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IMPACT OF DIRECT INCOME PAYMENTS ON PRODUCTIVE EFFICIENCY OF KOREAN RICE FARMS*

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Keywords
direct income payments, productive efficiency, stochastic frontier production function

Abstract
This paper examines the impact of direct income payments on productive efficiency of Korean rice farms, using farm-level cross sectional data in 2006. For representation of efficiency and its determinants, this paper uses a model that estimates the deviations of farms from a translog distance function and the determinants of these deviations. This paper especially estimates a stochastic frontier production function to explain deviations from best-practice productivity with a two-part error term including statistical noise from measurement error and technical inefficiency arising from farms not reaching the production frontier boundary. The empirical evidence finds that farms that get a higher share of direct payments in farm revenue are less efficient than others. This inefficiency is reduced by increases in farm size. Another result indicates that farms received greater direct payments on aggregate are more efficient than other farms since fixed payment, one part of rice direct payment, is tied to the amount of a farm's cropland that has been enrolled in programs, as well as yield histories.

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I. INTRODUCTION

Direct payments have taken up a larger portion of agricultural policy in many countries. The World Trade Organization (WTO) mechanism believes that price or product support policies have distorted production and trade, and consequently demands their reduction or conversion into production-neutral direct payment programs. Following the global trend, Korea is expanding the direct payment scheme to achieve the goal of agricultural structural reform and protect farm household income.

The introduction of Korean direct payment programs has been discussed since the mid-1990s, but one of the concerns about the programs is that the programs would negatively affect agricultural policy goals such as structural reform or demand/supply balance, despite the positive effect of compensating farm household's income reduction stemming from agricultural market opening. Especially the disputes regarding the relationship between direct payment programs and agricultural structural reform have evolved around the direct payment programs for income compensation.

The Korean agriculture is featured by a large number of small-sized farms. In this situation, some argue that the expansion of the direct income payment programs suppresses the leaving of small farms from agriculture, making the structural reform effort reversed, and the rice-centric direct income payment policy could exacerbate the rice supply glut (Lee, 2000; Lee 2002; Park et al., 2004).

In addition, others point out that the direct payment programs linked to the amount of a farm's cropland raises farmland rents, thereby restraining the farmland mobilization and setting a high barrier to young farmers' entry into the agriculture. In fact, there were such cases where landlords requested the grant of the direct income payments to them or raised the rents or even taken the land away from the tenanted farmers.

The literature also argues that the direct income payment program for rice farming is targeted to farmers cultivating land sized at 0.1ha or above, and this has restrained the exit of small farms from the farming, and reversed the trend of agricultural structural reform. However, some insist that considering the small cost of opportunity given to most small farms managed by old farmers and the small amount of direct payments offered to them, it is unnecessary to raise the minimum amount (Oh and Kim, 2005).

Chau and de Gorter (2000) points out that the AMTA (Agricultural Market Transition Assistance) of U.S. has prevented farms from exiting from farming due to government subsidy.[1] Adams et al. (2001) suggest that direct payments might be the cause of production surplus and environmental issues, and raises farmland rents, thereby blocking structural reform.

In summary, based on the literature, the arguing points to be clarified in defining the relation between direct payment programs and agricultural structural reform are as follows: 1) Does the direct income payment system suppress the leaving of marginal farms from agriculture?; 2) does the direct income payment program raise farmland rents?; and 3) what impact does the direct income payment policy have on the total number of farm households?

Among the arguments surrounding the direct income payment programs and agricultural structural reform, this study analyzes the impact of the direct payment on production efficiency and structural reform to find out if the direct income payment program restrains marginal farms from leaving farming. To this end, the focus of analysis is on the direct income payment program for rice farming.

Most literature on direct income payments and agricultural structural reform tend to depend on on-site case examples, instead of conducting an empirical analysis. More in-depth theories and empirical analyses have been lacking. In this regard, unlike other literature, this paper analyzes the impact of direct income payments for rice farms on rice productive efficiency using individual farm-level data in 2006 and derives the implications for agricultural structural reform. There are little studies on this issue in Korea.

While the primary objective of this paper is to empirically examine the impact of income support direct payment on rice production efficiency for Korean rice farms, another important aim is to shed some light on the relationship between direct payment policies and structural reform of the Korean rice industry. Gradual liberalization of the rice and other farm commodity markets could further enlarge the gap between farm and non-farm incomes, as internal prices in Korea are far above potential import prices of many farm commodities, especially rice. Under these situations, the current consensus in Korean ag-

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[1] Fixed direct payments (DP) replace production flexibility contract (PFC) payments, sometimes referred to as AMTA payments.

riculture is that expansion of individual farmland holdings via exit of marginal farmers, a process generally labeled “farm consolidation,” can improve productivity and competitiveness through increased productive efficiency (e.g., Kim, 1997; Lee, 1998). Many Korean economists argue that low rural income in Korea is less the result of depressed prices for agricultural products and more the consequence of small farm sizes, or lack of consolidation. Korean government policies also seek to expand land holdings per farm through the elimination of marginal farms and improve productive efficiency. However, income support direct payment may induce marginal farms to stay in farming longer, thus making difficult the farm consolidation necessary to improve productivity and competitiveness in the Korean rice industry.

