CHAPTER 5 RESULTS

5.1 Introduction

The OLS, Systems, CHTA, and CCTA estimators have been used to estimate the parameters of the area and yield equations. This chapter both reports results for wet-season and dry-season area and yield equations. Estimated short and long-run elasticities for area, yield and total output area also presented.

5.2 Area Equations

5.2.1 Area of Wet-Season Rice

Estimate parameters of the wet-season rice area equation are presented in Tables 5.1 and 5.2. The R-squared values are the same (0.96) for both the OLS and System estimators, while the CHTA and CCTA estimators yield a higher R-squared value (0.98). All methods provide similar results in terms of the expected signs, magnitudes and statistical significance of the estimated coefficients. The estimated coefficients of nearly half of the provincial dummy variables are statistically significant at the 5 per cent level, as are the coefficient of the lagged area and rainfall variables. The price variables are insignificant in both the pre- and post-1989 periods.

In Table 5.1 the estimates $\hat{\alpha}_0, \hat{\alpha}_2$ and $\hat{\alpha}_4$ are estimates of the intercept and price coefficients for the pre-1989 period. The t-ratios associated with these estimates suggest that these coefficients are not significantly different from zero. The estimates $\hat{\lambda}_1, \hat{\alpha}_3$ and $\hat{\alpha}_5$ are estimates of the differences in these coefficients between the pre-1989 and post-1989 periods, and the t-ratios associated with these estimates suggest that there are no statistically significant differences between these two periods.

Table 5. 1 Estimated Coefficients of Wet-season Rice Area Equation

Coefficient		Province	OLS	System	CHTA	CCTA
α_0	Constant		-1.77	-0.61	-0.73	-1.29
			(-0.28)	(-0.10)	(-0.43)	(-1.04)
λ_1	DT_{it}		1.37	0.22	1.77	4.18
			(0.23)	(0.04)	(1.09)	(1.12)
λ_{02}	Dum_{2t}	(Kandal)	2.77	2.79	-	-
			(0.55)	(0.55)		
λ_{03}	Dum_{3t}	(Kg. Cham)	21.00 **	20.97 **	-	-
			(3.43)	(3.43)		
λ_{04}	Dum_{4t}	(Svay Rieng)	21.45 **	21.42 **	-	-
			(3.64)	(3.64)		
λ_{05}	Dum_{5t}	(Prey Veng)	36.51 **	36.30 **	-	-
			(5.08)	(5.06)		
λ_{06}	Dum_{6t}	(Takeo)	24.57 **	24.41 **	-	-
			(4.08)	(4.06)		
λ_{07}	Dum_{7t}	(Kg. Thom)	15.40 **	15.40 **	-	-
			(2.63)	(2.74)		
λ_{08}	Dum_{8t}	(Siem Riep)	23.85 **	23.73 **	-	-
			(3.94)	(3.93)		
λ_{09}	Dum_{9t}	(Battambang)	43.40 **	43.09 **	-	-
			(5.41)	(5.39)		
λ_{10}	Dum_{10t}	(Pursat)	8.36	8.37	-	-
			(1.65)	(1.65)		
λ_{11}	Dum_{11t}	(Kg. Chhnang	5.45	5.52	-	-
			(1.05)	(1.07)		
λ_{12}	Dum_{12t}	(Kg. Som)	-7.64	-7.57	-	-
			(-1.12)	(-1.12)		
λ_{13}	Dum_{13t}	(Kom Pot)	13.18 *	13.24 *	-	-
			(2.31)	(2.33)		
λ_{14}	Dum_{14t}	(Koh Kong)	-8.44	-8.37	-	-
			(-1.24)	(-1.23)		
λ_{15}	Dum_{15t}	(Kg. Speu)	8.28	8.26	-	-
			(1.63)	(1.63)		
λ_{16}	Dum_{16t}	(Preah Vihea)	-4.64	-4.49	-	-
			(-0.89)	(-0.86)		
λ_{17}	Dum_{17t}	(Stung Treng)	-6.61	-6.41	-	-
			(-1.21)	(-1.18)		
λ_{18}	Dum_{18t}	(Ratanakiri)	-5.86	-5.67	-	-
			(-1.08)	(-1.04)		
λ_{19}	Dum_{19t}	(Mondulkiri)	-7.48	-7.27	-	-
			(-1.37)	(-1.33)		
λ_{20}	Dum_{20t}	(Kratie)	-4.65	-4.46	-	-
			(-0.85)	(-0.82)		
α_1	$A_{i,t-1}$		0.82 **	0.82 **	1.01 **	1.01 **
			(25.80)	(25.97)	(128.10)	(141.80)
α_2	$PRF_{i,t-1}$		3.04	3.55	-0.23	-2.23
			(0.28)	(0.33)	(-0.08)	(-0.89)
α_3	$DT_{it}PRF_{i,t-1}$		1.70	0.56	-1.58	3.64
			(0.15)	(0.05)	(-0.51)	(1.32)
α_4	$PMF_{i,t-1}$		-2.23	-2.39	-0.22	1.48
			(-0.44)	(-0.48)	(-0.17)	(1.19)
α_5	$DT_{it}PMF_{i,t-1}$		-0.06	-0.11	1.31	-1.60
			(-0.01)	(-0.02)	(0.92)	(-1.15)
α_6	$RP_{i,t-1}$		0.02 *	0.02 *	0.002	0.0002
			(1.78)	(1.69)	(0.57)	(-0.12)
α_7	$RP^2_{i,t-1}$		-1E-05 *	-1E-05	-1E-06	-2E-07
			(1.69)	(-1.59)	(-0.43)	(-0.16)
	R^2		0.957	0.957	0.981	0.985

Note: The numbers in parentheses are t-ratios. * =5% level and **=1 % level.

In addition, it is possible to obtain point estimates of the intercept and price coefficients in the post-1989 period as $(\hat{\alpha}_0 + \hat{\lambda}_1)$, $(\hat{\alpha}_2 + \hat{\alpha}_3)$ and $(\hat{\alpha}_4 + \hat{\alpha}_5)$. The variances can be calculated easily. For example, the variance of the intercept can be calculated as $Var(\hat{\alpha}_0 + \hat{\lambda}_1) = Var(\hat{\alpha}_0)$ + $Var(\hat{\lambda}_1) + 2Cov(\hat{\alpha}_0, \hat{\lambda}_1)$. The post-1989 estimates and their t-ratios are presented in Table 5.2. Again, the intercept and price coefficients are not significantly different from zero in the post-1989 period.

Only 8 out of 20 provincial dummy variable coefficients are statistically significant at 5 per cent levels. The constant term, which represents average area in Phnom Penh, is insignificant and has a negative sign. The significant provincial dummy variable coefficients represent the differences in average area between Phnom Penh and the provinces of Kompong Cham, Svay Rieng, Prey Veng, Takeo, Kompong Thom, Siem Riep, Battambang, Pursat, and Kompot, which are the largest rice producing provinces.

The estimated coefficient of lagged wet-season area $(\hat{\alpha}_1)$ is statistically significant at the 1 per cent level for all estimation methods (OLS, System, CHTA and CCTA). However, this coefficient is equal to $1-\gamma$, where γ is the coefficient of adjustment and should be less than 1. The OLS and System point estimates are less than one, but the CHTA and CCTA point estimates are theoretically implausible.

Because of the implausibility of the CHTA and CCTA estimates the remainder of this chapter tends to ignore them. Although the rest of the chapter will tend to focus on the OLS and Systems estimates, it still reports the CHTA and CCTA estimates for completeness, and to show that most of our results are robust to our assumptions concerning the intercept and error terms. In keeping with out new focus on the OLS and

Systems estimates, it is worth noting that the OLS and Systems estimates of the lagged area coefficient are 0.821 and 0.822 implying values of $\hat{\gamma}$ equal to 0.179 and 0.178. Thus the producers make area adjustments equivalent to about 18 per cent of the difference between planned area and last seasons actual area.

