayer and Schuch (1972)	Brazil	Cotton	1924-67	IRR = 39%+
Boughton and Henry de Frahan (1994)	Southern Mali	Maize	1969-90	IRR = 77- 110% IRR = 135%
Akino and Hayami (1975), Hayami and Akino (1977)	Japan	Rice	1915-50	IRR = 25-27%
			1932-61	IRR = 73-75%
Unnevehr (1986)	Philippines & Indonesia	Rice Grain Quality	1962-69	B/C = 49 IRR = 61%
	Indonesia		1969-81	B/C = 8 IRR = 37%
	Philippines		1969-85	B/C = 9 IRR = 29%
Dulyasatit (1984)	Thailand	Corn	1969-79	B/C = 3-4 IRR = 50%
Adulavidhaya *et al*. (1987)	Thailand	Rice	1969-83	B/C = 42-57
		Corn	1969-83	B/C = 8-14

Table 3 (Continued)

Study	Country	Commodity	Time period	Return
Imputation Method				
Oungsawat (1995)	Thailand	Rice	1987-92	Accumulation of real economic surplus = -15.2 – 10.8 billion Baht
Isvilanonda (2000)	Thailand	Jasmine Rice	1995-2009	B/C = 5-9
Statistical Method				
Griliches (1964)	USA	Aggregate	1949-59	IRR = 35-40%
Chavas and Cox (1992)	USA	Aggregate	1950-82	IRR = 28%
Evenson and Kislev (1975)	India	Aggregate	1953-71	IRR = 40%
Kahlon *et al*. (1977)	India	Aggregate	1960-61	IRR = 63%
Evenson *et al*. (1999)	India	Aggregate	1956-87	IRR = 58%

Nonetheless, the estimated return to investment in agricultural research might be questionable about biases. Fuglie *et al*. (1996) addressed six specific problems that were potentially serious sources of bias in measured rates of return to agriculture. These causes included as follows:

i) Research Lag: The main problem with directly estimating an unconstrained lag structure is that the number of lagged years that can be included is limited by data constraints. Econometric models introduce many independent variables in a data set that extends only 40 or 50 years. The usual approach is to assume that the weights for the lagged years follow a polynomial of a given degree, thus limiting the number of parameters that must be estimated.

ii) Spillovers: The productivity of the agricultural sector depends on both public agricultural R&D and private agricultural R&D. Studies of the social rate of return to public research may inappropriately include some spillover productivity gains due to private spending. This is a potential problem in both the economic surplus and production function approaches. Until recently, data on private R&D have not been available.

iii) Tax Collection and Deadweight Losses: The economic inefficiencies created by tax collection, termed “deadweight losses” by economists, increase the economic cost of publicly conducted research. This feature of the deadweight loss adjustment would likely affect the size of the adjustment among research components, such as basic research, applied research, and extension. The benefits of extension would likely be weighted more heavily toward the near-term, and extension advice may become obsolete relatively quickly as the available technology set, commodity and input prices, and other factors change. Thus, the deadweight loss adjustment for extension would likely be larger. In contrast, the benefits to basic research likely begin relatively small and may grow over time as applications of the basic research result are refined and broadened. Thus, the adjustment for basic research would likely be smaller.

iv) Commodity Programs and Agricultural Surpluses: The government intervention in farm commodity markets is widespread and diverse. Taken at face value, the government programs that generate surplus stocks and remove acreage from production may be in serious conflict with funding of research and development to increase yields. The research likely has small or negligible effects on the preexisting economic distortions caused by farm programs. Viewing farm programs as largely redistributing the gains from technology is more accurate. A more realistic consideration of farm programs leads to the conclusion that adjusting the rates of return to research for commodity program inefficiencies may lead to misguided decisions on research funding and allocation.

v) Environmental and Health Effects: The net environmental and health effects of new technology may be negative or positive. Without quantification of these effects, concluding whether estimated rates of return are too high or too low is not possible. For example, the introduction of new agricultural fertilizers and pesticides, largely developed by the private sector, and their increased use, has led to a number of environmental and health concerns. However, yield improvements and reduced crop losses from pests likely reduced the demand for land and consequently its price and the incentive to convert land to cropland.

vi) Dislocation and Adjustment Costs: Failure to account for dislocation and adjustment costs has concentrated on the possibility of job losses resulting from innovations. Smaller and poorer farmers who are slow to adopt new technologies may also face economic losses because of innovation leading to declines in market prices.

METHODOLOGY

Conceptual Framework

Tracking down several previous literatures, 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.

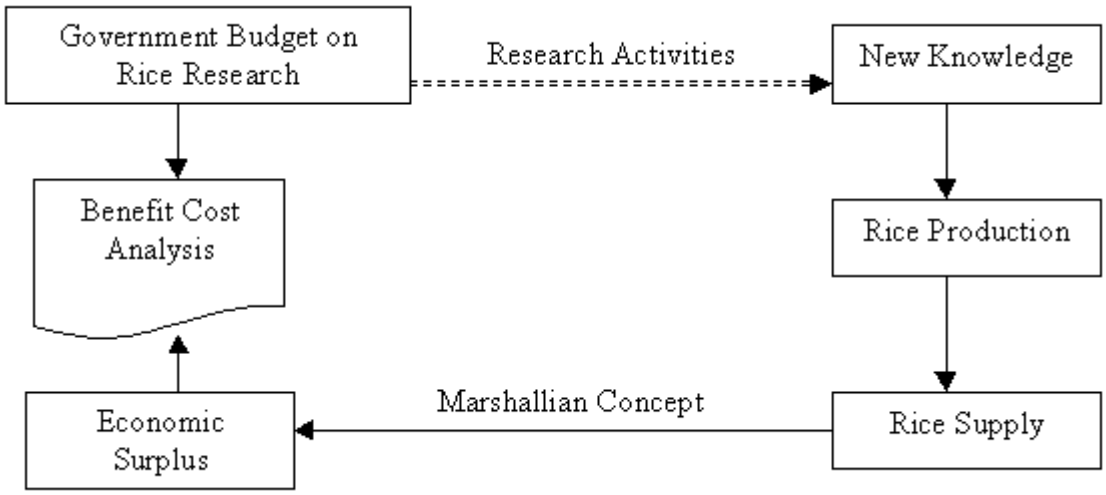

Figure 1 Conceptual framework

Theoretical Model

Such framework developed two theoretical models. The model of estimating production with consideration of the technical knowledge is firstly illustrated. The model of estimating social welfare is secondly described.

I. 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,

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

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

$$W(B)R = (W_0 + W_1B + W_2B^2 + \ldots)R_t$$
$$= W_0R_t + W_1R_{t-1} + W_2R_{t-2} + \ldots. \quad \ldots(M.2).$$

Based on the above theoretical model, the econometric models of estimating rice production are formulated. Before going on, the variable of current state of technical knowledge is identified. According to the equation (M.1) and (M.2), it looks very much like the stock of agricultural research budget. In the way of econometrics, the polynomial distributed lag model should be employed in order to estimate this variable. 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. Therefore, Pochanukul utilized a direct search method for measuring the stock of agricultural research budget. Ultimately, it is determined by the past government budget on rice research as follows:

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

where X_5 is the current state of technical knowledge for rice production at time t and G_{t-i} is the lag variable of government budget on rice research, i = 1 to 14.

For 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 in order to investigate the role of technical knowledge in rice production. The first model utilizes the land productivity, paddy quantity per unit of the planted area, as the dependent variable. It has been expressed as follows:

$$Ln[(Y/X_1)_t] = \beta_1 + \beta_2 Ln[(X_2/X_1)_t] + \beta_3 Ln[(X_3/X_1)_t] + \beta_4 Ln[(X_4/X_1)_t] + \beta_5 Ln[(X_5)_t] + \beta_6 Ln(X_{6,t}) + u_t \quad \ldots(M.4),$$

where Y = the total production of paddy in million tons.

X_1 = the planted area in million rais,

X_2 = the labor employed in rice production. Unfortunately, the complete time series data of this variable is not available. Following Isvilanonda *et al*. (1997), the ratio of number of agricultural household to rice household multiplied by the number of economically active persons in agriculture.

X_3 = the utilization of chemical fertilizers on paddy in million tons.

X_4 = the rainfall in millimeters.

X_5 = as previously seen, the current state of technical knowledge according to the shift factor.

X_6 = the ratio of harvested area to planted area is a proxy of the unanticipated incidence, i.e. heavy flood. The uncorrelated random error terms (u) are assumed to be zero mean and constant variance. The β_2, β_3, β_4, β_5 and β_6 is expected to be greater than zero.

The second model employs the paddy quantity as the dependent variable. With respect to the effect of technical knowledge on the rice planted area expansion, the model is specified in the recursive system as follows:

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

$$Ln(Y_t) = \alpha_{2,0} + \alpha_{2,1}Ln(X_{1,t}) + \alpha_{2,2}Ln(X_{2,t}) + \alpha_{2,3}Ln(X_{3,t}) + \alpha_{2,4}Ln(X_{4,t}) + \alpha_{2,5}Ln(X_{6,t}) + u_{2t} \quad \ldots(M.6),$$

where Y, X_1, X_2, X_3, X_4 and X_5 has been already defined. The disturbances (u_1 and u_2) are assumed to be zero contemporaneous correlation. The coefficient of $\alpha_{1,1}$, $\alpha_{2,1,}$ $\alpha_{2,2}$, $\alpha_{2,3}$, $\alpha_{2,4}$ and $\alpha_{2,5}$ is expected to be greater than zero.

II. 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 respectively 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. Moreover, the demand-supply model in retail market is assumed to be as follows: the purely competitive market equilibrium, no rice import, no farm household growing rice for own family and no government intervention. At the equilibrium, the shift in the supply schedule from Q_0^S to $Q_0^{S'}$ increases economic surplus by area OCE_1 plus area E_0E_1C.