Until now, public policy in Korean agriculture has been focused on boosting rural income with little attention to productivity. Assessing the unexplored productivity potential is an important component of evaluating the future path of productivity. The previous regime of autarky and considerable government interventions helped marginal farmers remain in business. No income support would be expected to induce some marginal farmers to retire from rice farming, which means that average current productivity would be misleading as an assessment of the productivity potential. This underscores the relevance of frontier methods.

This paper is divided into four sections. Section II specifies the current status of Korean direct payments in terms of contents and general effects. Section III provides an analytical framework for the impact of direct payment on rice production efficiency. Then, to provide a context to our analysis, section IV briefly describes the data used here. We then present estimation procedures in Section V. The estimated results are presented and discussed in Section VI. Conclusions are drawn in the final section.

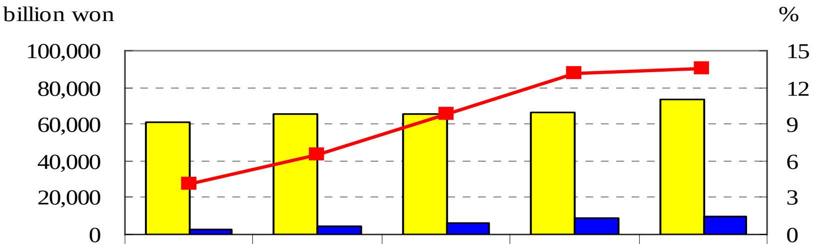
II. KOREAN DIRECT PAYMENTS

1. Types of Korean direct payments

In 1997, the direct payment program for farm management transfer by aged farmers was first introduced in Korea. Since then, the direct payment program for environment-friendly farming was introduced in 1999, followed by the direct payment program for rice farming in 2001 and the direct payment program for rice farming in 2002. In 2005, the income support direct payments for rice farms combined by two direct payment programs related to rice were newly introduced. Besides, a rice production adjustment program was conducted temporarily for three years from 2003, and a pilot project was launched in 2004 based on a plan of introducing a direct payment program for environmentally friendly livestock farms and a direct payment program for farms located in geographically less-favored rural areas. Among various direct payment programs, the program for rice income support direct payments takes up the largest portion.

The introduction of various direct payment programs each year has expanded the related budget amount from KRW 250.9 billion (4.1% of agricultural budget) to KRW 1.14 trillion (13.6% of agricultural budget). Besides, due to a sizable growth in variable direct payments in the direct income payment system for rice farming, the budget surged as much as 23.4%. The expansion of the direct payment program has emerged as a main task of agricultural policy, and according to the 'comprehensive measures for agriculture and rural areas,' the direct payment budget was scheduled to rise up to KRW 3.41 trillion (22% of agricultural budget).

FIGURE 1. Changes in direct payment budget, 2001-2005



	2001	2002	2003	2004	2005
Agricultural budget(billion won)	60,968	65,491	65,572	66,031	73,406
Direct payment budget(billion won)	2,509	4,289	6,432	8,675	10,014
Ratio(%)	4.1	6.5	9.8	13.1	13.6

Source: Korea Ministry of Agriculture and Fishery (www.maf.go.kr)

As of 2006, six direct payment programs are in place. Mostly, they are based on farmland size. For rice paddies, the direct payment programs for rice farms, environmentally friendly farming, and management transfer are applied, while the ones for geographically less-favored rural areas and environmentally friendly farming are applied for uplands.

TABLE 1. Direct payment programs in Korea

Type	Beginning year	Purpose	Payment Requirements
① Management transfer	1997	- Expand the farm size - Stabilize the income of retired farmers	Farmland sale or 5 year or above lease
② Environmentally friendly farming	1999	- Environment preservation	Compliance with the certification criteria of environmentally friendly agricultural products
③ Rice farming	2001	- Income compensation	Maintain the form of rice paddies
④ Direct payments for rice farming	2002	- Management stabilization	Joining agreement, contribution payment, and price fall below the reference price
⑤ Rice production adjustment	2003	- Rice supply/demand balance - Strongly positioned in the rice re-negotiations	3-year mandatory non-farming of rice and commercial crops
⑥ Environmentally friendly livestock farming	2004	- Build a sustainable livestock farming - Produce safe livestock products	Program implementation, handling of night soil created
⑦ Less-favored rural areas	2004	- Maintain agricultural diversity - Maintain local community	Village agreement execution, village fund creation, village vitality enhancement
⑧ Landscape conservation	2005	- Maintain agricultural landscape - Boost vitality in the rural areas	Landscape conservation planning, agreement signing, and compliance
⑨ Income support direct payment for rice farming: combination of ③, ④	2005	- Stabilize rice farm management	Maintain rice paddies' form

Source: Korea Ministry of Agriculture and Fishery (www.maf.go.kr)