Table 5.2 Post-1989 Estimates of Intercept and Slope Coefficients

Coefficient	OLS	System	CHTA	CCTA
Intercept	-0.397	-0.389	1.683	-0.128
	(-0.07)	(-0.07)	(0.68)	(-0.11
$PRF_{i,t-1}$	4.735	4.114	-1.816	1.401
	(0.85)	(0.74)	(-1.27)	(1.20)
$PMF_{i,t-1}$	-2.281	-2.500	1.097	-0.118
	(-0.77)	(-0.85)	(1.43)	(-0.19)

Note : The numbers in parentheses are t-ratios.

The OLS and Systems estimates of the coefficients of the rice/fertiliser price ratio $(\hat{\alpha}_2 + \hat{\alpha}_3)$ are statistically insignificant but correctly signed. This shows that the rice/fertiliser price ratio has no significant effect on rice growers' decisions to allocate area for wet-season rice production. This result seems plausible in the case of Cambodian farmers because it is consistent with the notion that the major purpose of production is home consumption.

Likewise, the OLS and Systems estimates of the coefficients of maize/fertiliser price ratio $(\hat{\alpha}_4 + \hat{\alpha}_5)$ have expected signs in the pre-1989 and post-1989 periods, Tables 5.1 and 5.2. They are, however, not statistically significant, implying that they do not influence the allocation of area for wet-season rice production. These results confirm our prior expectation that wet-season maize is not an alternative crop for Cambodian rice farmers.

The OLS and Systems estimates of the coefficients of the rainfall variables $(\hat{\alpha}_6 + \hat{\alpha}_7)$ are statistically significant at the 5 per cent level (for a one-tailed test) and have expected signs. Thus there is evidence of diminishing marginal returns to rainfall during the planting period. The values of these coefficients are, however, small (0.024 and -0.00001) probably because rainfall was measured in millimetres (the absolute size of ht e estimates can depend on the units in which rainfall is measured. The statistical significance of the rainfall coefficients suggests that farmers base their area allocation decision for wet-season rice production on the previous year's rainfall. It is important to note, however, that these lags have been introduced by way of the partial adjustment hypothesis. The results suggest that rainfall during the planting period is one of the most important factors affecting the planned area allocation for wet-season rice production.

5.2.2 Area of Dry-Season Rice

The results for the dry-season rice area equation are listed in Tables 5.3 and 5.4. The OLS and Systems regressions provide the same value of R-squared (0.96) and yield similar estimates of the coefficients and their standard errors.

In Table 5.3 the OLS and Systems estimates of α_0, α_2 and α_4 are estimates of the intercept and price coefficients for the pre-1989 period. The t-ratios associated with these estimates suggest that these coefficients are statistically insignificant. The estimates λ_1, α_3 and α_5 are estimates of the differences in these coefficients between the pre-1989 and post-1989 periods, and the t-ratios associated with these estimates suggest that there are statistically significant differences between these two periods. Again, it is possible to obtain point estimates of the intercept and price coefficients in the post-1989 period as it was done in the pervious section.

Table 5. 3 Estimated Coefficients of Dry-season Rice Area Equation

Coefficient		Province	OLS	System	CHTA	CCTA
α_0	Constant		-0.59	-0.30	-0.59 *	-1.10 **
			(-0.59)	(-0.31)	(-2.49)	(-5.82)
λ_1	DT_{it}		1.38	1.27	0.63	1.06 **
			(1.17)	(1.09)	(1.77)	(3.72)
λ_{02}	Dum_{2t}	(Kandal)	2.76 *	3.13 *	-	-
			(2.08)	(2.38)		
λ_{03}	Dum_{3t}	(Kg. Cham)	1.94	2.09 *	-	-
			(1.87)	(2.03)		
λ_{04}	Dum_{4t}	(Svay Rieng)	0.37	0.32	-	-
			(0.37)	(0.32)		
λ_{05}	Dum_{5t}	(Prey Veng)	3.76 **	4.04 **	-	-
			(3.18)	(3.44)		
λ_{06}	Dum_{6t}	(Takeo)	3.71 **	4.11 **	-	-
			(2.71)	(3.03)		
λ_{07}	Dum_{7t}	(Kg. Thom)	-0.09	-0.13	-	-
			(-0.09)	(-0.13)		
λ_{08}	Dum_{8t}	(Siem Riep)	0.18	0.19	-	-
			(0.18)	(0.20)		
λ_{09}	Dum_{9t}	(Battambang)	-0.10	-0.15	-	-
			(-0.10)	(-0.15)		
λ_{10}	Dum_{10t}	(Pursat)	-0.23	-0.28	-	-
			(-0.23)	(-0.29)		
λ_{11}	Dum_{11t}	(Kg. Chhnang)	0.15	0.16	-	-
			(0.15)	(0.16)		
λ_{13}	Dum_{13t}	(Kom Pot)	-0.08	-0.13	-	-
			(-0.08)	(-0.13)		
λ_{15}	Dum_{15t}	(Kg. Speu)	-0.15	-0.20	-	-
			(-0.15)	(-0.21)		
λ_{20}	Dum_{20t}	(Kratie)	0.13	0.13	-	-
			(0.14)	(0.14)		
α_1	$A_{i,t-1}$		0.95 **	0.93 **	1.04 **	1.03 **
			(29.64)	(29.68)	(104.00)	(198.50)
α_2	$PRF_{i,t-1}$		-3.38	-3.50	-0.42	-1.75 **
			(-1.48)	(-1.55)	(-0.64)	(-3.18)
α_3	$DT_{it}PRF_{i,t-1}$		11.45 **	11.91 **	3.85 **	9.92 **
			(2.81)	(2.95)	(3.28)	(10.59)
α_4	$PMF_{i,t-1}$		1.46	1.45	0.22	1.08 **
			(1.33)	(1.33)	(0.76)	(4.16)
α_5	$DT_{it}PMF_{i,t-1}$		-7.40 *	-7.85 **	-2.58 **	-6.94 **
			(-2.49)	(-2.66)	(-3.11)	(-10.34)
	R^2		0.960	0.960	0.979	0.994

Notes: The numbers in parentheses are t-ratios.

* Significant at 5 per cent level.

** Significant at 1 per cent level.

The post-1989 estimates and their t-ratios are presented in Table 5.4. Again this table shows that OLS and Systems estimates of the intercept are not statistically significantly different from zero in the post-1989 period. Unlike the pre-1989 period, the estimated coefficients of the price variables in the post-1989 period are statistically different from zero and have the expected signs.

Only 4 estimated coefficients of the provincial dummy variables are statistically significant at the 1 per cent level (Table 5.3). The significant dummy variable coefficients are those representing Kandal, Kompong Cham, Prey Veng and Takeo, which have higher values (positive) than the intercept (Phnom Penh). It should be noted that large-scale areas have been allocated for dry-season rice production in these provinces, which lie close to the capital of Cambodia. Farmers in these provinces seem to get more assistance from both government and Non-Governmental Organizations (NGOs) than do other remote provinces. Moreover, these provinces have gained the attention of policy makers and have become a target for irrigation system development. Therefore, many agricultural projects have been developed in these provinces.