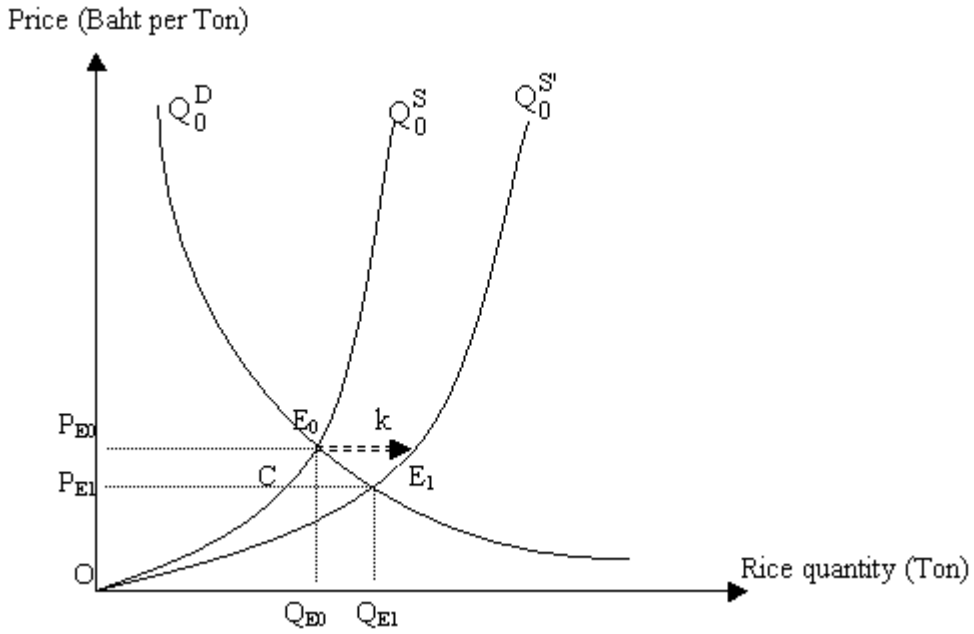

Figure 2 Impacts of rice research on demand-supply model
Source: Akino and Hayami (1975)

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 η is the retail price elasticity of demand.

Similarly, a constant elasticity supply function is assumed as

$$Q_0^S = bP^{\alpha},$$

where α 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 formulas of increase economic surplus held in equilibrium. Increase in economic surplus is equal to area E_0E_1C plus area $OC\ E_1$.

According to Figure 2, the area of E_0E_1C is derived from the value of $\left(\int_{P_{E1}}^{P_{E0}} Q_0^D \, dP\right)$ is subtracted by the value of $\left(\int_{P_{E1}}^{P_{E0}} Q_0^S \, dP\right)$, where P_{E0} and P_{E1} stands for price held in equilibrium with and without the improved technical, respectively.

$$\int_{P_{E1}}^{P_{E0}} Q_0^D \, dP = \int_{P_{E1}}^{P_{E0}} aP^{-\eta} \, dP \Rightarrow = \left.\frac{aP^{1-\eta}}{1-\eta}\right|_{P_{E1}}^{P_{E0}} = \frac{aP_{E0}^{1-\eta}}{1-\eta} - \frac{aP_{E1}^{1-\eta}}{1-\eta}$$

$$= \frac{aP_{E0}^{1-\eta}}{1-\eta} - \frac{a}{1-\eta}\left(P_{E0}\left(\frac{1}{1+k}\right)^{\frac{1}{\eta+\alpha}}\right)^{1-\eta}$$

$$\therefore \int_{P_{E1}}^{P_{E0}} Q_0^D \, dP = \frac{aP_{E0}^{1-\eta}}{1-\eta}\left(1-\left(\frac{1}{1+k}\right)^{\frac{1-\eta}{\eta+\alpha}}\right) \qquad \ldots(M.7)$$

Substitute $P_{E0} = \left(\frac{a}{b}\right)^{\frac{1}{\eta+\alpha}}$ into (M.7), then we have

$$\Rightarrow = \frac{a}{1-\eta}\left(\left(\frac{a}{b}\right)^{\frac{1}{\eta+\alpha}}\right)^{1-\eta}\left(1-\left(\frac{1}{1+k}\right)^{\frac{1-\eta}{\eta+\alpha}}\right) = \frac{a^{\frac{\alpha+1}{\eta+\alpha}} b^{\frac{\eta-1}{\eta+\alpha}}}{1-\eta}\left(1-\left(\frac{1}{1+k}\right)^{\frac{1-\eta}{\eta+\alpha}}\right)$$

$$\int_{P_{E1}}^{P_{E0}} Q_0^S \, dP = \int_{P_{E1}}^{P_{E0}} bP^{\alpha} \, dP = \left.\frac{bP^{\alpha+1}}{\alpha+1}\right|_{P_{E1}}^{P_{E0}} = \frac{b(P_{E0})^{\alpha+1}}{\alpha+1} - \frac{b(P_{E1})^{\alpha+1}}{\alpha+1}$$

Since $P_{E1} = P_{E0}\left(\frac{1}{1+k}\right)^{\frac{1}{\eta+\alpha}}$, then

$$\Rightarrow \quad = \frac{bP_{E0}^{\alpha+1}}{\alpha+1} - \frac{b}{\alpha+1}\left(P_{E0}\left(\frac{1}{1+k}\right)^{\frac{1}{\eta+\alpha}}\right)^{\alpha+1} = \frac{bP_{E0}^{\alpha+1}}{\alpha+1} - \frac{bP_{E0}^{\alpha+1}}{\alpha+1}\left(\frac{1}{1+k}\right)^{\frac{\alpha+1}{\alpha+\eta}}.$$

$$\Rightarrow \quad = \frac{bP_{E0}^{\alpha+1}}{\alpha+1}\left(1-\left(\frac{1}{1+k}\right)^{\frac{\alpha+1}{\alpha+\eta}}\right) \qquad \ldots(M.8)$$

Substitute $P_{E0} = \left(\frac{a}{b}\right)^{\frac{1}{\eta+\alpha}}$ into (M.8), then we have

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

Thus, area E_0E_1C

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

Based on Figure 2, the area of OCE_1 is derived from the value of $\left(\int_0^{P_{E1}} Q_0^{S'}\, dP\right)$ is subtracted by the value of $\left(\int_0^{P_{E1}} Q_0^{S}\, dP\right)$, where P_{E0} and P_{E1} represents the price held in equilibrium with and without the improved technical knowledge, respectively.

$$\int_0^{P_{E1}} Q_0^{S'}\,dP - \int_0^{P_{E1}} Q_0^{S}\,dP = \int_0^{P_{E1}} (1+k)bP^{\alpha}dP - \int_0^{P_{E1}} bP^{\alpha}dP$$

$$= \int_0^{P_{E1}} kbP^{\alpha}$$

$$= \frac{kbP_{E1}^{\alpha+1}}{\alpha+1} = \frac{kbP_{E1}^{\alpha+1}}{\alpha+1} = \frac{kb}{\alpha+1}\left(P_{E0}\left(\frac{1}{1+k}\right)^{\frac{1}{\eta+\alpha}}\right)^{\alpha+1}$$

$$= \left(\frac{a}{b}\right)^{\frac{\alpha+1}{\eta+\alpha}} b\left(\frac{k}{\alpha+1}\right)\left(\frac{1}{1+k}\right)^{\frac{\alpha+1}{\eta+\alpha}}$$

$$= a^{\frac{\alpha+1}{\eta+\alpha}} b^{\frac{\eta+\alpha-\alpha-1}{\eta+\alpha}} \left(\frac{k}{\alpha+1}\right)\left(\frac{1}{1+k}\right)^{\frac{\alpha+1}{\eta+\alpha}}$$

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

In summary, the area $E_0E_1C =$

$$\left\{\frac{a^{\frac{\alpha+1}{\eta+\alpha}} b^{\frac{\eta-1}{\eta+\alpha}}}{1-\eta}\left(1-\left(\frac{1}{1+k}\right)^{\frac{1-\eta}{\eta+\alpha}}\right)\right\} - \left\{\frac{a^{\frac{\alpha+1}{\eta+\alpha}} b^{\frac{\eta-1}{\eta+\alpha}}}{\alpha+1}\left(1-\left(\frac{1}{1+k}\right)^{\frac{\alpha+1}{\alpha+\eta}}\right)\right\} \qquad \ldots(M.9),$$

and area $OCE_1 = a^{\frac{\alpha+1}{\eta+\alpha}} b^{\frac{\eta-1}{\eta+\alpha}} \left(\frac{k}{\alpha+1}\right)\left(\frac{1}{1+k}\right)^{\frac{\alpha+1}{\eta+\alpha}}$ …(M.10).

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.

$$\text{B/C Ratio} = \sum_{t=1}^{n} \frac{B_t}{(1+r)^t} \Bigg/ \sum_{t=1}^{n} \frac{C_t}{(1+r)^t} \qquad \ldots(M.11),$$

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

Method and Procedure

Step I: Estimation of production with consideration of technical knowledge

Rice Research Institute was focused on this study. The scope of current state of technical knowledge in the equation (M.3) was based on data from 1974 to 2000. This is 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 usage of chemical fertilizer on paddy are drawn from the Office of Agricultural Economics. The data set for rainfall is drawn from the Climatology Division within Meteorological Department.

The labor use in rice production is manipulated according to Isvilanonda *et al*. (1997). The ratio of number of agricultural household to rice household multiplied by the number of economically active persons in agriculture. Unfortunately, the number of agricultural household is not continuously available from 1974 to 1992. On the one hand, the labor use in agricultural sector is available. Therefore, the labor use in rice production can be computed regarding following ratios. Isvilanonda *et al*. (1997) revealed that from 1973 to 1978, 1979 to 1984, 1985 to 1990 and 1991 to 1996, the ratio of labor use in rice production to agricultural sector is equal to approximately 70.89, 68.14, 65.32 and 60.80 per cent, respectively. The data sets see Appendix Table 2 (Appendix B). The models of production were estimated by OLS method.

Step II: Computation of Economic Surplus

The scope was analyzed over the past 15 years: 1986 to 2000. The data sets see Appendix Table 3 (Appendix B). The computation of economic surplus proceeds as follows: firstly, the parameterization is performed. Most of parameters are drawn from the related literatures. Secondly, the economic surpluses deriving from rice research is computed according to the equation (M.9) and (M.10), and then these surpluses is evaluated by B/C ratio. Thirdly, the sensitivity of the estimated economic surplus or social benefit is analyzed through alternative scenarios.

AN OVERVIEW OF AGRICULTURAL RESEARCH AND RICE RESEARCH IN THAILAND

This section organizes as follows. The first heading documents the overview of agricultural research. The second heading is concentrated on the rice research. It is separated into three parts: role of International Rice Research Institute in rice research, historical background of Thailand Rice Research Institute and development of rice breeding in Thailand. The last heading presents conclusion.

Historical Background of Agricultural Research

The Thai Government started to conduct active agricultural research after World War II, although pre-war government did select and propagate rice seeds with good eating quality, to enhance the returns to rice farming. In the early post-war period the government emphasized the buildup of research infrastructure--both human resources and research station. Kasetsart University, the main agricultural university, was established in 1942. Later, primarily in the 1960s and 1970s, regional universities with sizable faculties of agriculture were established in the north (Chiang Mai), northeast (Khon Kaen) and south (Songkhla and Pattani). Until the 1970s, public research was fairly low-keyed. There was relatively less pressure to increase the crop yield per area because Thailand had relatively abundant supply of land (Siamwalla *et al*., 1992)

Research on crops is the domain of the Department of Agriculture (DOA). Research on livestock, fisheries and forestry is conducted be the departments responsible for each of these subsectors. Apart from DOA, other government agencies are engaged in crop and other research as well. Most notable among these are the universities that together spend annually a quarter of the amount spent by the DOA. The DOA and the universities together spend more than 95 per cent of the total research expenditure for crops. Among the agencies within Ministry of Agriculture and Agricultural Cooperatives (MAAC), crop research under DOA took up the major

portion of the research expenditure. On the other hand, the private sector is very active in both livestock and fishery research (Siamwalla *et al*., 1992)

Until 1998, the government support for agricultural research precedes recent emphasis given to science and technology investment, and agriculture still accounts for most public expenditures for research. In 1998, the agricultural research was supported by a number of government ministries and agencies (Figure 3). The MAAC is the largest performer of agricultural research. The public universities also have significant programs in agricultural research, funded through the Ministry of University Affairs and through grants from the Thailand Research Fund and the National Research Council. A annual biotechnology research program, most of which is devoted to agriculture, is funded through the National Science and Technology Development Agency, an autonomous public corporation under the Ministry of Science, Technology, and Energy (Pray *et al*., 2001).