TABLE 2. Classification of current direct payment programs by function

Program	Description	Function
Income support direct payment for rice farming	Compensate the gap between target price and market price up to 85% Target price: KRW 170,083/80kg Market price: average supplier price during harvesting season	Income stabilization
Direct payment for less-favored rural areas	Applied to the geographically disadvantaged areas with 14% or above slant, sign an agreement between local governments and villages, create a joint fund of 30%	Enhanced agricultural diversity
Direct payment for landscape conservation	Plant and manage landscape crops such as rape and buckwheat, sign an agreement between local governments and villages	Enhanced agricultural diversity
Direct payment for environmentally friendly agriculture	Conduct environmentally friendly farming and make additional payment for fixed type of rice farm's income compensation	Environmentally friendly farming fostering
Direct payment for environmentally friendly livestock farming	Secure forage crop plot, use night soil for farming, maintain the proper livestock head density	Environmentally friendly farming fostering
Direct payment for management transfer	Encourage farmers aged from 63 to 69 years to sell or lease their farmland to contribute to the farm size increase of 3rd parties	Structural reform

2. Direct payment for stabilizing the income of rice farming

The income support direct payments for rice farming, which were newly introduced in 2005, did not set a ceiling in the targeted land size unlike previous direct payment systems. Instead, the payment consists of the fixed amount determined according to farmland size and the variable amount determined as a certain ratio of the gap between target price and market price.

The direct payments for the Korean rice industry are to compensate for the income loss resulting from the elimination of the government purchasing program which served as a market price support in such a manner as to not distort the rice market. This program consists of two types of direct payments, i.e., fixed and variable direct payments. The nature of fixed payment is like lump-sum transfer whereas variable payment is price-dependable.

The fixed direct payments introduced in 2005 are a variation of the direct payment system for rice farming introduced in 2001. It is paid for farmland maintenance and KRW 700,000/ha was paid in 2006. The farmland targeted include the farmland used for rice farming from January 1, 1998 to December 31, 2000. The land should perform the functions of farmland and maintain its form as farmland provided that the direct payment is given to rice farmland of the concerned year among qualified farmland, and pesticide and chemical fertilizer standards should be met.

The variable direct payments are paid only when the market price falls below the target price, and the amount of a variable direct payment is found by subtracting 85% of the gap between target price and market price by the fixed direct payment unit price. Target price is announced by the Ministry of Agriculture and Forestry considering the average rice price of main rice producing areas during the harvest season (from October to January of next year). Target price is adjusted every three years based on the consent from the Korea National Assembly. The target price from 2005 to 2007 is KRW 170,083/80kg. The unit price of fixed direct payment is equivalent to the amount found by dividing the fixed direct payment by the number of rice bags. For example, if 61 bags of rice are produced in an area of 1ha, the unit price is KRW 700,000 /61=KRW 11,475. The variable direct payment is determined as follows: Variable direct payment amount =(target price-market price)*0.85-(fixed direct payment unit price).

TABLE 3. Total area and upper limit for fixed direct payment

	2001	2002	2003	2004	2005	2006
Total area applied for fixed direct payment(1,000ha)	816	852	910	955	998	
Payment amount per ha (KRW1,000)	234	467	500	500	600	700
Upper limit for fixed direct payment(ha)	2	2	3	4	-	-

Source: Korea Ministry of Agriculture and Fishery (www.maf.go.kr)

If the market price moves above target price, the variable direct payment is not paid so that it is very similar to the U.S. Counter-Cyclical Payment (CCP).

The fixed direct payment is not linked to production and price so that it is put in the green box of the WTO, while the variable direct payment is classified as the amber box since it is linked to market price.

The variable payment amount is increasing at a much faster speed than the fixed payment amount. In 2003 when the variable direct payment was first introduced, the total spending for variable direct payment was KRW 24.4 billion, but it surged to KRW 698.6 billion in 2006, 37 times higher than that of the first year. The main reason lies in the constant fall of the market price although the target price is fixed for three years. Therefore, one of the problems of the fixed and variable direct payments is cited as the rapidly growing financial burden of the government.

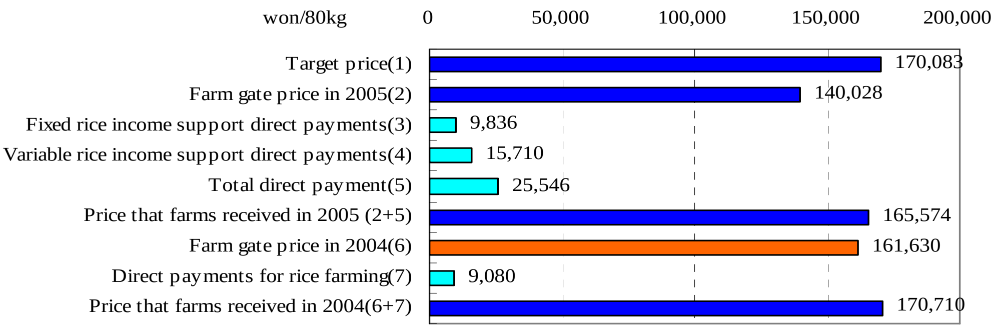
3. Features of Korean direct payments

3.1. Income support

Despite the increasing budget spending, the income support effect of the direct payments remains insignificant. The direct payment amount per household was KRW 509,000 in 2003 and KRW 699,000 in 2004, accounting for only 1.9% and 2.4% of the total farm household income respectively.