Both the OLS and Systems estimates of the coefficient of the lagged area variable (α_1) are statistically significant at the 1 per cent level and have the expected sign. The OLS estimate of this coefficient is 0.95 while the Systems estimate is 0.93. Again, the CHTA and CCTA estimations provide implausible estimate $(\hat{\alpha}_1 > 1)$. The estimated value of the lagged area coefficient implies an estimate for γ of 0.053 and 0.066 for the OLS and Systems regressions respectively. These results indicate that the existing dry-season areas are the most important factor influencing the area allocated to dry-season rice production. Farmers adjust only 5-6 per cent of their dry-season rice area in the short run, holding other factors constant. This seems to be the case for dry-season rice production in Cambodia because dry-season rice is mainly sown in the irrigation areas.

Even though the OLS and Systems regressions yield estimated coefficient of the rice to fertiliser price ratio during the first period (α_2) that is statistically insignificant and incorrectly signed, these estimated coefficient turns out to be significant at the 1 per cent level and correctly signed in the second period (Tables 5.3 and 5.4). The t-ratio shows that, after price deregulation and major policy changes, dry-season rice farmers have been responsive to the relative market prices of output and inputs. As the price ratio increases, perhaps due to an increase in the price of output while the input price is constant, or a decrease in the input price while the output price is constant, the area allocated to dry-season rice production increases.

Table 5.4 Post-1989 Estimates of Intercept and Slope Coefficients

Coefficient	OLS		System		CHTA		CCTA	
Intercept	0.788		0.969		0.045		-0.048	
	(0.75)		(0.92)		(0.17)		(-0.22)	
$PRF_{i,t-1}$	8.074	*	8.404	*	3.436	**	8.174	**
	(2.40)		(2.52)		(3.54)		(10.75)	
$PMF_{i,t-1}$	-5.944	*	-6.408	*	-2.359	**	-5.861	**
	(-2.16)		(-2.35)		(-3.02)		(-9.44)	

Note : The numbers in parentheses are t-ratios.
* Significant at 5 per cent level.
** Significant at 1 per cent level.

Similarly, the OLS and Systems estimated coefficients of the maize to fertiliser price ratio (α_3) are insignificant and incorrectly signed in the first period, but significant and correctly signed in the second period. The insignificance of the maize to fertiliser price ratio in the first period is evidence that maize did not compete for arable land in the dry season.

The negative estimated coefficients of the maize to fertiliser price ratio imply that when the price ratio increases the planned area devoted to rice decreases. Farmers who can do so switch to a more profitable alternative crop (maize) in the free market economy.

5.3 Yield Equations

5.3.1 Yield of Wet-Season Rice

The estimation results for the wet-season yield wet-season equation are presented in Tables 5.5 and 5.6. The R-squared values are only 0.46 for the OLS regression and 0.49 for the Systems regression. Most of the estimated slope coefficients are statistically insignificant.

In Table 5.5 the estimates $\hat{\delta}_0$ and $\hat{\delta}_1$ are estimates of the intercept and price coefficients for the pre-1989 period. All estimated price coefficients are statistically insignificant. The estimates $\hat{\omega}_1$ and $\hat{\delta}_2$ are estimates of the differences in these coefficients between the pre-1989 and post-1989 periods. The t-ratios associated with these estimates suggest that there is no statistically significant difference in average yield or the yield response to price changes between these two periods. Again, it is possible to obtain point estimates of the intercept and price coefficients in the post-1989 period. These estimates and their t-ratios are presented in Table 5.6. The results show that the estimated intercept is still significantly different from zero in the post-1989 period, whereas the estimated coefficient of the price ratio is not statistically different from zero. The OLS and Systems intercept estimates have the expected signs.

The estimated coefficients of 8 provincial dummy variables are also significantly different from zero at 5 per cent level.

Table 5. 5 Estimated Coefficients of Wet-season Rice Yield Equation

Coefficient		Province	OLS	System	CHTA	CCTA
δ_0	Constant		1.24 **	1.25 **	1.07 **	0.95 **
			(5.22)	(5.27)	(6.23)	(4.51)
ω_1	DT_{it}		0.01	-0.01	0.10	0.17
			(0.08)	(-0.05)	(0.93)	(1.39)
ω_{02}	Dum_{2t}	(Kandal)	0.24 **	0.24 **	-	-
			(3.15)	(3.13)		
ω_{03}	Dum_{3t}	(Kg. Cham)	0.04	0.03	-	-
			(0.45)	(0.44)		
ω_{04}	Dum_{4t}	(Svay Rieng)	-0.48 **	-0.48 **	-	-
			(-6.15)	(-6.18)		
ω_{05}	Dum_{5t}	(Prey Veng)	-0.26 **	-0.26 **	-	-
			(3.35)	(-3.35)		
ω_{06}	Dum_{6t}	(Takeo)	-0.20 *	-0.20 *	-	-
			(-2.53)	(-2.52)		
ω_{07}	Dum_{7t}	(Kg. Thom)	-0.33 **	-0.33 **	-	-
			(-4.33)	(-4.34)		
ω_{08}	Dum_{8t}	(Siem Riep)	-0.33 **	-0.33 **	-	-
			(-4.27)	(-4.26)		
ω_{09}	Dum_{9t}	(Battambang)	0.15	0.15	-	-
			(1.95)	(1.94)		
ω_{10}	Dum_{10t}	(Pursat)	-0.13	-0.13	-	-
			(-1.71)	(-1.71)		
ω_{11}	Dum_{11t}	(Kg. Chhnang)	-0.15	-0.15	-	-
			(-1.94)	(-1.94)		
ω_{12}	Dum_{12t}	(Kg. Som)	-0.04	0.05	-	-
			(-0.36)	(-0.45)		
ω_{13}	Dum_{13t}	(Kom Pot)	-0.15	-0.15	-	-
			(-1.88)	(-1.92)		
ω_{14}	Dum_{14t}	(Koh Kong)	-0.22 *	-0.23 *	-	-
			(-2.09)	(-2.19)		
ω_{15}	Dum_{15t}	(Kg. Speu)	-0.15	-0.14	-	-
			(-1.84)	(-1.83)		
ω_{16}	Dum_{16t}	(Preah Vihea)	0.15 *	0.15 *	-	-
			(2.00)	(1.98)		
ω_{17}	Dum_{17t}	(Stung Treng)	0.08	0.08	-	-
			(1.05)	(1.01)		
ω_{18}	Dum_{18t}	(Ratanakiri)	-0.09	-0.09	-	-
			(1.09)	(-1.13)		
ω_{19}	Dum_{19t}	(Mondulkiri)	-0.11	-0.11	-	-
			(-1.41)	(-1.44)		
ω_{20}	Dum_{20t}	(Kratie)	-0.56	-0.01	-	-
			(0.07)	(0.08)		
δ_1	PFR_{it}		-0.07	-0.06	-0.08	-0.05
			(-0.88)	(-0.83)	(-1.48)	(-0.79)
δ_2	$DT_{it}PFR_{it}$		0.02	0.01	0.07	0.09
			(0.26)	(0.17)	(1.22)	(1.27)
δ_3	T_{it}		0.02 *	0.02 *	0.02 **	0.03 **
			(2.20)	(2.11)	(2.97)	(3.02)
δ_4	RG_{it}		0.00	0.00	0.00	0.00
			(0.58)	(0.62)	(1.57)	(0.14)
δ_5	RG^2_{it}		-1.5E-08	-1.4E-08	-5.9E-08	1.9E-08
			(-0.18)	(-0.17)	(-1.30)	(0.35)
	R^2		0.464	0.464	0.162	0.126

Notes: The numbers in parentheses are t-ratios.

* Significant at 5 per cent level.

** Significant at 1 per cent level.

The significant coefficients of the dummy variables again represent the major rice producing provinces. The results show that there are differences between those provinces in the undefined factors influencing yield of wet-season rice.