According to the content of research, the agricultural research is focused on understanding in areas of pure science and development of technologies in areas of applied science. It is roughly separated into the four general areas. The first area is in line with the theme of the genetic manipulation through traditional breeding and molecular biological techniques. The second area involves with the environmental manipulation to optimize soil, water, nutrients, temperature and other external factors of plant or animal production. This area also attempts to minimize deleterious natural effects on final yield via control of pets. The third area is concentrated on enhancing input and post-harvest technologies that is increase efficiencies of inputs, i.e. fertilizers, pesticides and machinery. Meanwhile, this area is to maximize harvest yields, while minimizing post-harvest losses during transport, storage and preliminary processing. The last area deals with processing reduces losses. The research attempt to develop the products to suit market demand, health and preservation requirement together with the creation of new markets and products from commodities in which Thailand has a comparative production advantage, i.e. rice (Falvey, 2000).

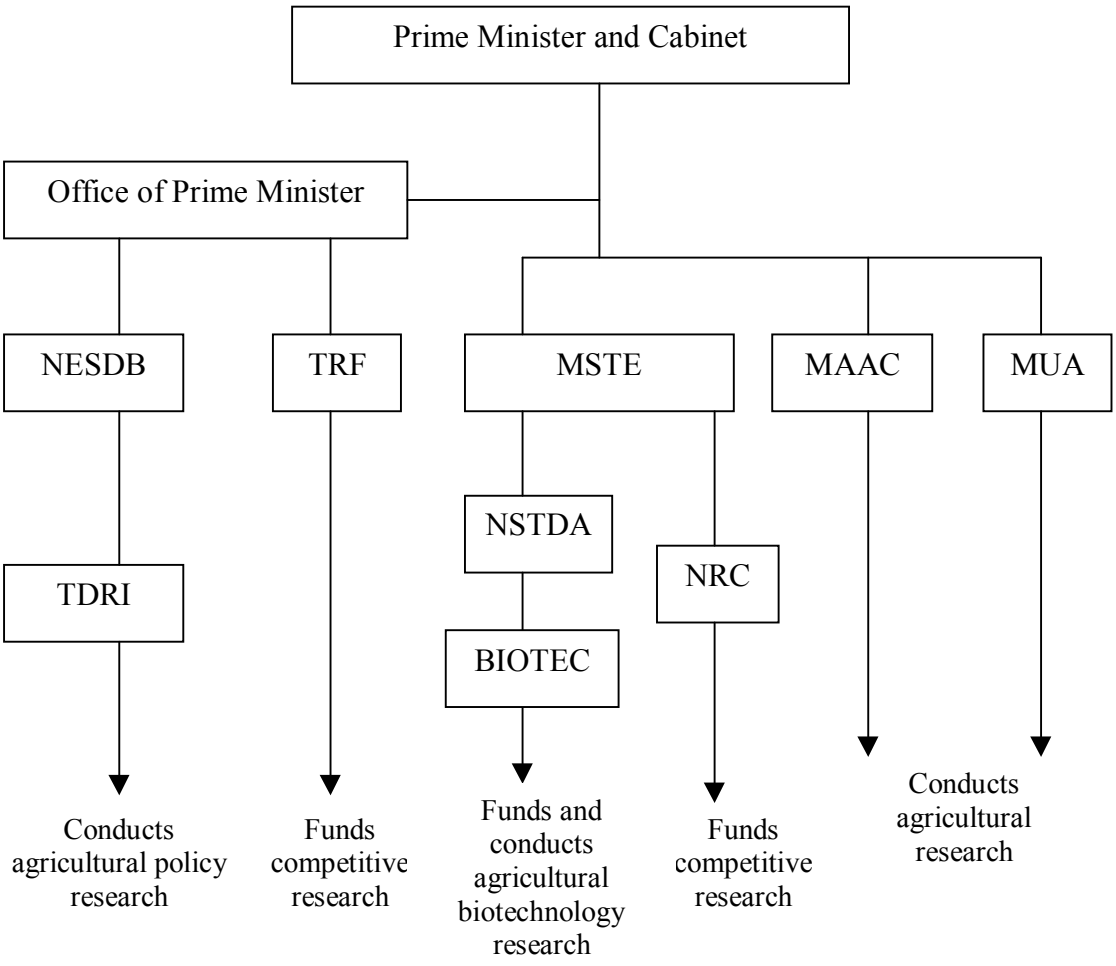

Figure 3 Agencies funding and performing agricultural research, Thailand, 1998

Note: BIOTEC = National Center for Genetic Engineering and Biotechnology
NESDB = Office of the National Economic and Social Development Board
NRC = National Research Council
NSTDA = National Science and Technology Development Agency
MAAC = Ministry of Agriculture and Agricultural Cooperatives
MUA = Ministry of University Affairs
MOSTE = Ministry of Science, Technology and Energy
TDRI = Thailand Development Research Institute
TRF = Thailand Research Fund

Source: Pray *et al*. (2001)

Historical Background of Rice Research

I. International Rice Research Institute

A. IRRI and Rice breeding (Siamwalla and Kaosa-ard, 1994)

The establishment of International Rice Research Institute (IRRI) in the year 1960 is deemed the first important step for rice research even though rice is not a new plant but it has been originated in Asia since at least 3,000 BC. Since the distribution or the first crossbreed rice production, IR8, to the farms, IRRI has not stop crossbreeding rice consistently along with exporting the new technology to other countries in Asia including supporting the exchange of new technology adaptive research. Additionally, IRRI assists in national researches such as Rice Department of Thailand in both the establishment and rice research operation.

The vital characteristic of the first step of the rice research technology by IRRI is the research for new crossbreed rice that would yield high productivity, responses to new factor well, endures disease, short stock, and fast growing, then exchanging this new technology to other countries. Afterward, the activities of IRRI started to diversify resulting in new problems for the scientist to search for solution. Examples of such diversities are the expansion of research for rice breed for high ground or lack of irrigation condition, necessity for the rice enemy prevention such as Brown Planthopper, research for agricultural machinery, the adjustment of the taste of new rice breed, etc. The important direct affect from IRRI rice technology is helping numerous countries in Asia that were unable to produce enough rice for consumption, such as Indonesia, to become self-reliance and, in some years, able to export rice.

After the first wave IR8 has dispersed to rice production business, the second wave of rice research was developed by IRRI scientists, IR20 rice, which has high endurance against rice enemy. This is closely followed by the third wave of rice research that produced rice that requires shorter term to grow than previous local and IR breed. The numerous countries that accept this new breed must adjust their

production societies such as the forming of Group Farming in Indonesia; therefore IRRI itself must pay more attention to cropping system along with promoting systematic research. The over two-century experience of IRRI helps the institute scientists create the fourth wave of rice research. By using biotechnology as the tool, the researchers focus on rice breed that would endure dry weather and/or salty soil conditions. Concerning rice physiology, IRRI scientists focus on the ideal of the breed to have all the needed qualities. This is expected to be successful prior to the next century.

In conclusion, by increasing the production capability for the world rice growing area, especially in Asia since the establishment of IRRI, is considered an important afford to respond to the demand for rice from the world population. However, if we would look deeper into the specific areas for improvement the benefit from rice production technology improvement for such area for the next century it would be the high-income countries in the Temperate Zone, except China. It is due to the ability to invest in research and development, which would focus on responding to the appropriate environment for the breeding. The research and development and promotion are similar to links in the chain but the strength of the each chain may not be equal. In other words, the readiness to accept rice technology from the source, such as IRRI, for poor countries and the promotion may be unsuccessful. In the next century, the countries that have low production per growing area will still be clustered in Storm Zone of Asia and Southeast Asia. Since these countries are still poor and obsolete in research, their production is in the hand of environment destiny; whereas, China has succeeded in cross breeding rice research making China a potentially important variable in the world market.

Future research must pay attention to the effort for increasing productivity from IR8 along with the yield gap reduction of the sample plots productivity and farmer plots productivity. By doing so, not only would the past total production ceiling be expanded, it would also give suggestion to researcher to pay attention to farmer with obsolete production power problem. This is because it seems that farmers who benefit from past researches are farmers who already had irrigation condition and production factors available to them.

B. Thailand-IRRI Collaboration (International Rice Research Institute, n.d.)

i) Joint research and training program for deepwater rice: As far back as 1941, Thailand recognized the importance of deepwater rice research by building the Huntra Rice Experiment Station. Although about 9 million hecta of deepwater rice was harvested annually in Asia, there were numerous constraints to increased production. Yields were low and unstable. Rice crops were subject to soil problems, to both drought and deep flooding, and to yield-reducing pests. In 1974, the Royal Thai Government and IRRI established a joint research and training program for deepwater rice.

In 1975, the Prachinburi Rice Research Center was established. It became one of the leading centers in Asia for deepwater rice because of its excellent facilities and experienced staff. The research program for deepwater rice emphasized the need for collaborative research with national agricultural research systems (NARS) for extensive testing in the target environments. The Thai Department of Agriculture (DOA) of the Ministry of Agriculture and Cooperatives (MOAC) had provided physical facilities and support staff while IRRI had provided scientists as resource persons and given some financial support. Since then, the MOAC and IRRI had cooperated in rice research.