However, the income support direct payment program for rice farming has a relatively high effect on income stabilization. In 2005, the average supplier price of rice was set at KRW 140,028, thus the amount received by farm household including direct payments was KRW 165,518 per 80kg. Compared

FIGURE 2. Direct payment for rice income support, 2005



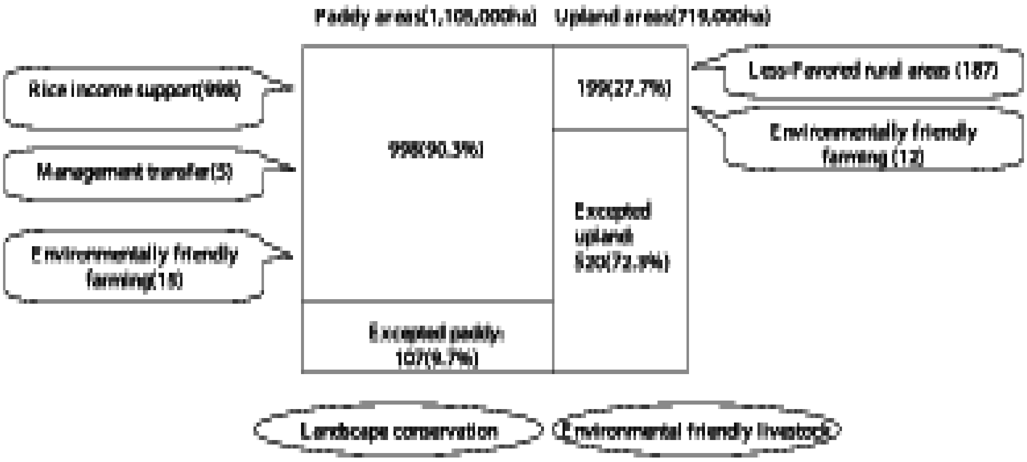
Source: Korea Ministry of Agriculture and Fishery (www.maf.go.kr)

with 2004, this is slightly above the average supplier price (KRW 161,630), but below the farm gate price (KRW 170,710).

3.2. Implementation ratio between rice paddies and uplands

In terms of the farmland type applied with the direct payments, the programs have been mainly implemented on rice paddies. Under the 2006 implementation plan, 90.3% of the total rice paddies (1,105,000 ha) are subjected to the income support direct payments for rice farms, management transfers, and environmentally friendly farming. However, in the case of uplands, only 27.7% are subjected to the direct payment for less-favored rural areas and the direct payment for environmental friendly farming.

FIGURE 3. Farmland areas subject to direct payment, 2006



Note: ( ) represents areas
Source: Korea Ministry of Agriculture and Fishery (www.maf.go.kr)

3.3. Payment method

Payment amount is determined mostly by farmland size. Excluding environmentally friendly livestock farms, the direct payments are paid based on the size of farmland. To determine the amount, the payment unit per ha is set and it is applied nationwide.

III. ANALYTICAL FRAMEWORK

This paper applies a parametric stochastic frontier function to measure the productive (or technical) efficiencies of farms in Korea.[2] Frontier estimation models allow the measurement of farm specific indices of technical efficiency, which may be interpreted as multilateral indices of total factor productivity (Caves et al., 1982; Page, 1984)[3]. Frontier econometric techniques also explain deviations from best-practice productivity with a two-part error term including statistical noise from measurement error and technical inefficiency arising from farms not reaching the production frontier boundary. A parametric stochastic approach recognizes inherent randomness in production due to variations in weather and other conditions. Due to such unpredictability, this study uses the parametric stochastic approach to estimate the technical efficiency of farms. This contrasts with typical econometric approaches that fit a function through the data assuming a normal error distribution, and with nonparametric or deterministic econometric frontier approaches that limit statistical inference (Paul et al., 2000).

For representation of efficiency and its determinants, this paper uses a model that estimates the deviations of farms from a production function and the determinants of these deviations. Direct payment is used as an independent variable in explaining the efficiency scores from the frontier. Instead of the commonly used multi-stage estimation technique (e.g., Wan, 1992), the simultaneous estimation procedure of Battese and Coelli (1995) is employed. This procedure yields efficient and consistent parameter estimates for the production function as well as the function relating technical efficiency to its determinants.

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2 Since our panel data do not include prices, productivity efficiency is measured using a primal method that does not require price data. Thus, productive efficiency can be also called as technical efficiency in this study. Technical efficiency is a purely physical notion that can be measured without price information and without having to impose a behavioral objective function on producers. Cost, revenue, and profit efficiency, however, are economic concepts whose measurement requires both price information and the imposition of an appropriate behavioral objective function on producers (Kumbhakar and Lovell, 2000).

3 Farrell (1957) introduced the concept of frontier or “best practice” production function, which defines the maximum output attainable from a given vector of measured inputs, for a set of observations.

As an initial step to formulate the parametric approach, denote production technology with the following function:

(1) $y = f(x)\exp(-u)$,

where f(x) is a production frontier and exp(-u) is the value of the output distance function that is less than or equal to one. Thus, exp(-u) is often represented as the technical inefficiency score, i.e., the inefficiency of transforming inputs into output. Variations of technical efficiency are further assumed to correlate with explanatory variables associated with the technical efficiency effects. For this purpose, the distribution for the technical efficiency term is modeled as a linear function of a set of explanatory variables.