The estimated coefficients of the fertiliser to rice price ratio $(\hat{\delta}_1)$ in both periods are insignificant but have the expected signs. The OLS estimates of these coefficients are -0.066 and -0.049 for the pre- and post-1989 periods, respectively. These results show that wet-season rice productivity is not influenced by price variables. In other words, farmers still do maintenance and harvest carefully, ignoring by price fluctuation in the markets.

Table 5.6 Post-1989 Estimates of Intercept and Slope Coefficient

Coefficient	OLS	System	CHTA	CCTA
Intercept	1.245 **	1.241 **	1.162 **	1.119 **
	(7.06)	(3.42)	(10.62)	(8.39)
$PFR_{i,t-1}$	-0.049	-0.051	-0.006	0.038
	(-0.89)	(-0.93)	(-0.13)	(0.66)

Note : The numbers in parentheses are t-ratios.

* Significant at 5 per cent level.

** Significant at 1 per cent level.

Interestingly, the estimated coefficient of the simple time trend variable (δ_3) which was introduced to represent technological and productivity improvements has the expected sign and is statistically significant at the 5 per cent level. The OLS and Systems estimates of this coefficient are similar (about 0.02). The positive response was expected, given the apparent adoptation of new technologies increasing fertiliser use and an increase in the use of high-yielding rice varieties.

Unfortunately, the estimated coefficients of the variables representing rainfall during the growing period are statistically insignificant, although they do have expected signs. The results seem to challenge the view that rainfall during the growing period, August-November, has an important influence on the productivity of wet-season rice. The unexpected insignificance of these rainfall variables could be due to the fact that the rainfall data are inaccurate.

5.3.2 Yield of Dry-Season Rice

The results for the estimations of the dry-season rice yield equation are presented in Tables 5.7 and 5.8. A reasonable number of estimated coefficients are statistically significant in each regression. As was the case with wet-season rice yield equation, the R-squared values for the dry-season rice yield equation are around 0.55 for the OLS and Systems regressions.

In Table 5.7 the estimates $\hat{\delta}_0$ and $\hat{\delta}_1$ are estimates of the intercept and price coefficients for the pre-1989 period. The t-ratios associated with the intercept estimates suggest that these coefficients are significantly different from zero, while the estimated price coefficients are statistically insignificant in all cases. The estimates $\hat{\omega}_1$ and $\hat{\delta}_2$ are estimates of the differences in these coefficients between the pre-1989 and post-1989 periods, and the t-ratios suggest that there is a statistically significant difference in the intercept between these two periods, but no difference in the price ratio coefficient. Again, it is possible to obtain point estimates of the intercept and prices coefficients in the post-1989 period and these are presented in Table 5.8. The results show that the intercept is significantly different from zero in the post-1989 period, but the coefficient of the price ratio is not.

Table 5. 7 Estimated Coefficients of Dry-season RiceYield Equation

Coefficient		Province	OLS	System	CHTA	CCTA
δ_0	Constant		1.10 **	1.22 **	0.70 **	0.68 **
			(2.74)	(3.05)	(2.13)	(3.04)
ω_1	DT_{it}		0.66 **	0.66 **	0.78 **	0.83 **
			(3.38)	(3.39)	(3.96)	(6.53)
ω_{02}	Dum_{2t}	(Kandal)	0.58 **	0.57 **	-	-
			(4.50)	(4.41)		
ω_{03}	Dum_{3t}	(Kg. Cham)	-0.24	-0.25	-	-
			(-1.85)	(-1.93)		
ω_{04}	Dum_{4t}	(Svay Rieng)	-0.36 **	-0.37 **	-	-
			(-2.79)	(-2.87)		
ω_{05}	Dum_{5t}	(Prey Veng)	0.12	0.11	-	-
			(0.95)	(0.87)		
ω_{06}	Dum_{6t}	(Takeo)	-0.12	-0.13	-	-
			(-0.95)	(-1.03)		
ω_{07}	Dum_{7t}	(Kg. Thom)	-0.18	-0.19	-	-
			(-1.42)	(-1.50)		
ω_{08}	Dum_{8t}	(Siem Riep)	-0.61 **	-0.62 **	-	-
			(-4.72)	(-4.79)		
ω_{09}	Dum_{9t}	(Battambang)	0.25 *	0.24 *	-	-
			(1.96)	(1.87)		
ω_{10}	Dum_{10t}	(Pursat)	-0.36 **	-0.37 **	-	-
			(-2.78)	(-2.86)		
ω_{11}	Dum_{11t}	(Kg. Chhnang	0.04	0.03	-	-
			(0.34)	(0.25)		
ω_{13}	Dum_{13t}	(Kom Pot)	-0.28 *	-0.29 *	-	-
			(-2.18)	(-2.26)		
ω_{15}	Dum_{15t}	(Kg. Speu)	-0.17	-0.18	-	-
			(-1.32)	(-1.40)		
ω_{20}	Dum_{20t}	(Kratie)	-0.07	-0.08	-	-
			(-0.56)	(-0.65)		
δ_1	PFR_{it}		-0.10	-0.26	-0.06	-0.07
			(-0.69)	(-1.14)	(-0.55)	(-0.85)
δ_2	$DT_{it}PFR_{it}$		0.18	0.23	0.26 *	0.27 **
			(1.41)	(1.84)	(2.21)	(3.52)
δ_3	T_{it}		0.10 **	0.09 **	0.11 **	0.11 **
			(4.94)	(4.60)	(6.31)	(9.20)
δ_4	R^2		0.534	0.534	0.336	0.557

Notes: The numbers in parentheses are t-ratios.

* Significant at 5 per cent level.

** Significant at 1 per cent level.

Table 5.8 Post-1989 Estimates of Intercept and Slope Coefficients

Coefficient	OLS		System		CHTA		CCTA	
Intercept	1.759	**	1.877	**	1.479	**	1.509	**
	(6.13)		(6.56)		(7.13)		(10.36)	
$PFR_{i,t-1}$	0.080		0.726		0.197		0.206	
	(0.81)		(0.72)		(2.18)		(3.38)	

Note : The numbers in parentheses are t-ratios.
* Significant at 5 per cent level.
** Significant at 1 per cent level.

The constant term, representing average dry-season yield in Phnom Penh, is significant at the 1 per cent level using both the OLS and Systems estimation methods. Seven provincial dummy variable coefficients are also statistically significant. Those provinces are Kandal, Kompong Cham, Svay Rieng, Siem Riep, Battambang, Pursat and Kom Pot. The results demonstrate that there are differences between the provinces in the factors influencing the average yield of dry-season rice.

The estimated coefficients of the fertiliser to rice price ratio ($\hat{\delta}_1$ and $\hat{\delta}_2$) are insignificant. The pre-1989 coefficient has the expected sign but the post-1989 coefficient period has an unexpected sign. However, the t-ratio is so small that the conclusion can be drawn that the slopes in both periods are the same.

The estimated coefficients of simple time trend representing technological and productivity improvement has the expected sign and is statistically significant at the 1 per cent level. This was expected, given that there was a change in the adoptation of new technology in dry-season rice production, increased fertiliser use and an increase in the use of high-yielding rice varieties.