Through the Thailand-IRRI deepwater rice program, scientists shared resources and cooperated in the selection and evaluation of deepwater rice genotypes suitable for the environments of Southeast Asia and in the development and dissemination of supporting technology. A memorandum of understanding (MOU) between Thailand's MOAC and IRRI was signed in 1991 at IRRI during the visit of Her Royal Highness, Princess Maha Chakri Sirindhorn. It called for Thai and IRRI scientists to work together to improve deepwater rice culture and to develop new rice varieties and farming practices for farmers in Thailand and other countries in the region. Thailand accepted leadership of the deepwater rice breeding program for Southeast Asia in 1993. Through this agreement, most of IRRI's deepwater rice breeding activities was transferred to Thailand.

ii) Small farm machinery project: The small farm machinery project funded by the United States Agency for International Development (USAID) was conducted from 1976 to 1985. A successful product of this project was the axial flow thresher. IRRI provided the basic design which was modified by Thai engineers and manufacturers. Operated by contractors as a mobile thresher, it became popular throughout Thailand with 3000-5000 units produced locally every year. In turn, Thailand sent blueprints of its axial flow water pump to IRRI where it was modified to increase efficiency. The machine became widely fabricated and distributed by manufacturers throughout Asia using blueprints provided by IRRI.

iii) Interregional research program on methane emission: From 1993 to 1997, the MOAC was involved in a project aimed to provide technologies that mitigated methane emissions from rice fields. The project was funded by the United Nations Development Program (UNDP) and implemented by IRRI in cooperation with the Prachinburi Rice Research Center. The immediate beneficiaries were national rice and environmental programs in Asia and international programs on global climate change. The ultimate beneficiaries, however, were the farmers in the deepwater rice ecosystem. Through the project, acceptable soil, water, fertilizer (organic and inorganic) and crop management and breeding strategies/options for high-yielding rice cultivars were developed that allowed to mitigate methane emission from rice fields.

II. Rice Research Institute in Thailand

Since Thailand opened up for international trade in 1855, the rice became a crucial product of the country. Increase demand for rice owing to the external demand together with the increased rice price stimulated the peasants to increase their rice production. The government assisted the rice production through undertaking mainly the irrigation projects. Throughout the period of King Ramma IV and V (1851-1858 and 1858-1910), many canals were constructed mostly in the Central Plain. They were utilized for both transportation and flood control for paddy fields (Pochanukul, 1988).

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).

In the beginning, Rice Department was separated into 4 departments and 10 testing stations in different regions. Then in the year 1971, 11 additional testing regional stations were established, totaling 21 stations. In the year 1972, the Rice Department and Department of Agriculture combined and became Department of Agriculture resulting in Rice Nourishment Division, which used to be governed by the Rice Department, became Rice Division under the governance of Department of Agriculture. In the year 1982, there was a Royal Decree separating Department of Agriculture resulting in Rice Division being renamed to Rice Research Center. In the beginning the central agency was separated into 3 sections and 1 academic group. The regional section comprises of 6 rice research centers, 17 rice testing stations, and 2 Cold Weather Wild Rice and Grain Testing Stations, totaling 25 locations. Afterward, the Rice Research Institute changed the amount to 7 rice research centers, 16 rice testing centers, 2 Cold Weather Wild Rice and Grain Testing Stations, and 2 Cold Weather Rice and Grain Testing Stations totaling 27 locations. The separation of central agency still remained the same. Currently, the Rice Research Institute has another project by becoming Bureau of Rice Research and Development under the governance of the Rice Department with rice research center totaling 27 centers dispersed all over the country (Table 4).

Table 4 Rice research center within Bureau of Rice Research and Development

Region	Rice Research Center
1. Upper Northern Region	1. Chiang Mai Rice Research Center
	2. Phrae Rice Research Center
	3. Samerng Rice Research Center
	4. Mae Hong Son Rice Research Center
	5. Chiang Rai Rice Research Center
2. Lower Northern and Western Region	1. Phitsanulok Rice Research Center
	2. Suphan Buri Rice Research Center
	3. Lopburi Rice Research Center
	4. Chai Nat Rice Research Center
	5. Ratchaburi Rice Research Center
3. Central and Eastern Region	1. Ayutthaya Rice Research Center
	2. Khlong Luang Rice Research Center
	3. Pathum Thani Rice Research Center
	4. Prachin Buri Rice Research Center
	5. Chachoengsao Rice Research Center
4. Upper Northeastern Region	1. Udon Thani Rice Research Center
	2. Nong Khai Rice Research Center
	3. Sakon Nakhon Rice Research Center
	4. Khon Kaen Rice Research Center
	5. Chumphae Rice Research Center
5. Lower Northeastern Region	1. Ubon Ratchathani Rice Research Center
	2. Nakhon Ratchasima Rice Research Center
	3. Surin Rice Research Center
6. Southern Region	1. Nakhonsrithammarat Rice Research Center
	2. Krabi Rice Research Center
	3. Phatthalung Rice Research Center
	4. Pattani Rice Research Center

Source: Bureau of Rice Research and Development

III. Development of rice breeding in Thailand

During the 1950s, the rice research goal was to enhance the quality of rice and maintain the standards rather than to enhance yield per planted area. As a means, both of the pure line selection and seed multiplication work were focused and conducted mainly in the Central Plain. The rice variety contests were held to select varieties with high quality, long and slender grain, which were wanted by the world market. The good varieties from the contests were used in rice seed multiplication program and, finally, distributed to farmers. Nevertheless, a little success was met owing to the lack of well-trained personals to conduct these programs (Pochanukul, 1988).

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). Together with the establishment of International Rice Research Institute (IRRI) in the year 1960 is deemed the first important step for rice research.

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 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).

Until the present period, rice breeding has been on going continuously creating certified rice varieties, recommended rice varieties, and general varieties for the farmers to be able to grow in different geological systems. These varieties are lowland

rice, upland rice, floating rice, floating rice, deepwater rice and other varieties totaling 84 varieties (Figure 4). These include white rice and glutinous rice. These varieties also comprise of rice that is grown seasonal and year round. Moreover, some are fragrance rice. Most of the varieties yield high production, have high endurance against disease and insect, have cooking quality in accordance with the consumer demand, as well as endure against significant environmental problems. Nonetheless, the rice breeding works still have to be performed continuously. This is because the farmers are still growing some of the varieties that were introduced but some are not owing to some disadvantages. It is also because with the some of the varieties, which are appropriate for growing during the suggestion period but become inappropriate later on due to the changing environment or disease or insects. In addition, the good quality rice that is being demanded by the world market and has the capability to compete in the world market still must be searched; therefore, the rice breeding must be performed continuously (Department of Agriculture, 2003).

Conclusion

Over the past 40 years, much of agricultural research investment in Thailand has been conducted by the public sector. Ministry of Agriculture and Agricultural Cooperatives has been the largest performer of agricultural research via Department of Agriculture. The scientist in this department has devoted to the crop research in particularly rice simply because its production is the largest component of crop. The important rice research involved with the rice breeding programs. According to the Rice Research Institute as well as Thailand-International Rice Research Institute collaboration, the breeding programs have been on going continuously generating the recommended rice varieties for the farmers to be able to grow in different geological systems. Of course, these varieties have a longer-term effect on the enhancing the yield per rai. Further, it is stated that the rice research investment played as an important role in rice productivity. As the way of quantitative analysis, the role of rice research investment in productivity will be investigated in the next section.

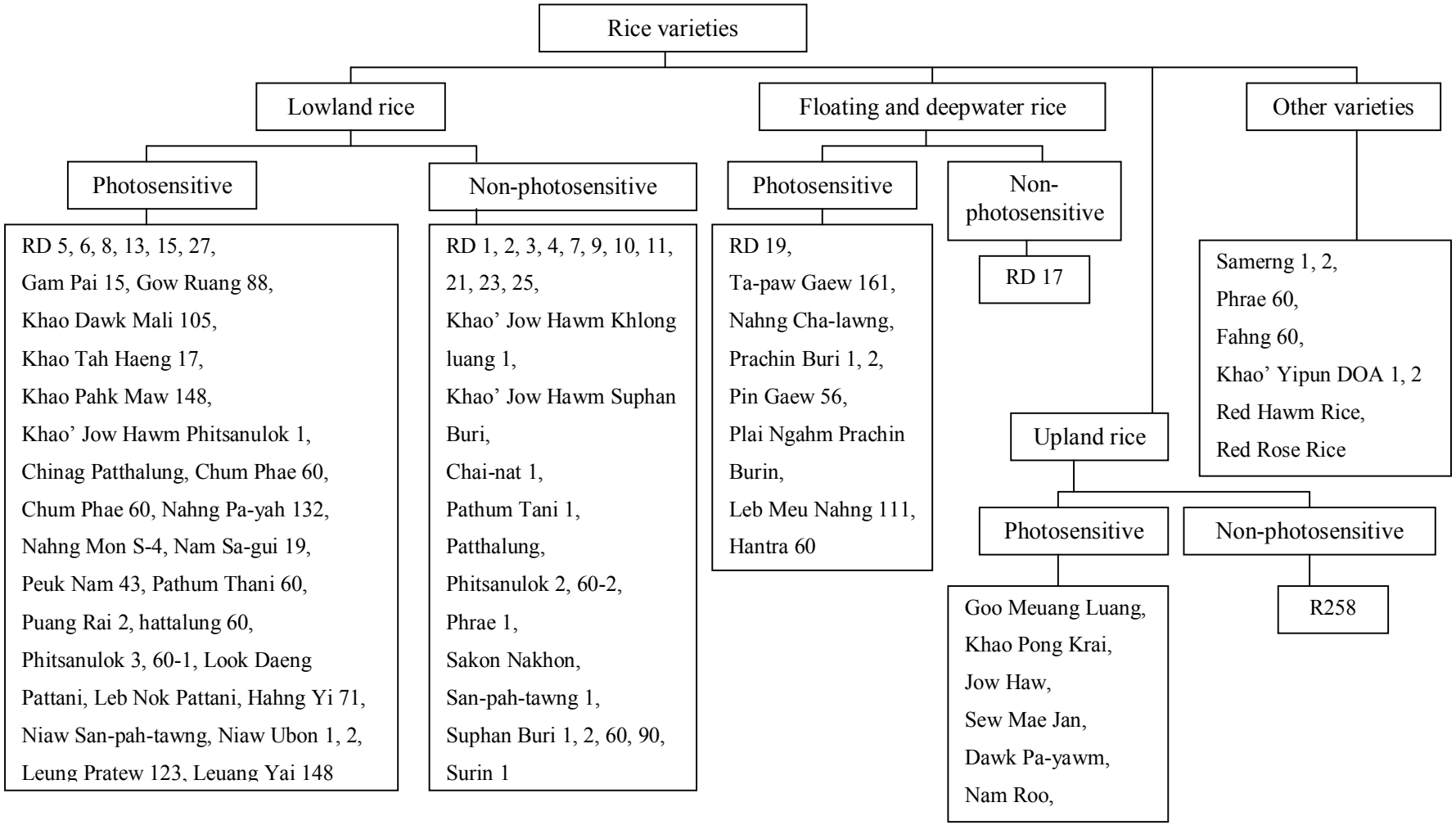

Figure 4 Rice varieties in Thailand

Source: Department of Agriculture (2003)

RESULTS AND DISCUSSION

As mentioned in the preceding section, many recommended varieties have been derived from rice research up to the present time. These varieties represented as the technical knowledge according to the theoretical model of this study. Therefore, this section presents the role of technical knowledge in the sense of economic. Its contribution to yield per rai and production structure was illustrated in the first section regarding the quantitative analysis. Not merely productivity but also social welfare has been affected by the rice research. Following Marshallian concept, the assessment of economics surplus deriving from rice research is presented in the second section.