IV. DATA AND VARIABLES

This study relies primarily upon farm-level data containing statistics associated with the special rice farmer survey administered by the Korea National Statistical Office. The survey is based on 1,209 randomly selected farms and collects rice specific production data and income support direct payments in 2006[4].

Our data set is comprised of one output and four inputs. The output of rice is unhusked rice measured in kilogram. The inputs are land, labor, capital, and other inputs[5]. Land and labor are measured by quantities. Land is planted area measured by hectare. Labor is hours spent on farm work and includes both family labor and hired labor. Capital and other inputs are measured in value terms by won. Capital includes the average estimated replacement cost of structures, machinery depreciation, repairs, and leased farm equipment. Other inputs include expenditures on fertilizers, pesticides, fuel, electricity, seeds, and

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4 The data used in this paper exclude Jeju; less than one percent of farms in Jeju province - 0.007% - produce rice.

5 The data collected on some inputs are in value terms rather than quantities. When input prices vary systematically over the period (changing in real terms) and across space, the data in value terms will systematically bias the estimation results due to inflation and quality differences (Kwon and Lee, 2004).

miscellaneous operating expenses. National level input-specific deflators rescale inputs in value terms. Through these processes, inputs become implicit quantities.

Descriptive statistics for the output and four inputs are summarized in Table 4, representing mean per farm household. The data confirm that rice farms in Korea are small, with an average landholding of 1.20 hectares per farm in the sample. The average farm is run by a part-time operator with about 1,000 total hours of labor used, including both family and hired labor.

TABLE 4. Summary Statistics of Output and Inputs

Variable	Rice (kg)	Land (ha)	Labor (hour)	Capital (1,000 won)	Other inputs (1,000 won)
Mean	13,894.3 (16,882)	1.20 (1.32)	1,324.2 (1,367)	883.7 (1,422)	882.9 (1,208)

Note: Standard deviations are in parentheses.

Our data represent only the amounts of agricultural subsidies including both income support direct payment and other input subsidies. Even though our data cannot exactly divide the subsidies into income support direct payments and others, we regard the variable as direct payments because most government supports for rice farms are well-known as income support direct payments. The summary statistics for Tables 5 provide that the average direct payments tend to rise as farm size gets larger. This evidence results from the fact that fixed direct payments for Korean rice farms are tied to the amount of a farm's crop-land that has been enrolled in programs, as well as yield histories.

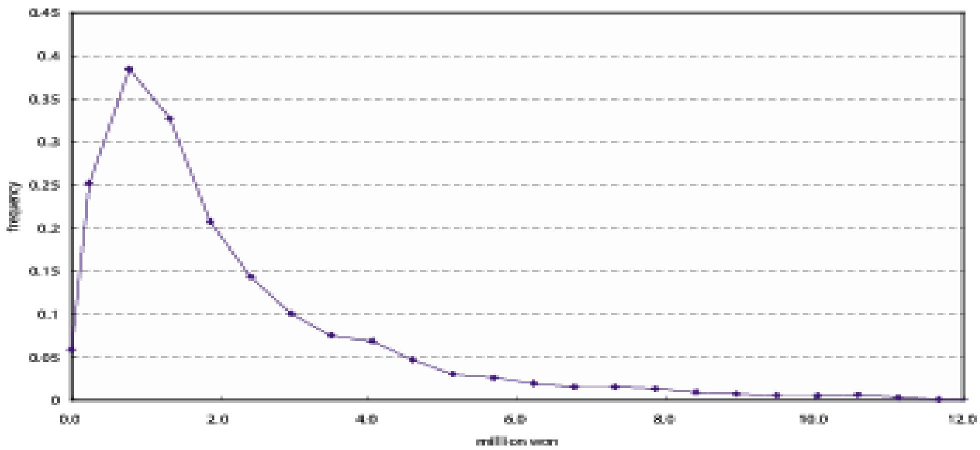
TABLE 5. Summary statistics of rice income support direct payments for rice farms

Unit: million won

Variable	Obs.	Mean	Std. Dev.
Total	1,209	1.90	2.11
Below 0.5ha	365	0.70	1.02
0.5-1.0ha	376	1.38	1.36
1.0-1.5ha	174	1.85	0.82
1.5-2.0ha	111	2.92	1.77
2.0-3.0ha	93	3.46	1.56
3.0-5.0ha	62	5.12	1.86
Above 5.0ha	28	8.72	4.23

The distribution obtained by nonparametric kernel density is skewed towards the left, indicating the presence of a large proportion of small direct payments and a smaller proportion of large direct payments[6].

FIGURE 4. Kernel densities for income support direct payments



To investigate the inequality of the direct payments by the direct payment types across rice farms, Gini coefficients by two types of the direct payment and contributions of each type on inequality are presented in Table 6.