5.4 Short-run Elasticities

Short-run elasticities, which are interpreted as estimates of the percentage change in area or yield resulting from a percentage change in the explanatory variables, while other factors are held constant, can be calculated as follows. If the equation (4.1) is lagged one time period we obtained

$$\begin{aligned} A_{i,t-1} &= \alpha_{0i} + \lambda_{01} DT_{i,t-1} + \alpha_1 A_{i,t-2} + \alpha_2 PRF_{i,t-2} + \alpha_3 DT_{i,t-1} PRF_{i,t-2} \\ &\quad + \alpha_4 PMF_{i,t-2} + \alpha_5 DT_{i,t-1} PMF_{i,t-2} + \alpha_6 RP_{i,t-2} + \alpha_7 RP_{i,t-2}^2 + e_{1i,t-1} \end{aligned} \tag{5.1}$$

This implies that equation (4.1) can be written as:

$$\begin{aligned} A_{it} &= \alpha_{0i} + \alpha_1 (\alpha_{0i} + \lambda_1 DT_{i,t-1} + \alpha_1 A_{i,t-2} + \alpha_2 PRF_{i,t-2} + \alpha_3 DT_{i,t-1} PRF_{i,t-2} \\ &\quad + \alpha_4 PMF_{i,t-2} + \alpha_5 DT_{i,t-1} PMF_{i,t-2} + \alpha_6 RP_{i,t-2} + \alpha_7 RP_{i,t-2}^2 + e_{1i,t-1}) \\ &\quad + \lambda_1 DT_{it} + \alpha_2 PRF_{i,t-1} + \alpha_3 DT_{it} PRF_{i,t-1} + \alpha_4 PMF_{i,t-1} + \alpha_5 DT_{it} PMF_{i,t-1} \\ &\quad + \alpha_6 RP_{i,t-1} + \alpha_7 RP_{i,t-1}^2 + e_{1it} \\ &= \alpha_{0i}(1 + \alpha_1) + \lambda_1 \left(DT_{it} + DT_{i,t-1}\alpha_1\right) + \alpha_1^2 A_{i,t-2} \\ &\quad + \alpha_2 \left(PRF_{i,t-1} + \alpha_1 PRF_{i,t-2}\right) + \alpha_3 \left(DT_{it} PRF_{i,t-1} + \alpha_1 DT_{i,t-1} PRF_{i,t-2}\right) \\ &\quad + \alpha_4 \left(PMF_{i,t-1} + \alpha_1 PMF_{i,t-2}\right) + \alpha_5 \left(DT_{it} PMF_{i,t-1} + \alpha_1 DT_{i,t-1} PMF_{i,t-2}\right) \\ &\quad + \alpha_6 \left(RP_{i,t-1} + \alpha_1 RP_{i,t-2}\right) + \alpha_7 \left(RP_{i,t-1}^2 + \alpha_1 RP_{i,t-2}^2\right) + e_{1it} + \alpha_1 e_{1i,t-1} \end{aligned} \tag{5.2}$$

Repeating this process of recursive substitution results in:

$$\begin{aligned} A_{it} &= \alpha_0 \left(1 + \alpha_1 + \alpha_1^2 + \cdots + \alpha_1^{t-1}\right) + \lambda_1 DT_{it} \left(1 + \alpha_1^{t-1}\right) + \alpha_1^t A_{i0} \\ &\quad + \alpha_2 \left(PRF_{i,t-1} + \alpha_1 PRF_{i,t-2} + \cdots + \alpha_1^t PRF_{i0}\right) \\ &\quad + \alpha_3 \left(DT_{it} PRF_{t-1} + \alpha_1 DT_{i,t-1} PRF_{i,t-2} + \cdots + \alpha_1^t DT_{i1} PRF_{i0}\right) \\ &\quad + \alpha_4 \left(PMF_{i,t-1} + \alpha_1 PMF_{i,t-2} + \cdots + \alpha_1^t PMF_{i0}\right) \\ &\quad + \alpha_5 \left(DT_{it} PMF_{i,t-1} + \alpha_1 DT_{i,t-1} PMF_{i,t-2} + \cdots + \alpha_1^t DT_{i1} PMF_{i0}\right) \\ &\quad + \alpha_6 \left(RP_{i,t-1} + \alpha_1 RP_{i,t-2} + \cdots + \alpha_1^t RP_{i0}\right) \\ &\quad + \alpha_7 \left(RP_{i,t-1}^2 + \alpha_1 RP_{i,t-2}^2 + \cdots + \alpha_1^t RP_{i0}^2\right) \\ &\quad + \left(e_{1it} + \alpha_1 e_{1i,t-1} + \cdots + \alpha_1^{t-1} e_{1i1}\right) \end{aligned} \tag{5.3}$$

The impact effects of changes in exogenous variables on area are given by the derivatives of equation (5.3) with respect to PRF_{it}, PMF_{it} and RP_{it}:

$$\frac{\partial A_{it}}{\partial PRF_{it}} = \frac{\partial A_{it}}{\partial PMF_{it}} = \frac{\partial A_{it}}{\partial RP_{it}} = 0 \tag{5.4}$$

The lagged responses are:

$$\frac{\partial A_{it}}{\partial PRF_{i,t-j}} = \alpha_1^{j-1}\left(\alpha_2 + \alpha_3 DT_{i,t-j+1}\right) \qquad j = 1, 2, \ldots, \mathrm{k} \tag{5.5}$$

$$\frac{\partial A_{it}}{\partial PMF_{i,t-j}} = \alpha_1^{j-1}\left(\alpha_4 + \alpha_5 DT_{i,t-j+1}\right) \tag{5.6}$$

$$\frac{\partial A_{it}}{\partial RP_{i,t-j}} = \alpha_1^{j-1}\left(\alpha_6 + 2\alpha_7 RP_{i,t-j+1}\right) \tag{5.7}$$

In the case of the yield equation (4.2) the derivative of yield with respect to PRF_{it} and RG_{it} can be obtained as follows:

$$\begin{aligned}\frac{\partial Y_{it}}{\partial PRF_{it}} &= \frac{\partial Y_{it}}{\partial\left(1/PRF_{it}\right)} \\ &= \frac{\partial Y_{it}}{\partial PRF_{it}} \cdot \frac{\partial\left(1/PRF_{it}\right)}{\partial PRF_{it}} \\ &= -\left[\frac{\partial Y_{it}}{\partial PRF_{it}} \cdot \left(PRF_{it}\right)^2\right] \\ &= -\left(\delta_1 + \delta_2 DT_{it}\right) \cdot \left(PRF_{it}\right)^2\end{aligned} \tag{5.8}$$

$$\frac{\partial Y_{it}}{\partial RG_{it}} = \delta_4 + 2\delta_5 RG_{it} \tag{5.9}$$

The lagged yield effects are all zero because there are no lagged variables on the right hand side of equation (4.2).

Measures of the one period lagged effects of changes in the exogenous variables on areas and yields are elasticities which, for example, can be calculated (using equation 5.5):

$$\frac{\partial A_{it}}{\partial PRF_{i,t-1}} \cdot \frac{\overline{PRF}}{\overline{A}} = \left(\alpha_2 + \alpha_3 \overline{DT}\right) \cdot \frac{\overline{PRF}}{\overline{A}} \qquad (5.10)$$

Measures of the impact effects of changes in the exogenous variables on yields are elsticities of the type

$$\frac{\partial Y_{it}}{\partial PRF_{it}} \cdot \frac{\overline{PRF}}{\overline{Y}} = \left(\delta_4 + 2\delta_5 \overline{RG}\right) \cdot \frac{\overline{PRF}}{\overline{Y}} \qquad (5.11)$$

These so-called short-run elasticities can be evaluated at average pre-1989 or post-1989 values of the exogenous variables. These estimates are presented in Table 5.9. It is noticeable from Table 5.9 that no elasticities were calculated measuring the effects on dry-season area and yield of changes in rainfall variables because rainfall variables do not appear on the right hand side of these equations.

In general, the estimated short-run elasticities for wet-season rice reported in Table 5.9 have the expected signs. The short-run elasticities of wet-season rice area with respect to the rice/fertiliser price ratio are similar in both the pre- and post-1989 periods (about 0.04, using the OLS and Systems estimates) showing that a one per cent increase in the price ratio leads to a 0.04 per cent increase in the area allocated for wet-season rice. Moreover, the OLS and Systems estimates of the elasticities of wet-season rice area with respect to the maize to fertiliser price ratio are -0.05 in the pre-1989 period but increase to -0.03 in the post-1989 period. Finally, the OLS and Systems estimates of short-run elasticities with respect to rainfall during the planting period are approximately 0.11 for the period covered by the study (1980-1997).