Role of Public Rice Research in Production

The estimation result of production equation is reported in Table 5. 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 serial correlation problems, both of the estimated models perform well.

I. Role of technical knowledge in land productivity

According to the first model in Table 5, 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. Chai-nat 1, Patthum Thani 1 and Suphan Buri 60, 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.

Table 5 Rice production function with consideration of technical knowledge

Model 1: Land productivity function
$Ln[(Y/X_1)_t] = 4.11 + 0.04Ln[(X_2/X_1)_t] + 0.07Ln[(X_3/X_1)_t] + 0.06\ Ln[(X_4/X_1)_t]$
t-statistic $(3.26)^{***}$ $(0.30)^{NS}$ $(1.23)^{NS}$ $(0.63)^{NS}$
$+ 0.28Ln(X_5)_t + 0.97Ln(X_6)_t + [AR(1)= -0.30]$
t-statistic $(2.10)^{***}$ $(2.35)^{***}$
Adjusted $R^2 = 0.81$,
LM test = 1.15(0.28), ARCH test = 0.25(0.62), RESET test = 0.11 (0.75)
$r_{Ln(X_2/X_1),Ln(X_3/X_1)} = 0.57,\ r_{Ln(X_3/X_1),Ln(X_4/X_1)} = -0.74$
Model 2
Effect of technical knowledge on rice planted area expansion
$Ln(X_{1,t}) = 3.25 + 0.13Ln(X_{5,t}) + [AR(1) = 0.35]$
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
$Ln(Y_t) = 5.50 + 0.84Ln(X_{1,t}) + 0.24Ln(X_{2,t}) + 0.14Ln(X_{3,t}) + 0.07Ln(X_{4,t}) + 1.99Ln(X_{6,t})$
t-statistic $(1.67)^{*}$ $(1.14)^{NS}$ $(1.67)^{*}$ $(3.05)^{***}$ $(1.08)^{NS}$ $(4.67)^{***}$
+ [AR(1) = -0.75, AR(2) = -0.46, AR(3) = -0.16]
Adjusted $R^2 = 0.88$,
LM test = 0.00(0.98), ARCH test = 2.95(0.09), RESET test = 2.27(0.16)

Note: An asterisk *, ** and *** denoted statistical significance at the 0.15, 0.10 and 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.

Source: Author's Computation

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 6). 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).

Table 6 Average land productivity of rice crop

(Unit: kilogram per rai)

	Whole	**Region[a]**			
	Kingdom	**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

II. Role of technical knowledge in production structure

With respect to the second model in Table 5, 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.

The largest share of the planted area was for a major rice crop (about 90 per cent) with relatively quite small planted area for a second rice crop (about 10 per cent). 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 5). On the average, the planted area of local varieties was only 20% of total planted area of major rice crop. 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 7).

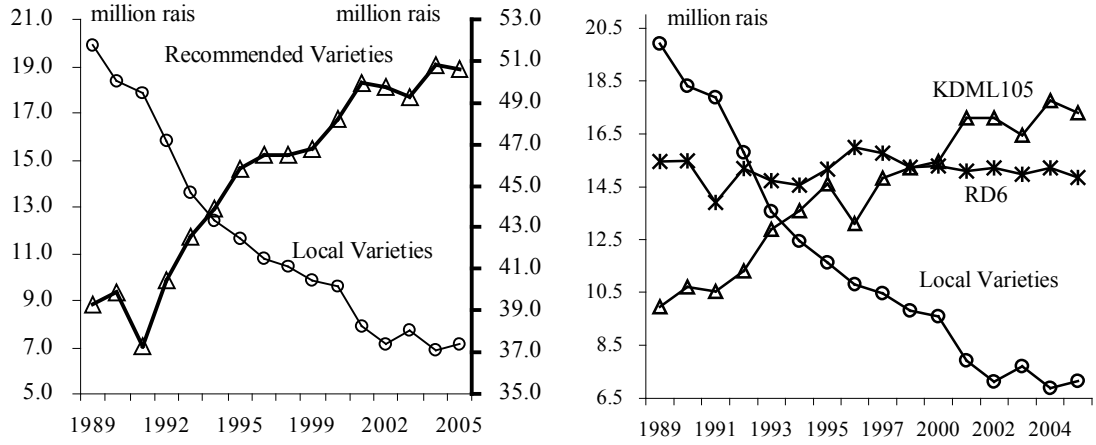

Figure 5 Planted area of major rice crop: Selected varieties

Moreover, the recommended varieties may be broadly classified under two headings: 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. Consequently, the land 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 5). On the average, the planted area of RD6 and KDML105 accounted for 33 and 31 per cent of the rice planted area of recommended varieties, respectively (Table 7).

Table 7 Planted area of rice crop

(Unit: million rais)

	Whole Kingdom	**Region**			
		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

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.

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 (M.9) and (M.10) in the section of theoretical model, the economic surplus was computed by substituting several estimated parameters. At first, the parameterization should be considered. Since most of parameters are drawn from the related literatures except the rate of shift in supply schedule, the sensitivity of the estimated economic surplus is analyzed. The scope of impacts of public rice research on social welfare is analyzed over the past 15 years: 1986 to 2000.

I. Parameterization

The parameters that used for estimating the economic surplus are summarized in Table 8. The further detail of deriving parameter is described as follows.

Table 8 Parameter for estimating economic Surplus

Parameter	Estimated value
a_t	The numbers vary in any particular year t.
b_t	The numbers vary in any particular year t.
α	0.153
η	0.986
k_t	The numbers vary in any particular year t.

A. Parameter of demand and supply function

Based on rice demand and supply function, $a_t = Q_{E0,t}/(P_{E0,t})^{-\eta}$ and $b_t = Q_{E0,t}/(P_{E0,t})^{\alpha}$, where $Q_{E0,t}$ and $P_{E0,t}$ stand for the rice quantity and retail price without the improved technical knowledge in period t, respectively. Unfortunately, these variables are not available. Following Oungsawat (1995), rice quantity and price in "period t-1" represents rice quantity and price without the improved technical knowledge in "period t". In order to compute a_t and b_t, the data set for rice quantity and retail price is drawn from Pojean and Wiratpong (2004).

B. Rice retail price elasticity of supply

According to the definition of rice retail price elasticity of supply,

$$\alpha = \frac{dQ_0^S}{dP_r}\frac{\overline{P}_r}{\overline{Q}_0^S} \qquad \ldots(R.1),$$

where $\overline{P}_r$ and $\overline{Q}_0^S$ stand for the average of rice retail price and quantity, respectively. Instead of the equation (R.1), this elasticity is computed by following formula.

$$\alpha = \left(\frac{dQ_0^S}{dP_f}\frac{\overline{P}_f}{\overline{Q}_0^S}\right)\left(\frac{\overline{P}_r}{\overline{P}_f}\right)\left(\frac{dP_f}{dP_W}\right)\left(\frac{dP_W}{dP_r}\right) \qquad \ldots(R.2),$$

where $\left(\frac{dQ_0^S}{dP_f}\frac{\overline{P}_f}{\overline{Q}_0^S}\right)$ or α_f = elasticity of rice supply with respect to price received by farmer. According to the previous literatures, Pojean & Wiratpong (2004) and Sungudom (2003) provides the elasticity of supply with respect to one lag price of paddy received by farmer, their values are not suitable for this study (Table 9). Thus, the parameter of α_f employs the elasticity of Itharattana (1999) that is equal to 0.301.

Table 9 Summary studies of the estimated price elasticity of supply

Study	Time period	Type of elasticity	Estimate	Method of estimation
Isvilanonda *et al*. (1997)	1961-1992	Paddy wholesales price elasticity of supply in the short run. Paddy wholesales price elasticity of supply in the Long Run.	0.0798 0.0835	Seemingly unrelated regression Estimation
Itharattana (1999)	1978-1996	Elasticity of supply with respect to price of paddy received by farmer at mean value.	0.301	OLS estimation
Sungudom (2003)	1981-2001	Elasticity of supply with respect to price of paddy received by farmer in the short run	0.096	Iterative 3SLS estimation
Pojean and Wiratpong (2004)	1981-2001	Elasticity of supply with respect to price of paddy received by farmer in the short run	0.1485	Iterative 3SLS estimation

$\left(\frac{\overline{P}_r}{\overline{P}_f}\right)$ = the average ratio of rice retail price to price received by farmer in real terms. In order to compute this ratio, the data set is drawn from Pojean & Wiratpong (2004). The value of ratio is equal to 1.806.

$\left(\frac{dP_f}{dP_W}\right)$ is derived from the slope of price linkage equation. $P_f = f(P_w)$, where P_f = price received by farmer and P_w = rice wholesale price. It is drawn from the estimated equation of Pojean & Wiratpong (2004). The value of slope is equal to 0.651.

$\left(\frac{dP_W}{dP_r}\right)$ is derived from the slope of price linkage equation. $P_r = f(P_w)$, where P_r = rice retail price, P_w = rice wholesale price. Since the slope is drawn from the estimated equation of Pojean & Wiratpong (2004), the reciprocal of slope is equal to 0.432.

C. Rice retail price elasticity of demand

According to the definition of rice retail price elasticity of demand,

$$\eta = \frac{dQ_0^D}{dP_r}\frac{\overline{P}_r}{\overline{Q}_0^D} \qquad \ldots(R.3),$$

where $\overline{Q}_0^D$ and $\overline{P}_r$ represents the average of rice demand and retail price, respectively. Instead of the equation (R.3), this elasticity is computed regarding Oungsawat (1995).

$$Q_0^D = Q_C^D + Q_X^D,$$

where Q_C^D and Q_X^D stand for rice domestic consumption and export, respectively.

$$\frac{dQ_0^D}{dP_r} = \frac{dQ_C^D}{dP_r} + \frac{dQ_X^D}{dP_r}$$

$$\frac{dQ_0^D}{dP_r}\frac{\overline{P}_r}{\overline{Q}_0^D} = \frac{dQ_C^D}{dP_r}\frac{\overline{P}_r}{\overline{Q}_0^D} + \frac{dQ_X^D}{dP_r}\frac{\overline{P}_r}{\overline{Q}_0^D}$$

$$= \frac{dQ_C^D}{dP_r}\frac{\overline{P}_r}{\overline{Q}_0^D}\frac{\overline{Q}_C^D}{\overline{Q}_C^D} + \frac{dQ_X^D}{dP_r}\frac{\overline{P}_r}{\overline{Q}_0^D}\frac{\overline{Q}_X^D}{\overline{Q}_X^D}$$

$$= \left(\frac{dQ_C^D}{dP_r}\frac{\overline{P}_r}{\overline{Q}_C^D}\right)\left(\frac{\overline{Q}_C^D}{\overline{Q}_0^D}\right) + \left(\frac{dQ_X^D}{dP_r}\frac{\overline{P}_r}{\overline{Q}_X^D}\right)\left(\frac{\overline{Q}_X^D}{\overline{Q}_0^D}\right)$$