The most widely used summary measure of the degree of inequality in income support direct payment distribution is the Gini coefficient. It represents an overall measure of the cumulative direct payment share against the share in

TABLE 6. Gini Decomposition by types of income support direct payments

Source	Share of each type in total direct payments	Gini coefficient	Share of each type in total inequality
Variable direct payments	0.467	0.534	0.465
Fixed direct payments	0.533	0.531	0.535
Total direct payments	1	0.500	1

6 The distributions obtained by nonparametric kernel densities do not require arbitrary size class distinctions, as histograms do. Also, the estimators “let the data speak” and ensure robustness of the results against possible misspecification. The flexibility in the estimates facilitates identification of salient distribution features.

the population. The Gini Coefficient ranges from 0 to 1, 0 representing perfect equality and 1 total inequality.

The shares of variable and fixed direct payments in total direct payments are 0.467 and 0.533, respectively, which represent that the share of fixed direct payments is larger.

The Gini coefficients for two types of direct payments indicate that both of them reveal unequal distributions. The inequality of fixed direct payments is especially more serious, indicating a higher share of fixed direct payments in total inequality.

V. EMPIRICAL IMPLEMENTATION

For empirical implementation, a functional form for the stochastic production function has to be chosen first. This study employs the translog functional form that has been adopted widely in frontier studies (Lovell et al., 1994; Grosskopf et al., 1997; Paul et al., 2000; Brmmer et al., 2002). The translog function allows for a variety of possible production relationships including nonconstant returns to scale, nonhomothetic production, and nonconstant elasticities of inputs.

A translog stochastic production function with one output and four inputs is specified as:

$$(2) \quad \ln y^i = \alpha_0 + \sum_n \alpha_n \ln x_n^i + \frac{1}{2}\sum_n \sum_{n'} \beta_{nn'} \ln x_n^i \ln x_{n'}^i + v^i - u^i$$

where $\beta_{nn'} = \beta_{n'n}$, v^i is the two-sided noise component following an *iid* normal distribution of zero mean and variance of σ_v^2, and u^i represents the technical (in)efficiency of the i*th* producer. u^i (intended to capture technical efficiency in output) are assumed to be non-negative, independently distributed as truncations at zero of the $N(\omega_i, \sigma_u^2)$, where $\omega_i = \varphi' K_i$, K_i is a vector of determinants of an individual farm's efficiency, and φ is a vector of parameters to be estimated (Battese and Coelli, 1995). Thus the means may be different for different farms but the variances are assumed to be the identical.

Having specified the production frontier, attention is now turned to factors influencing technical efficiency, K_i. Variations in the mean of technical efficiency ω_i are assumed to correlate with relevant explanatory variables as[7]

$$(3)\quad \omega_i = \varphi_0 + \varphi_1 Size_i + \varphi_2 Age_i + \varphi_3 Edu_i + \varphi_3 Dpayment_i + \varphi_3 Fpayment_i + \varphi_r D_{rent} + \varphi_f D_{full},$$

where $Size_{it}$ is farm size measured by paddy operated, and Age_i and Edu_i are farm operator's years of age and education[8]. $Dpayment_i$ is income support direct payments expressed as a share of the farm revenue, and $Fpayment_i$ is an interaction term of direct payment share and farm size. Here, income support direct payments for rice farms consist of two types of direct payments, i.e., fixed and variable direct payments. Land rental dummies D_{rent} represent whether farm has land rented, and dummies D_{full} represent whether farm operator is a full-time farmer. The parameter vector φ indicates the impact of variables in K_i on technical efficiency.

Combining equations (2) and (3) yields a single-stage production frontier model as,

$$(4)\quad \ln y_i = TL(x_i, \alpha, \beta) + v_i - u_i, \text{ and } u_i = \varphi' K_i + \mu_i,$$

where μ_i are assumed to be independently distributed, obtained by truncation of the normal distribution with mean zero and unknown variance, σ^2, such that u_i is non-negative (i.e., $\mu_i \geq -\varphi' K_i$).

The parameters of the frontier production function are simultaneously estimated with those of the efficiency model, in which the technical efficiency effects are specified as a function of relevant variables. In other word, determinants of technical efficiency are incorporated in an one-step model estimated with the stochastic production frontier function by maximum likelihood. Producer-specific estimates of technical inefficiency are then given by $\exp\{-\hat{u}_i\}$.

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7 In most empirical studies, conventional inputs such as land, labor and capital or their equivalents are usually included in the production function, with other variables to be included in the efficiency function (Tian and Wan, 2000).

8 The farm size variable is both an input in the frontier production function and a factor associated with technical efficiency. A large number of studies use the same variable in the production function and in the efficiency model (e.g., Huang and Liu, 1994; Coelli and Battese, 1996; Battese and Broca, 1997).

VI. ESTIMATION RESULTS

This section first considers the preliminary step by presenting the results of the estimation of the rice production frontier, and then technical efficiency effects are discussed.

About 70 percent of the parameters in the frontier function are statistically significant at ten percent or lower level in Table 7. The wald-chi square test for significance of the regression rejects the null hypothesis that the coefficients of the explanatory variables are all zero at the one percent level. The variance parameter σ_u^2, which measures the relative importance of inefficiency, is statistically significant at the one percent level. The other variance parameter σ_v^2, which indicates inherent randomness in production due to variations in weather and other conditions, is statistically significant at the one percent level. Statically significant two variance parameters confirm the importance of using the stochastic frontier approach to estimate the technical (in)efficiency.