Table 5.9 also reports estimate of short-run elasticities for dry-season rice area with respect to the price ratios of rice/fertiliser and maize/fertiliser. These short-run elasticities generally have opposite signs in the pre- and post-1989 periods implying that farmers did not respond to the state price system. These elasticities have the correct signs in the post-1989 period. The Systems estimates of the short-run elasticities of the dry-season rice area with respect to price ratios of rice/fertiliser and maize/fertiliser in the post-1989 period are 0.57 and -0.47.

Table 5.9 Short-run Elasticities[(a)]

Coefficient	Pre-1989				Post-1989			
	OLS	System	CHTA	CCTA	OLS	System	CHTA	CCTA
Wet-season rice area (one-period lagged effect)								
PRF	0.041	0.048	-0.003	-0.030	0.047	0.040	-0.018	0.014
PMF	-0.052	-0.056	-0.005	0.034	-0.031	-0.034	0.014	-0.002
RP	0.113	0.108	0.010	0.001	0.113	0.108	0.010	0.001
Dry-season rice area (one-period lagged effect)								
PRF	-0.330	-0.342	-0.040	-0.171	0.548	0.571	0.233	0.555
PMF	0.233	0.231	0.035	0.172	-0.439	-0.473	-0.174	-0.433
RP	-	-	-	-	-	-	-	-
Wet-season rice yield (impact effect)								
PRF	0.036	0.033	0.041	0.026	0.029	0.031	0.004	-0.023
RG	0.059	0.064	0.068	0.001	0.059	0.064	0.068	0.001
Dry-season rice yield (impact effect)								
PRF	0.033	0.055	0.020	0.023	-0.032	-0.028	-0.078	-0.082
RG	-	-	-	-	-	-	-	-

Note: (a) The elasticities with respect to rainfall variables are evaluated at average rainfall levels for the whole period 1980-1997.

The short-run elasticities of wet-season rice area with respect to price ratios of rice/fertiliser are slightly lower than those for the dry-season rice area. The OLS and Systems estimates of the short-run wet-season yield elasticities with respect to price are similar in both pre- and post-1989 periods (approximately 0.03). Moreover, the estimated elasticity of wet-season rice yield with respect to rainfall during the growing period is around 0.06.

Unlike the wet-season elasticities, the short-run elasticities of dry-season rice yield with respect to the price ratio have opposite signs in both pre- and post-1989 periods. It should be kept in mind that the coefficients used to construct these estimates are statistically insignificant. Time constraints prevented the estimation of standard errors for our elasticity estimates.

5.5 Long-run Elasticities

The longer-run effects of a sustained change in exogenous variables on area and yield can be obtained from equations (5.5) to (5.11). Thus, for example, the long-run effect on area of a sustained change in the rice/fertiliser price ratio is given by:

$$\frac{\partial A_t}{\partial PRF_{i,t-1}} + \frac{\partial A_t}{\partial PRF_{i,t-2}} + \cdots + \frac{\partial A_t}{\partial PRF_{i,t-k}} = \frac{(\alpha_2 + \alpha_3 DT_{it})}{1-\alpha_1} \tag{5.12}$$

In elasticity form, the long-run elasticity of wet-season rice area with respect to average price ratio of rice/fertiliser is calculated as:

$$\xi^{WA}_{PRF} = \left(\frac{\alpha_2 + \alpha_3 \overline{DT}}{1-\alpha_1}\right) \cdot \frac{\overline{PRF}}{\overline{A}} \tag{5.13}$$

Again the long-run elasticities of area with respect to the rice/fertiliser price ratio can be calculated at average pre- and post-1989 values. It is important to keep in mind that there are no yield effects in the long-run because there are no lagged variables on the right hand side of the yield equation. The estimated long-run area and yield elasticities are presented in Table (5.10). The long-run elasticities of wet-season and dry-season rice area have correct signs when constructed using OLS and Systems estimates, while they have opposite signs if the CHTA and CCTA estimates are used due to the fact that the estimated values of α_1 in these two regressions are greater than one, contradicting the economic theory. Hence, the results of the OLS and Systems estimates will be the focus of the following discussion.

Table 5.10 Long-run Elasticities[(a)]

Coefficient	Pre-1989				Post-1989			
	OLS	System	CHTA	CCTA	OLS	System	CHTA	CCTA
Wet-season rice area								
PRF	0.205	0.244	0.315	3.025	0.260	0.228	1.995	-1.539
PMF	-0.151	-0.282	0.502	-3.462	-0.172	-0.190	-1.651	0.179
RP	0.624	0.597	-1.144	-0.118	0.624	0.597	-1.144	-0.118
Dry-season rice area								
PRF	-5.500	-3.545	1.308	4.275	6.088	5.767	-5.825	-13.875
PMF	3.833	2.333	-1.162	4.300	-2.588	-4.777	4.350	10.825

Note: [(a)] The elasticities with respect to rainfall variables are calculated at average rainfall levels over the whole period, 1980-1997.

The long-run elasticities of wet-season rice area with respect to the rice to fertiliser and maize to fertiliser price ratios are only slightly different in the two periods, pre- and post-1989. The System results indicate that the long-run elasticity with respect to the rice/fertiliser price ratio is approximately 0.24 (inelastic) showing that sustained a one per cent change in the price ratio leads to a 0.24 per cent change in the wet-season rice area in the long run. The OLS estimate of the maize/fertiliser price elasticity is 0.15 with the more efficient Systems estimate is -0.28.

Unlike the long-run elasticities of wet-season area with respect to price ratios, those for dry-season rice are highly elastic. While the elasticities in the first period have incorrect signs (due to incorrectly signed estimated coefficients) they have correct signs in the second period. The Systems estimate of the long-run rice/fertiliser price elasticity is 5.8 and the estimate of the maize/fertiliser elasticity is -4.8.

Using equation (3.1), which states that output is the product of area and yield, the impact and lagged effects on total output of a change in the rice/fertiliser price ratio, for example, can be calculated as:

$$\begin{aligned} \frac{\partial Q_{it}}{\partial PRF_{it}} &= \frac{\partial A_{it}}{\partial PRF_{it}} \cdot Y_{it} + \frac{\partial Y_{it}}{\partial PRF_{it}} \cdot A_{it} \\ &= -\left(\delta_1 + \delta_2 DT_{it}\right) \cdot PRF_{it}^2 \cdot A_{it} \end{aligned} \tag{5.14}$$

$$\begin{aligned} \frac{\partial Q_{it}}{\partial PRF_{i,t-1}} &= \frac{\partial A_{it}}{\partial PRF_{i,t-1}} \cdot Y_{it} + \frac{\partial Y_{it}}{\partial PRF_{i,t-1}} \cdot A_{it} \\ &= \left(\alpha_2 + \alpha_3 DT_{i,t-1}\right) \cdot Y_{it} \end{aligned} \tag{5.15}$$

$$\begin{aligned} \frac{\partial Q_{it}}{\partial PRF_{i,t-2}} &= \frac{\partial A_{it}}{\partial PRF_{i,t-2}} \cdot Y_{it} + \frac{\partial Y_{it}}{\partial PRF_{i,t-2}} \cdot A_{it} \\ &= \left(\alpha_1 \alpha_2 + \alpha_1 \alpha_3 DT_{i,t-2}\right) \cdot Y_{it} \\ &\;\vdots \\ &\;\vdots \end{aligned} \tag{5.16}$$

and so on.