Since $\left(\frac{dQ_X^D}{dP_r}\frac{\overline{P}_r}{\overline{Q}_X^D}\right) = \left(\frac{dQ_X^D}{dP_X}\frac{\overline{P}_X}{\overline{Q}_X^D}\right)\left(\frac{\overline{P}_r}{\overline{P}_X}\right)\left(\frac{dP_X}{dP_W}\right)\left(\frac{dP_W}{dP_r}\right)$,

then

$$\eta = \left(\frac{dQ_C^D}{dP_r}\frac{\overline{P}_r}{\overline{Q}_C^D}\right)\left(\frac{\overline{Q}_C^D}{\overline{Q}_0^D}\right) + \left(\frac{dQ_X^D}{dP_X}\frac{\overline{P}_X}{\overline{Q}_X^D}\right)\left(\frac{\overline{Q}_X^D}{\overline{Q}_0^D}\right)\left(\frac{\overline{P}_r}{\overline{P}_X}\right)\left(\frac{dP_X}{dP_W}\right)\left(\frac{dP_W}{dP_r}\right) \quad \ldots(R.4),$$

where $\left(\frac{dQ_C^D}{dP_r}\frac{\overline{P}_r}{\overline{Q}_C^D}\right)$ or η_C = the retail price elasticity of domestic rice demand at mean value. According to the previous literatures, Isvilanonda *et al*. (1997), Isvilanonda & Kongrithi (2006) and Pojean & Wiratpong (2004) revealed that this elasticity in terms of absolute value was estimated to have been 0.486, 0.055 and 0.392, respectively (Table 10). Nevertheless, the weakness point of Pojean & Wiratpong (2004) is that rice retail price did not deflated by consumer price index. Thus, the estimated value would be less reliable. On the other hand, it should be noted that the estimated value between Isvilanonda *et al*. (1997) and Isvilanonda & Kongrithi (2006) not quite different. Since the study period of latter one is not rather corresponding with this study, the parameter of η_C employs the elasticity of the former one.

$\left(\frac{\overline{Q}_C^D}{\overline{Q}_0^D}\right)$ = the average ratio of rice domestic consumption to rice consumption. In order to compute this ratio, the data set is drawn from Pojean & Wiratpong (2004). The value of ratio is equal to 0.618.

$\left(\frac{dQ_X^D}{dP_X}\frac{\overline{P}_X}{\overline{Q}_X^D}\right)$ or η_X = the rice export price elasticity of export demand. For the major rice, Patmasiriwat and Sathidsirikul (1990) and Sungudom (2003) revealed that this elasticity in terms of absolute value was estimated to have been 1.259 to 1.726 and 0.853, respectively (Table 10). Meanwhile, Pojean & Wiratpong (2004) revealed that the rice export price elasticity of export demand was estimated to

have been 0.242. Since most of the previous literatures pointed out that the rice export demand was rather sensitive to rice export price (Patmasiriwat and Sathidsirikul, 1990), this study utilizes 1.726 as the proxy of η_X.

$\left(\frac{\overline{Q}_X^D}{\overline{Q}_0^D}\right)$ = the average ratio of rice export to rice consumption. In order to compute this ratio, the data set is drawn from Pojean & Wiratpong (2004). The value of ratio is equal to 0.393.

$\left(\frac{\overline{P}_r}{\overline{P}_X}\right)$ = the average ratio of rice retail price to rice export price in real term. In order to compute this ratio, the data set is drawn from Pojean & Wiratpong (2004). The value of ratio is equal to 1.425.

$\left(\frac{dP_X}{dP_W}\right)$ is derived from the slope of price linkage equation. $P_W = f(P_X)$, where Pw = rice wholesale price, Px = rice export price. Since the slope is drawn from the estimated equation of Pojean & Wiratpong (2004), the reciprocal of slope is equal to 1.640.

$\left(\frac{dP_W}{dP_r}\right)$ is derived from the slope of price linkage equation. $P_r = f(P_W)$, where P_r = rice retail price, P_W = rice wholesale price. Since the slope is drawn from the estimated equation of Pojean & Wiratpong (2004), the reciprocal of slope is equal to 0.432.

Table 10 Summary studies of the estimated price elasticity of demand

Study	Time Period	Type of Elasticity	Estimate	Method of Estimation
Patmasiriwat and Sathidsirikul (1990)	1961-1988	Export price elasticity of major rice export	- 1.259 to - 1.726	Ordinary least squares (OLS) estimation
Isvilanonda *et al*. (1997)	1990	Price elasticity of rice demand	-0.486	Indirect estimation
Itharattana (1999)	1978-1996	Wholesale price elasticity of rice demand	-0.007	OLS estimation
Sungudom (2003)	1981-2001	Wholesale price elasticity of rice demand	-0.049	Iterative three-stage least squares (3SLS)
		Export price elasticity of major rice export	-0.853	estimation
Pojean and Wiratpong (2004)	1986-2003	Price elasticity of rice demand	-0.055	Iterative 3SLS estimation
		export price elasticity of rice export	-0.242	
Isvilanonda and Kongrithi (2006)	2002	Price elasticity of rice demand	-0.392	Indirect estimation

D. Rate of shift in supply schedule

According to Figure 2 in the section of theoretical model, the rate of shift in supply schedule can be written as

$$k \equiv \frac{Q_{E1} - Q_{E0}}{Q_{E0}} \equiv \frac{\Delta Q}{Q} \qquad \ldots(R.5),$$

where Q represents the quantity of rice in tons.

Based on the second model in Table 5, the elasticity of paddy production with respect to the current state of technical knowledge is express as

$$\tilde{\beta}_5 = \left(\frac{d \ln Y}{d \ln X_1}\right)\left(\frac{d \ln X_1}{d \ln X_5}\right) \qquad \ldots.(R.6),$$

where Y = the total production of paddy in million tons. X_1 = the planted area in million rais and X_5 = the current state of technical knowledge. Because the conversion ratio was express as Y = 0.66Q, $\tilde{\beta}_5$ is the elasticity of rice production with respect to the current state of technical knowledge. Therefore, the equation (R.6) is rearranged as

$$\Delta Q = \left(\tilde{\beta}_4 \frac{Q}{X_5}\right)\Delta X_5 \qquad \ldots(R.7).$$

Plug equation (R.7) into equation (R.5), then we have

$$k_t = \left(\tilde{\beta}_5 \frac{\Delta X_{5,t}}{X_{5,t}}\right) \qquad \ldots(R.8),$$

where $\Delta X_{5,t}$ represents the change in stock of public investment in rice research. Its values vary in any particular year t.

II. Estimation of economic surplus

From 1986 to 2000, the main result reveals that the accumulation of economic surplus deriving from the rice research is estimated to have been approximately 7,922.31 million baht at 1988 price (Table 11). 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 2.83, 6.55 and 2.32 baht for every baht spent by 5, 10 and 15 percent discount rate, respectively. 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 12). 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.

Nevertheless, the estimated return to investment in rice research might be questionable about biases. According to Fuglie *et al*. (1996), the biases would be derived from the research lag. The main problem with directly estimating an unconstrained lag structure is that the number of lagged years that can be included is limited by data constraints. Econometric models introduce many independent variables in a data set that extends only 40 or 50 years. Furthermore, the biases would be derived from the net environmental and health effects of new technology may be

negative or positive. Without quantification of these effects, concluding whether estimated rates of return are too high or too low is not possible.

Notwithstanding the public investment in rice research appears high benefits, the income distribution would not be clarified. In other word, the economic impacts of this investment are to keep within bounds. This is mainly because the improvement of varieties deriving rice research of Rice Research Institute has been beneficial for the irrigated areas. Isvilanonda and Wattanutchariya (1994) revealed that in terms of direct effects, a difference in production environments, particularly in the degree of water control, was a major factor in determining the adoption of modern rice varieties compared to socio-economic factors. Their study can provide further based for policy discussion with the understanding that the public funds for investment in irrigation are quite limited. To increase the income of rural household in rainfed environments, the research should be directed to ward new comparative advantage crop rather than rice.

Table 11 Economic surplus and rice research expenditure

(Unit: million baht at 1988 price)

Year	**Economic surplus**	**Rice research expenditure**
1986-1990	136.97	112.79
1991-1995	393.54	182.36
1996-2000	1,053.95	211.56
1986-2000	528.15	168.90
Accumulation value	7,922.31	2,533.57
B/C ratio	Net present value at r = 5%	
2.83	4,701.33	1,663.58
B/C ratio	Net present value at r = 10%	
2.55	2,952.57	1,156.53
B/C ratio	Net present value at r = 15%	
2.32	1,960.72	845.65

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

Source: Author's computation

Table 12 Sensitivity analysis

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%
a. Rate of shift in supply curve remained the same (k)					
η = 0.986	α = 0.153	7,922.31	2.83	2.55	2.32
η+25%η	α = 0.153	7,944.09	2.83	2.56	2.32
η= 0.986	α +25%α	7,669.69	2.74	2.47	2.24
η+25%η	α +25%α	7,693.75	2.74	2.48	2.25
η-25%η	α = 0.153	7,913.66	2.82	2.55	2.32
η= 0.986	α -25%α	8,192.75	2.92	2.64	2.40
η-25%η	α - 25%α	8,185.87	2.92	2.64	2.40
b. Rate of shift in supply curve decreased to 25% (k-25%k)					
η = 0.986	α = 0.153	5,946.46	2.12	1.92	1.74
η+25%η	α = 0.153	5,958.74	2.13	1.92	1.74
η= 0.986	α +25%α	5,756.54	2.05	1.85	1.68
η+25%η	α +25%α	5,770.10	2.06	1.86	1.69
η-25%η	α = 0.153	5,941.59	2.12	1.91	1.74
η= 0.986	α -25%α	6,149.69	2.19	1.98	1.80
η-25%η	α - 25%α	6,145.81	2.19	1.98	1.80

Table 13 (Continued)

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%
c. Rate of shift in supply curve increased to 25% (k+25%k)					
η = 0.986	α = 0.153	9,895.03	3.53	3.19	2.90
η+25%η	α = 0.153	9,928.99	3.54	3.20	2.90
η= 0.986	α +25%α	9,580.01	3.42	3.09	2.80
η+25%η	α +25%α	9,617.53	3.43	3.10	2.81
η-25%η	α = 0.153	9,881.54	3.53	3.19	2.89
η= 0.986	α -25%α	10,232.41	3.65	3.30	3.00
η-25%η	α - 25%α	10,221.69	3.65	3.29	2.99

Source: Author's computation

CONCLUSIONS AND FINAL REMARK

Conclusions

According to the crop researches, the rice research has been continuously received the highest priority. The current and past public expenditures that 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). Therefore, the first question of how the public investment in rice research affects production was examined. The main result 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 estimated model indicated 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. Thus, the public rice research had been contributing to production.