TABLE 7. Parameter Estimates of the Stochastic Distance Function

Variable		Estimate	Variable
Land	β_1	0.151	(0.0972)
Labor	β_2	0.593	(0.0980)*
Capital	β_3	-0.060	(0.0567)
Other	β_4	0.388	(0.0758)*
$(Land)^2$	β_{11}	0.288	(0.0209)*
(Land) × (Labor)	β_{12}	-0.109	(0.0154)*
(Land) × (Capital)	β_{13}	-0.006	(0.0101)*
(Land) × (Other)	β_{14}	-0.162	(0.0132)*
$(Labor)^2$	β_{22}	0.035	(0.0203)*
(Labor) × (Capital)	β_{23}	-0.016	(0.0090)**
(Labor) × (Other)	β_{24}	0.060	(0.0090)**
$(Capital)^2$	β_{33}	0.012	(0.0071)
(Capital) × (Other)	β_{34}	0.036	(0.0077)
$(Other)^2$	β_{44}	0.058	(0.0138)*
Variance parameters		0.039	(0.0020)*
		0.038	(0.0010)*
Log likelihood: 552.8			
Wald chi^2 (14): 20959.3*			

Note: *, **, and *** indicate significance at the 1%, 5% and 10% levels.

Table 8 displays regression results for the determinants of technical efficiency. The model for efficiency determinants is estimated with the production frontier simultaneously. Analysis concentrates on the impact of income support direct payment on technical efficiency in the context of rice production technology. We set two models according to the forms of the variable representing direct payment; one uses a share of direct payments in farm revenues, and the other uses the amount of direct payments themselves. The technical inefficiency scores, as measured relative to the technically efficient producers, are regressed against direct payments (or a share of direct payments), farm size, interaction of direct payment (or a share of direct payments) and farm size, farm operator's human capital variables such as years of age and education, land rental dummies, and full-time dummies.

The positive coefficient of farm size indicates that technical efficiency increases as farm size increases. If farm size rises by one hectare, the technical efficiency score increases by about 9 percent. Farm consolidation leads to improvement of technical efficiency considerably.

Human capital variables of farm operators are also important in explaining technical efficiency. Technical efficiency decreases as operator's age increases. Highly educated operators are more likely to improve technical efficiency. These results confirm that the positive role of human capital on technical efficiency, outlined in productivity theory, is consistent with Korean agriculture.

A positive coefficient on the dummy variable, representing whether farms rent land or not, indicates that farms with rented land are more efficient than those with owned land. This result may be interpreted as either farming based on renting is more efficient than farming own land or farmland on the rental market being, in general, of better quality than farmland not on the rental market. A positive coefficient of dummy representing whether a farmer is a full-time worker denotes that a full-time farmer has higher technical efficiency relative to a part-time farmer.

We find that income support payments expressed as a share of the farm revenue have a negative impact on technical efficiency. Farms that get a higher share of direct payments in farm revenue are less efficient than others. However, this inefficiency is reduced by increases in farm size, and this is evident from positive and significant coefficient on the cross product of direct payment share and farm size.

When the variable of a share of direct payment in farm revenue is substituted in the technical efficiency model II, the new result indicates that the farms that received greater direct payments on aggregate are more efficient than other farms. One part of rice direct payment, fixed payment, is tied to the amount of a farm's cropland that has been enrolled in programs, as well as yield histories. As a result, farms that operate larger farmland of rice generally receive higher payments. In our sample, farms with less than 2ha (84 percent of total farms) received 62 percent of the payments in 2006. But, farms with more than 2ha (15 percent of total farms) received 38 percent of the payments. Furthermore, this positive impact on efficiency falls with an increase in farm size, that is, farms with a larger farm size get smaller efficiency benefits from the extra amount of direct payments than farms with smaller farms.

TABLE 8. Regression Results For the Determinants of Technical efficiency

Explanatory variable	Model I	Model II
Share of direct payments	-0.0115 (0.0058)**	
Share of direct payments × farm size	7.80e-08 (3.15e-08)**	
Direct payments		0.0012 (0.0007)**
Direct payments × farm size		-1.97e-07 (-5.01e-08)*
Farm size	0.0898 (0.0447)**	
Operator age	-0.0078 (-0.0033)*	
Operator education	0.0098 (0.0055)***	
Rent	0.0197 (0.0123)***	
Full-time	0.0157 (0.0072)**	
Constant	0.9881 (0.3188)*	

Note: Standard errors are in parentheses. *, **, and *** indicate significance at the 1%, 5% and 10% levels.
The variable 'Rent' denotes a land rental dummy variable representing whether farms rent land or not. The variable 'Full-time' denotes farm operator's job status dummy variable representing whether operator is a full-time farmer or not.

VII. SUMMARY AND CONCLUSIONS

Despite the caution required in interpreting the results, we can draw some general conclusions about the impact of direct payments on Korean rice productive efficiency for the period examined. The results found that farms with a higher share of direct payments in the farm revenue exhibited lower productive efficiency and this inefficiency is reduced by increases in farm size, suggesting that the farms that have a strong dependence on direct payment in their farm income tend to be inefficient. However, larger farms with a higher direct payment share are more efficient than others, suggesting that direct payments help larger farms get closer to the frontier. On the other hand, we found that farms gaining greater direct payments are likely to be more efficient; however, this gain in efficiency decreases with the fall in farm size. The direct payment for Korean rice farms is tied to the amount of a farm's cropland that has been enrolled in programs; therefore, farms that operate larger farm size generally receive higher payments.