The long-term effect of a sustained change in this price ratio is the sum of these equations:

$$\frac{\partial Q_{it}}{\partial PRF_{it}} + \frac{\partial Q_{it}}{\partial PRF_{i,t-1}} + \cdots = \frac{\left(\alpha_2 + \alpha_3 DT_{it}\right)}{1-\alpha_1} \cdot Y_{it} - \left(\delta_1 + \delta_2 DT_{it}\right) \cdot PRF_{it}^2 \cdot A_{it} \tag{5.17}$$

In elasticity form, long-run effect on wet-season rice output of a change in the price ratio of rice to fertiliser is:

$$\begin{aligned} \xi_{PRF}^{WQ} &= \left\{ \frac{\alpha_2 + \alpha_3 \overline{DT}}{1-\alpha_1} \cdot \overline{Y} - \left(\delta_1 + \delta_2 \overline{DT}\right) \cdot \overline{PRF}^2 \cdot \overline{A} \right\} \cdot \frac{\overline{PRF}}{\overline{Q}} \\ &= \frac{\alpha_2 + \alpha_3 \overline{DT}}{1-\alpha_1} \cdot \frac{\overline{PRF}}{\overline{A}} - \left(\delta_1 + \delta_2 \overline{DT}\right) \cdot \overline{PRF}^2 \cdot \frac{\overline{PRF}}{\overline{Y}} \end{aligned} \tag{5.18}$$

Other long-run elasticities can be obtained the same way. Again, equation such as (5.14) can be evaluated using average values over the pre-1989 and post-1989 periods. The results are presented in Table (5.11). Moreover, the long-run elasticity of wet-season rice output with respect to the rice/fertiliser price ratio is inelastic. The OLS and Systems estimates are 0.24 and 0.28 in the first period, and 0.29 and 0.26 in the second.

Table 5.11 Long-run Elasticities of Rice Outputs

Coefficient	Pre-1989				Post-1989			
	OLS	System	CHTA	CCTA	OLS	System	CHTA	CCTA
Wet-season rice output								
PRF	0.241	0.277	0.356	3.051	0.289	0.259	-5.821	-1.562
Dry-season rice output								
PRF	-5.467	-3.490	1.328	4.298	6.056	5.739	-5.903	-13.957
Total output								
PRF	-0.608	-0.312	0.509	3.234	0.841	0.786	-5.432	-2.969

In contrast, the long-run elasticity of dry-season rice output with respect to the rice/fertiliser price ratio is highly elastic. The Systems estimates are -3.5 in the pre-1989 period and 5.7 in the post-1989 period. The sign reversal in post-1989 period brings this estimate into line with economic theory.

Finally, the long-run elasticities of total rice output can be calculated by assuming that total output equals the sum of wet-season rice output and dry-season rice output:

$$\begin{aligned} Q_{it}^{T} &= Q_{it}^{W} + Q_{it}^{D} \\ &= A_{it}^{W} \cdot Y_{it}^{W} + A_{it}^{D} \cdot Y_{it}^{D} \end{aligned} \qquad (5.19)$$

where superscripts *T*, *W* and *D* represent total, wet-season rice and dry-season rice, respectively.

The long-term effect on total quantity supplied of a sustained change in the rice/fertiliser price ratio, for example, can be calculated as:

$$\begin{aligned}\frac{\partial Q_{it}^{T}}{\partial PRF_{it}}+\frac{\partial Q_{it}^{T}}{\partial PRF_{i,t-1}}+\frac{\partial Q_{it}^{T}}{\partial PRF_{i,t-2}}+\cdots &= \frac{\partial Q_{it}^{W}}{\partial PRF_{it}}+\frac{\partial Q_{it}^{W}}{\partial PRF_{i,t-1}}+\cdots\\ &+\frac{\partial Q_{it}^{D}}{\partial PRF_{it}}+\frac{\partial Q_{it}^{D}}{\partial PRF_{i,t-1}}+\cdots\end{aligned} \tag{5.20}$$

The components on the right hand side of equation (5.16) are given by equation (5.17), implying

$$\begin{aligned}\frac{\partial Q_{it}^{T}}{\partial PRF_{it}}+\frac{\partial Q_{it}^{T}}{\partial PRF_{i,t-1}}+\cdots &= \frac{\left(\alpha_2^W+\alpha_3^W DT_{it}\right)}{1-\alpha_1^W}\cdot Y_{it}^W-\left(\delta_1^W+\delta_2^W DT_{it}\right)\cdot PRF_{it}^2\cdot A_{it}^W\\ &+\frac{\left(\alpha_2^D+\alpha_3^D DT_{it}\right)}{1-\alpha_1^D}\cdot Y_{it}^D-\left(\delta_1^D+\delta_2^D DT_{it}\right)\cdot PRF_{it}^2\cdot A_{it}^D\end{aligned} \tag{5.21}$$

Thus the elasticity of total quantity supplied with respect to the price ratio of rice to fertiliser can be written as:

$$\begin{aligned}\xi_{PRF}^{TQ} = &\left[\frac{\left(\alpha_2^W+\alpha_3^W\overline{DT}\right)}{1-\alpha_1^W}.\overline{Y}^W-\left(\delta_1^W+\delta_2^W\overline{DT}\right)\cdot\overline{PRF}^2\cdot\overline{A}^W\right]\cdot\frac{\overline{PRF}}{\overline{Q}^T}\\ +&\left[\frac{\left(\alpha_2^D+\alpha_3^D\overline{DT}\right)}{1-\alpha_1^D}\cdot\overline{Y}^D-\left(\delta_1^D+\delta_2^D\overline{DT}\right)\cdot\overline{PRF}^2\cdot\overline{A}^D\right]\cdot\frac{\overline{PRF}}{\overline{Q}^T}\end{aligned} \tag{5.22}$$

An alternative form of equation (5.22) is

$$\xi_{PRF}^{TQ} = \xi_{PRF}^{WQ}\left(\frac{\overline{A}^W\overline{Y}^W}{\overline{A}^W\overline{Y}^W+\overline{A}^D\overline{Y}^D}\right)+\xi_{PRF}^{DQ}\left(\frac{\overline{A}^D\overline{Y}^D}{\overline{A}^W\overline{Y}^W+\overline{A}^D\overline{Y}^D}\right) \tag{5.23}$$

which states that the total quantity elasticity is a weighted average of wet- and dry-season elasticities, with set- and dry-season quantities used as weights. The elasticities of the total output, equation (5.23), can be calculate at average values in the pre- and post-1989 periods and the results are presented in Table 5.10. The results show that during the planned economy, 1980-1989, farmers responded negatively to the changes in the price ratio of rice to fertiliser. This could be explained by the fact that even when the price ratio increased prices were still fixed at a level lower than free market prices.

After the major economic reforms in 1989, all output prices were deregulated and farmers were no longer forced to sell their products to the state. The elasticity of total rice output with respect to the rice/fertiliser price ratio is positive (0.84 and 0.78 using OLS and Systems estimates) in this period. This estimated long-run elasticity is inelastic. In other words, a one per cent change in the price ratio leads to a 0.8 per cent change in the total output of rice in Cambodia in the long-term when other factors influencing output are held constant.

5.6 Summary

This chapter reports and discusses several sets of estimates of the parameters of the yield and area equations described in Chapter 4. The CHTA and CCTA estimates of the adjustment coefficient in the area equations are theoretically implausible so the focus was on the OLS and Systems estimates. The Systems estimates are more efficient than the OLS estimates if the error terms in the area and yield equations are correlated.