The improvement of technical knowledge deriving from rice research 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 high. Consequently, the benefit cost ratio pointed out the government expenditure on rice research generated of 2.83, 2.55 and 2.32 Baht for every Baht spent by 5, 10 and 15% discount rate.

Policy Implication

The policy implication is firstly drawn from the estimated production function with consideration of current state technical knowledge. 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.

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The implication is secondly taken from the net returns to rice research. The estimated B/C ratio implied the public investment in rice research is sufficiently attractive. Further, it may be indicated that the rice research in Thailand still appeared underfunded. Apart from this, notwithstanding the model is a static approach, the policy makers are informed of the potential effects of rice research on Thai economy. 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.

Limitation of the Study

Even through the social benefits deriving from rice research is still profitable and more investment should be encouraged. Nevertheless, the decomposition analysis of these benefits is the shortcoming of this study. According to the sense of income distribution, the theoretical model for future research may separated into rainfed and irrigated environment. Certainly, the secondary data is not appropriate for conducting this issue. Therefore, the location of study area needs to be specified instead of macro level. Apart from this, not merely agricultural research program but also development of extension program has been beneficial for the farmers. Therefore, the research-extension linkage should be attended in the future direction of study.

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APPENDICES

Appendix A

Conversion methods of annual data to quarterly data

I. Boot technique (Boot *et al.* 1967 cited Inthisang, 1998)

Because the data set for wage rate from 1997 until 1998 and capital stock in agricultural sector from 1997 until 1998 was not collected on a quarterly basis, it was interpolated by Boot Technique. Let $y_i^*(i=1,2,...,N)$ and $y_j(j=1,2,...,4N)$ be related annual and quarterly series, respectively; N was the number of years.

$$\text{Minimize} \sum_{j=2}^{4n}(y_j - y_{j-1})^2$$

$$\text{subject to} \sum_{j=4i-3}^{4i} y_i = y_i^* \quad (i=1,2,...,N)$$

Thus, the solution of minimize problem would be expressed as

$$\begin{bmatrix}\hat{y}\\ \lambda\end{bmatrix} = \begin{bmatrix}B & C'\\ C & 0\end{bmatrix}^{-1} * \begin{bmatrix}0\\ y^*\end{bmatrix}$$

where $\hat{y}$ = 4N×1 matrix of quarterly figure,

λ, μ = N×1 matrix LaGrange multiplier,

0 = N×N zero matrix,

B,C = the following 4N×4N matrix, respectively,

$$B = \begin{bmatrix} 1 & -1 & & & & & \\ -1 & 2 & -1 & & 0 & & \\ & -1 & 2 & -1 & & & \\ & & & \bullet & & & \\ & 0 & & -1 & 2 & -1 & \\ & & & & -1 & 1 & \end{bmatrix},$$

$$C = \begin{bmatrix} 1 & 1 & 1 & 1 & & & & & & & & & \\ & & & & 1 & 1 & 1 & 1 & & & 0 & & \\ & & & & & & & \bullet & & & & & \\ & & 0 & & & & & & \bullet & & & & \\ & & & & & & & & 1 & 1 & 1 & 1 & \\ & & & & & & & & & & & 1 & 1 & 1 & 1 \end{bmatrix}.$$

II. Demographic technique (Piampiti 1985 cited Charoenkittayawut, 2001)

Because in the year 1998 the surveys of National Statistic Office had just two rounds, i.e. round 1 (February) and round 3 (August), the employment in agricultural sector for round 2 (May) and round 4 (November) was manipulated by a demographic technique. The formula was expressed as follows.

$$\bar{P} = P_1 + (n/N)(P_2-P_1)$$

where $\bar{P}$ = Number of population was estimated in the concerning period.

P_1 = Number of population was surveyed in the first period.

P_2 = Number of population was surveyed in the second period.

n = Number of month was between the first period and the concerning period.

N = Number of month was between two periods of survey.

Appendix B

Data set for estimation

Appendix Table 1 Data set for macroeconomic-agricultural linkage model

(Unit: million baht at 1988 price)

Year	GDP	Private consumption	National investment	Government consumption	Exports for goods & services
1997:1	774,119	420,784	279,849	62,320	330,967
1997:2	769,190	438,422	272,821	60,041	332,248
1997:3	765,475	416,320	281,088	71,220	351,379
1997:4	763,831	395,652	216,747	59,519	389,661
1998:1	719,305	384,549	152,106	58,490	386,268
1998:2	662,415	373,663	116,197	56,736	366,911
1998:3	658,899	357,932	121,972	80,178	376,515
1998:4	709,065	362,641	125,726	67,558	390,298
1999:1	717,789	371,892	134,771	59,364	381,333
1999:2	685,245	379,177	144,634	66,214	381,263
1999:3	714,340	388,274	132,645	75,117	426,928
1999:4	754,606	403,432	147,672	70,334	467,734
2000:1	764,339	399,389	174,385	64,624	465,613
2000:2	727,229	405,922	159,100	64,416	448,287
2000:3	731,689	402,025	135,664	79,749	516,546
2000:4	785,144	416,380	153,929	68,343	516,635
2001:1	777,523	417,519	180,154	66,569	456,469
2001:2	743,138	424,910	156,607	70,372	445,649
2001:3	746,884	417,211	144,416	82,492	470,877
2001:4	806,056	431,004	158,818	64,593	492,088
2002:1	812,458	433,587	172,125	73,095	483,131
2002:2	780,037	449,127	171,673	68,332	500,810
2002:3	789,845	442,122	160,288	80,853	544,337
2002:4	854,702	457,812	174,115	63,779	560,490
2003:1	867,352	462,724	193,353	67,159	543,902
2003:2	831,219	476,491	176,061	71,957	524,194
2003:3	842,943	467,444	181,772	84,736	567,117
2003:4	923,187	489,668	220,108	68,825	600,451
2004:1	925,577	492,016	230,454	72,693	594,869
2004:2	884,664	505,696	216,548	76,242	592,382
2004:3	895,978	495,477	212,477	85,932	620,925

Appendix Table 1 (Continued)

Year	Imports for goods & services (millions baht at 1988 price)	Tax revenue (millions baht at current market price)	Real effective exchange rate	GDP of the U.S. (Billions of chained 2000 Dollars)	Import price index
1997:1	348,470	171,906	105.7	8,536	120.2
1997:2	360,502	221,184	106.6	8,666	116.3
1997:3	344,907	205,374	87.8	8,774	142.7
1997:4	307,042	158,976	76.3	8,838	173.0
1998:1	256,561	170,507	71.3	8,936	196.4
1998:2	260,372	181,039	84.2	8,995	167.8
1998:3	271,224	138,920	84.4	9,099	161.6
1998:4	278,164	135,928	87.6	9,237	144.8
1999:1	235,878	168,771	87.5	9,316	142.8
1999:2	300,946	171,465	87.5	9,393	142.2
1999:3	308,738	143,933	84.0	9,502	149.7
1999:4	332,608	141,184	81.7	9,671	156.2
2000:1	355,764	165,961	85.6	9,696	150.3
2000:2	365,341	188,783	84.5	9,848	157.7
2000:3	397,995	165,495	81.0	9,837	174.7
2000:4	378,572	149,393	77.9	9,888	197.1
2001:1	355,216	150,179	79.1	9,876	205.1
2001:2	350,926	207,105	77.7	9,906	211.3
2001:3	357,877	177,840	77.2	9,871	203.6
2001:4	351,336	159,339	78.3	9,910	198.5
2002:1	366,719	168,213	80.7	9,977	189.2
2002:2	405,524	227,679	80.7	10,032	180.2
2002:3	426,778	202,764	79.6	10,091	178.7
2002:4	410,244	186,918	77.5	10,096	190.1
2003:1	415,947	199,410	77.0	10,139	188.4
2003:2	414,586	252,873	77.1	10,230	187.4
2003:3	446,242	230,612	78.6	10,411	184.7
2003:4	468,743	219,684	79.1	10,503	184.8
2004:1	482,339	223,160	79.2	10,613	189.3
2004:2	497,813	285,601	78.8	10,704	201.6
2004:3	506,408	280,670	76.7	10,809	212.0

Appendix Table 1 (Continued)

Year	Minimum lending rate (% per annum)	Interbank overnight lending rates (% per annum)	Money supply (Millions baht at current price)	Federal funds rate (% per annum)	Consumer price index for U.S. (% change)
1997:1	13.1	11.3	426,971	5.28	2.95
1997:2	12.8	12.0	396,390	5.52	2.30
1997:3	13.9	19.3	400,523	5.53	2.23
1997:4	14.9	20.1	428,785	5.51	1.89
1998:1	15.3	20.6	405,877	5.52	1.48
1998:2	15.4	18.0	381,672	5.50	1.58
1998:3	15.0	9.6	389,288	5.53	1.60
1998:4	12.6	3.8	441,733	4.86	1.53
1999:1	10.4	2.7	458,041	4.73	1.69
1999:2	9.2	1.5	429,226	4.75	2.11
1999:3	8.8	1.5	431,901	5.09	2.35
1999:4	8.4	1.4	575,039	5.31	2.62
2000:1	8.3	2.1	494,989	5.68	3.26
2000:2	8.3	2.0	463,098	6.27	3.29
2000:3	8.1	1.9	483,467	6.52	3.47
2000:4	7.9	1.8	525,691	6.47	3.44
2001:1	7.6	1.7	533,328	5.59	3.41
2001:2	7.5	2.0	517,693	4.33	3.33
2001:3	7.5	2.5	538,152	3.50	2.68
2001:4	7.4	2.2	579,426	2.13	1.88
2002:1	7.2	1.9	600,228	1.73	1.25
2002:2	7.1	1.7	584,351	1.75	1.30
2002:3	7.1	1.7	599,859	1.74	1.58
2002:4	6.8	1.7	663,493	1.44	2.24
2003:1	6.7	1.4	671,139	1.25	2.88
2003:2	6.5	1.4	672,259	1.25	2.16
2003:3	5.6	1.0	679,368	1.02	2.22
2003:4	5.6	1.3	766,800	1.00	1.89
2004:1	5.6	1.0	761,419	1.00	1.82
2004:2	5.6	0.9	758,947	1.01	2.80
2004:3	5.6	1.2	784,429	1.43	2.71

Appendix Table 1 (Continued)