The empirical results indicate that income support direct payments help inefficient farms to stay in farming and, furthermore, suggest that the Korean rice industry can improve its technical efficiency and potential productivity by the exit of farms that get a higher share of direct payment in their farm revenue. The exit of inefficient farms will thus raise the average productivity of resources remaining in agriculture.

This paper also found that farmers with younger and higher schooling were more efficient than those with less human capital, implying that farmers with both less human capital and small farms are inefficient and will eventually exit the Korean agriculture sector.

REFERENCES

Adams, Gary, Westhoff, Patrick, Willott, Brian and Young, Robert E. II. 2001. "Do 'Decoupled' Payments Affect US Crop Area? Preliminary Evidence from 1997-2000." *American Journal of Agricultural Economics* 83(5).

Battese, G. E., and S. Broca. 1997. "Functional forms of stochastic frontier production functions and models for technical inefficiency effects: A comparative study for wheat farmers in Pakistan." *Journal of Productivity Analysis* 8(4): 395-414.

Battese G. E. and T. J. Coelli. 1995. “A model for technical inefficiency effects in a stochastic frontier production function for panel data.” *Empirical Economics* 20(2): 325-332.

Brmmer, B., T. Glauben and G. Thijssen. 2002. “Decomposition of productivity growth using distance functions: The case of dairy farms in three European countries.” *American Journal of Agricultural Economics* 84(3): 628-644.

Caves, D. W., L. R. Christensen and W. E. Diewert. 1982. “Multilateral comparisons of output, input and productivity, using superlative index numbers.” *Economic Journal* 92(365): 73-86.

Chau, N.H. and H. de Gorter. 2000. “Disentangling the Production and Export Consequences of Direct Farm Income Payments.” Paper presented at the American Agricultural Economics Association Annual Meeting, Tampa, Florida.

Coelli, T. J. and G. E. Battese. 1996. “Identification of factors which influence the technical inefficiency of Indian farmers.” *Australian Journal of Agricultural Economics* 40(2): 103-128.

Farrell, M. J. 1957. “The Measurement of Productive Efficiency.” Journal of the *Royal Statistical Society.* Series A. 120(3): 253-281.

Grosskopf, S., K. Hayes, L. Taylor and W. Weber. 1997. “Budget constrained frontier measures of fiscal equality and efficiency in schooling.” *The Review of Economics and Statistics* 79(1): 116-124.

Huang, C. J. and J. T. Liu. 1994. “Estimation of a non-neutral stochastic frontier production function.” *Journal of Productivity Analysis* 5(2): 171-180.

Kim, H. S. 1997. “Evaluation and policy tasks of large-scale farming.” Korean Rural Economics 20.

Kim, T. G. 2006. “Directions and tasks for Korean direct payment policy.” Seminar for National Budget Operational Plans.

Kwon, O. S. and H. O. Lee. 2004. “Productivity Improvement in Korean Rice Farming: Parametric and Nonparametric Analysis.” *Australian Journal of Agricultural and Resource Economics* 48(2): 323-346.

Kumbhakar, S. C. and C. A. K. Lovell. 2000. *Stochastic Frontier Analysis.* Cambridge University Press.

Lee, M. H. 2000. “Direct payment policies in Korean agriculture.” *Finance Forum.* Korea Institute of Public Finance.

Lee, J. H. 1998. *Transformation of Korean farm structure: From beginning to end.* Research series 21. Korea Rural Economic Institute.

Lee, T. H. 2002. “Risk managements of farm households and ways for income stabilization.” Korea Rural Economic Institute.

Lovell, C.A.K., S. Richardson, P. Travers and L. L. Wood. 1994. “Resources and functions: A new view of inequality in Australia.” in W. Eichhorn, eds., *Models and Measurement of Welfare and Inequality*: Berlin: Springer-Verlag Press.

Oh, N. W. and B. S. Kim. 2005. *The impact of direct payments on agriculture production and structural adjustments.* Korea Rural Economic Institute.

Page, J. M. 1984. "Firm size and technical efficiency." *Journal of Development Economics* 16(2): 129-152.

Park, D. G. et al. 2004. "Research for mind- and long-term direct payment policy." Korea Rural Economic Institute.

Paul, C. J. M., W. E. Johnston, and G. A. G. Frengley. 2000. "Efficiency in New Zealand sheep and beef farming: The impacts of regulatory reform." *The Review of Economics and Statistics* 82(2): 325-337.

Tian, W. and G. H. Wan. 2000. "Technical efficiency and its determinants in China's grain production." *Journal of Productivity Analysis* 13(2): 159-174.

Wan, G. H. 1992. "Production risk, technical efficiency and the theory of input demand and output supply: An alternative frontier production function." Paper presented at the 36th Annual Conference of the Australian Agricultural Economists Society, Australia.