Year	Headline consumer price index	CPI for non-food & alcoholic beverages	CPI for food & non-alcoholic beverages	World agricultural price index	Import price index for non-food
1997:1	153.5	140.7	173.5	94.4	112.2
1997:2	155.1	142.2	175.2	91.2	108.0
1997:3	159.5	144.0	184.0	83.7	129.5
1997:4	163.6	149.1	186.2	79.6	154.6
1998:1	167.3	152.0	191.8	82.6	180.6
1998:2	171.1	154.6	197.9	84.5	147.7
1998:3	172.5	155.6	200.0	80.8	146.0
1998:4	171.6	155.6	197.5	75.6	130.7
1999:1	171.6	155.8	197.5	73.4	127.5
1999:2	170.4	154.6	195.5	67.8	128.9
1999:3	170.9	156.0	194.3	66.6	136.8
1999:4	171.8	157.8	193.6	66.1	151.1
2000:1	173.2	159.6	194.2	67.5	146.3
2000:2	173.0	160.1	192.4	64.7	152.0
2000:3	174.5	161.8	193.4	62.1	165.5
2000:4	174.6	162.6	192.2	62.5	187.8
2001:1	175.5	163.4	193.4	62.6	186.3
2001:2	177.5	165.6	194.7	60.4	189.8
2001:3	177.3	165.1	195.1	59.5	185.2
2001:4	176.4	164.2	194.2	54.5	176.0
2002:1	176.6	164.6	194.0	57.3	165.6
2002:2	177.8	166.2	194.3	57.4	162.6
2002:3	177.8	165.9	194.9	60.1	159.6
2002:4	178.9	166.7	196.3	60.7	169.1
2003:1	180.0	167.7	197.9	65.8	169.4
2003:2	180.9	166.7	202.3	65.4	169.9
2003:3	181.2	166.6	203.5	65.0	167.7
2003:4	181.8	167.1	204.7	68.9	167.3
2004:1	183.5	168.1	207.4	72.3	171.9
2004:2	185.7	168.9	212.5	77.6	182.8
2004:3	187.3	170.7	212.9	73.2	194.3

Appendix Table 1 (Continued)

Year	Import price index for food	Farm price index	PPI for machinery & equipment products	Wage in agricultural sector (baht per month)	Employment in agricultural sector (thousand persons)
1997:1	87.2	91.76	84.9	3,725	11,850
1997:2	81.4	94.14	83.2	3,956	13,728
1997:3	95.4	95.17	84.9	4,096	16,545
1997:4	108.2	98.81	89.7	4,145	14,550
1998:1	124.2	114.57	94.5	4,103	11,559
1998:2	100.9	117.17	93.2	4,004	11,036
1998:3	101.2	116.54	94.8	3,847	16,311
1998:4	85.6	103.14	94.7	3,634	14,911
1999:1	81.1	101.76	94.2	3,572	12,461
1999:2	80.8	95.19	94.3	3,256	12,865
1999:3	77.0	92.85	94.9	3,366	15,422
1999:4	80.0	92.34	96.7	3,220	14,764
2000:1	73.3	90.61	96.8	3,559	12,025
2000:2	70.0	91.65	97.1	3,801	12,756
2000:3	72.6	93.34	97.6	3,581	15,971
2000:4	77.3	93.34	97.8	3,849	14,820
2001:1	76.1	92.24	98.1	3,674	11,442
2001:2	82.1	95.39	98.4	3,288	12,653
2001:3	81.4	96.34	98.6	3,214	15,409
2001:4	77.2	94.38	99.1	3,052	14,944
2002:1	74.9	96.98	99.6	3,337	12,136
2002:2	72.2	100.14	100.2	3,422	13,116
2002:3	69.4	100.91	100.0	3,370	15,800
2002:4	72.1	101.97	100.2	3,345	15,116
2003:1	74.7	102.93	100.3	3,453	12,254
2003:2	73.7	109.85	100.1	3,616	13,001
2003:3	72.0	112.41	99.9	3,513	15,561
2003:4	69.2	111.65	99.8	3,393	14,704
2004:1	68.1	117.77	99.5	3,460	11,938
2004:2	70.9	132.36	100.1	3,575	12,568
2004:3	72.9	124.15	100.7	3,778	15,115

Appendix Table 1 (Continued)

(Unit: million baht at 1988 price)

Year	Capital stock in agricultural Sector	Private consumption for food	GDP for agricultural sector
1997:1	383,294	103,800	74,957
1997:2	394,993	106,983	64,046
1997:3	407,135	98,599	55,638
1997:4	418,223	97,667	92,192
1998:1	426,762	100,382	75,242
1998:2	432,730	96,474	56,946
1998:3	436,106	88,989	52,554
1998:4	436,869	96,180	97,864
1999:1	434,998	96,934	78,086
1999:2	431,759	96,619	60,103
1999:3	428,419	93,924	55,700
1999:4	426,244	102,589	95,289
2000:1	425,722	100,391	80,517
2000:2	426,073	100,763	68,274
2000:3	426,518	98,900	60,458
2000:4	426,277	106,200	100,699
2001:1	425,685	105,104	82,368
2001:2	425,075	105,050	69,480
2001:3	424,783	103,828	60,528
2001:4	425,143	108,300	107,640
2002:1	426,025	109,115	83,720
2002:2	427,301	108,093	69,030
2002:3	428,840	107,485	63,571
2002:4	430,513	112,593	105,858
2003:1	432,306	114,035	94,151
2003:2	434,203	113,954	79,151
2003:3	436,189	110,460	70,298
2003:4	438,250	121,689	115,432
2004:1	440,367	118,296	91,001
2004:2	442,521	120,703	71,347
2004:3	444,694	115,694	66,446

Appendix Table 1 (Continued)

(Unit: million baht at current market price)

Year	Export for food	Import for food
1997:1	67,124	15,368
1997:2	71,363	15,843
1997:3	88,892	20,224
1997:4	106,824	20,916
1998:1	123,717	23,408
1998:2	92,963	18,997
1998:3	92,992	21,150
1998:4	92,014	17,518
1999:1	84,047	17,470
1999:2	91,346	19,789
1999:3	98,715	19,131
1999:4	105,144	20,911
2000:1	89,128	17,973
2000:2	88,004	19,737
2000:3	106,923	22,133
2000:4	117,862	24,900
2001:1	98,187	22,965
2001:2	110,878	27,579
2001:3	120,142	28,943
2001:4	116,931	27,714
2002:1	103,648	25,211
2002:2	106,923	25,833
2002:3	103,974	24,517
2002:4	113,628	32,006
2003:1	109,328	27,036
2003:2	119,628	28,529
2003:3	119,767	28,877
2003:4	123,457	30,740
2004:1	111,094	29,977
2004:2	124,331	30,494
2004:3	130,964	35,112

Appendix Table 2 Data set for rice production function

Year	Paddy (millions tons)	Planted area (million rais)	Labor use in rice production (millions persons)	Use of chemical fertilizer (millions tons)
1974	13.39	49.89	10.42	0.19
1975	15.30	55.60	10.56	0.24
1976	15.07	53.60	10.78	0.32
1977	13.92	56.44	11.06	0.37
1978	17.47	62.67	10.90	0.42
1979	15.76	58.97	11.17	0.48
1980	17.37	60.11	11.38	0.42
1981	17.77	59.97	11.58	0.49
1982	16.88	60.13	11.79	0.54
1983	19.55	62.60	11.50	0.67
1984	19.91	62.33	11.63	0.65
1985	20.26	63.42	11.82	0.61
1986	18.87	61.57	11.95	0.66
1987	18.43	58.89	12.08	0.64
1988	21.26	64.68	11.43	0.85
1989	20.60	64.44	11.49	1.11
1990	17.19	61.91	12.34	1.00
1991	20.40	59.67	12.41	0.85
1992	19.92	60.45	12.43	0.99
1993	18.45	59.25	14.73	1.04
1994	21.11	60.68	14.72	1.41
1995	20.02	63.35	13.94	1.51
1996	22.33	63.73	13.77	1.66
1997	23.58	64.19	14.48	1.85
1998	23.00	62.70	14.61	1.76
1999	24.17	64.44	13.86	1.93
2000	25.84	66.49	14.00	2.00

Appendix Table 2 (Continued)

Year	Rainfall (millimeter)	Harvested area (million rais)	Year	Government budget on rice research (million baht)	Year	Government budget on rice research (million baht)
1974	1,117	46.95	1960	9.23	1987	101.26
1975	1,184	52.23	1961	6.95	1988	105.16
1976	1,079	51.04	1962	10.50	1989	107.16
1977	914	54.69	1963	10.37	1990	164.51
1978	1,029	55.84	1964	12.85	1991	173.01
1979	884	54.09	1965	13.56	1992	202.95
1980	1,071	57.50	1966	17.39	1993	256.60
1981	986	56.91	1967	19.54	1994	263.08
1982	1,105	55.88	1968	20.61	1995	284.34
1983	1,142	60.04	1969	22.46	1996	342.25
1984	982	60.19	1970	25.03	1997	359.23
1985	1,030	61.46	1971	27.61	1998	355.66
1986	956	57.46	1972	27.87	1999	333.14
1987	1,006	57.17	1973	29.73	2000	344.70
1988	1,214	61.91	1974	30.10		
1989	1,007	61.74	1975	39.88		
1990	926	54.95	1976	47.20		
1991	833	56.58	1977	51.48		
1992	787	57.25	1978	53.49		
1993	825	53.02	1979	63.54		
1994	1,044	56.10	1980	71.25		
1995	1,030	56.87	1981	83.87		
1996	997	57.92	1982	88.17		
1997	881	61.96	1983	120.02		
1998	934	59.45	1984	91.78		
1999	841	62.31	1985	96.00		
2000	852	61.82	1986	98.33		

Appendix Table 3 Data set for estimating economic surplus

Year	Total rice consumption (tons)	Domestic rice consumption (tons)	Rice export (tons)	Rice retail prices[1] (baht per ton)	Rice farm prices[1] (baht per ton)	Rice export prices[1] (baht per ton)
1985	13,373,580	8,524,560	4,522,000	7,698	3,874	4,867
1986	12,452,220	8,500,800	4,442,000	7,500	4,590	5,436
1987	12,162,480	8,310,060	5,088,000	8,904	6,508	7,072
1988	14,032,920	8,212,380	6,139,000	9,412	6,314	7,403
1989	13,596,660	8,368,140	4,016,000	9,281	5,468	6,561
1990	11,347,380	8,412,360	4,332,000	8,929	5,330	6,307
1991	13,463,340	7,986,000	5,150,000	8,708	4,899	5,955
1992	13,145,220	8,175,420	4,988,000	8,144	4,134	5,369
1993	12,175,020	8,125,920	4,858,000	8,244	4,635	6,345
1994	13,932,600	8,199,840	6,197,000	8,246	4,599	5,875
1995	14,529,900	8,585,940	5,459,000	9,067	5,569	6,582
1996	14,738,460	9,054,540	5,566,000	10,025	5,545	7,818
1997	15,562,800	8,985,900	6,539,000	11,724	6,362	8,406
1998	15,178,680	8,836,740	6,838,000	10,089	4,953	6,323
1999	15,952,860	9,038,040	6,140,000	9,635	4,259	6,237

Note: [1]The data are deflated by consumer price index (1988=100).

Data set for paddy is drawn from Pojean and Wiratpong (2004).

1 paddy ton = 0.66 rice ton