The Systems results suggest that farmers make dry-season area decision on the basis of last season's area and, in the post-1989 period, the rice to fertiliser and maize to fertiliser price ratio's. Wet-season area decisions appear to be based on last season's area only. Yield levels appear not to be a function of prices or rainfall, but appear to be increasing over time. Short and long-run elasticity estimates are plausible. For example, the long-run elasticity which measures the effect of a change in the rice/fertiliser price ratio on total wet and dry-season rice output is estimated to be 0.786 in the post-1989 period. Some implications of these results will be discussed in the next chapter.

CHAPTER 6 POLICY IMPLICATIONS

6.1 Introduction

As the staple food for about 10 million Cambodians and the most important crop, rice production is a central concern of the Cambodian government. Since 1980, the Cambodian government has launched many government policies to increase production and, hence, achieve self-sufficiency in basic foodstuffs, especially for rice, and to improve rural welfare through export earnings. The major government policies relating to rice production in Cambodia have been a ceiling price policy (1980-1989), price deregulation and a fertiliser subsidy (post-1989).

Some policies, such as the ceiling price policy, have actually worked in the direction of impeding production in an attempt to keep rice prices low for consumers. Others, such as the fertiliser subsidy policy, have benefited rice producers and consumers but at a cost to the government.

Analyses of the effects of these policies require information about a number of key market parameters, of which the degree of supply response is one. Insofar as this study only produces evidence on supply response, it doesn't produce all the information required for the analysis of rice price policies. The purpose in this Chapter is merely to show how differing degrees of supply response influence policy outcomes. Full analyses of the policies will have to await further empirical information about market parameters.

6.2 Ceiling Price

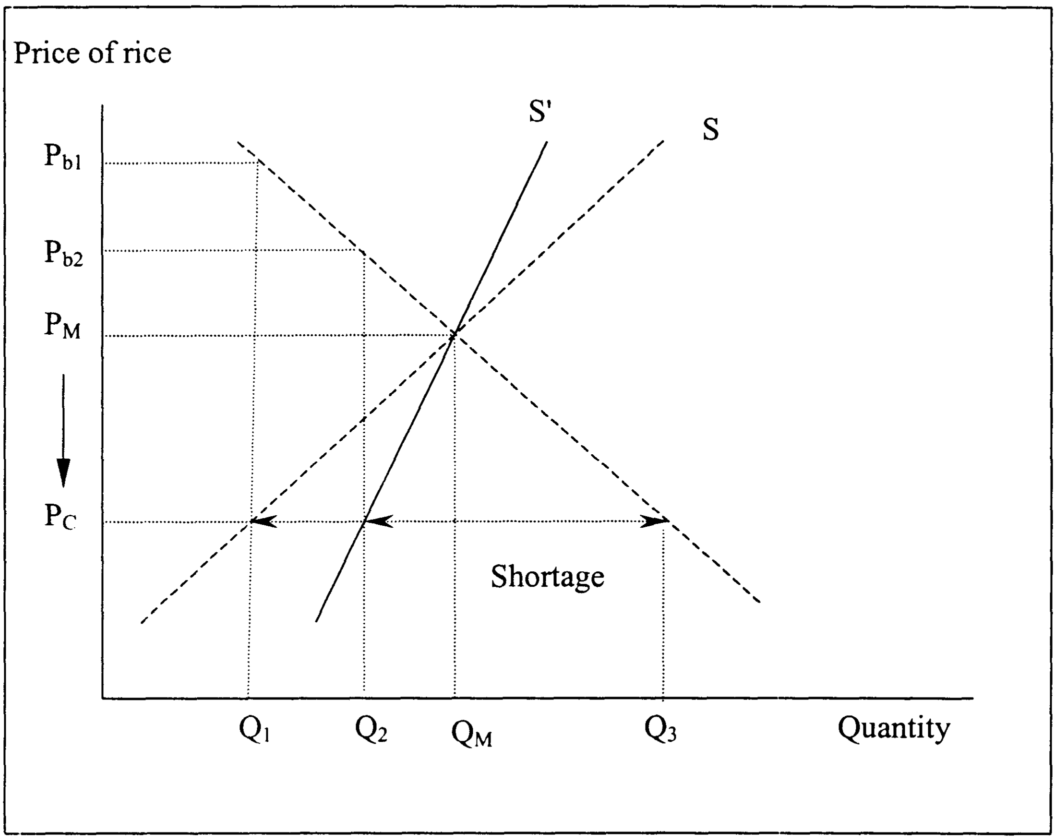
Ceiling price policies for basic foodstuffs have been implemented not only in Cambodia but also in other countries such as Tanzania, the former USSR, China and Burma. The policy was in action in Cambodia between 1980 and 1989. Under the ceiling price policy, the prices of rice and other agricultural commodities were fixed. Black market sales took place at prices higher than the official ceiling price. The ceiling for agricultural commodities were fixed, based on the calculation of production costs with a 20 per cent margin for farm profits. All the prices for production inputs were estimated using government prices, which were lower than market prices, so that the prices of outputs were set lower than the market rate.

The ceiling price policy was implemented in Cambodia under two main constraints. Firstly, the domestic market had been isolated from international markets by having trading relationships only with former communist countries. It was obvious that almost all non-communist countries had jointly isolated Cambodia due to the communist alienation. Most of the trade, business operations and assistance from non-communist countries were cut off and the Cambodian government was not recognised by the United Nations (UN). However, marginal trade and business activities with former communist countries occurred in the form of supports and exchange for goods and services.

Secondly, to ensure the procurement of rice output, the government forced peasants to sell their surpluses to the government in exchange for some goods, services and inputs when they were available. Furthermore, the movement of rice output was strictly controlled. Tickner (1996) argues that an authorisation was needed to transport a bucket of rice from one village to another.

The effects of the ceiling price policy are diagrammed in Figure 6.1. Suppose the government fixed the price of rice at the ceiling price, P_C, which is less than the market clearing price, P_M. The discrepancy between the ceiling price and the market clearing price discouraged many farmers from producing sufficient rice to satisfy domestic demand. Some simply stopped producing (Blaustein 1989, p. 227). Conceptually, the quantity of rice supplied was reduced to Q_1 and, hence, the shortage of rice was Q_1Q_3, the magnitude of this shortage depending upon the elasticity of the supply and demand curves.

Figure 6.1 Effects of Ceiling Price Policy



Source: Adapted from Samuelson et al., 1992, p. 104.

In this study it was found that supply is inelastic with respect to the rice-fertiliser price ratio. Given the functional form used, the degree of supply response with respect to the rice price is the same as the degree of response with respect to he rice-fertiliser price ratio. In Figure 6.1, Q_M is the quantity of rice bought and sold in the absence of the ceiling price policy. The excess demand for rice at the ceiling price level is due to two influences: a reduction in quantity supplied (compared to Q_M) and an increase in quantity demanded (compared to Q_M). The more inelastic the supply, the greater is the component due to the increase in quantity demanded. Perhaps more importantly, it can be seen that the reduction in producer surplus (for given values of P_M and P_C) is greater the more inelastic is supply.

Another effect of the degree of supply response on the outcome from a ceiling price policy can be seen from Figure 6.1. For a given demand function, the greater the degree of supply response, the greater is the black market price likely to be. In the limit, if all production is sold on the black market despite the government administrative controls, the black market price would be P_{b1} when the supply curve is given by S, and P_{b2} when the supply curve is given by S'. In reality, some rice would be sold at the ceiling price (and, perhaps, the same rice subsequently resold on the black market) and other rice would be sold directly to the black market at a price above P_C. Nevertheless, it should be clear from the diagram that the degree of supply response determines the extent of upward pressure on the price of illegally traded rice. The empirical findings in this study suggest that the upward pressure on black market prices as a result of the ceiling price policy may not have been all that great.

6.3 Fertiliser Subsidy

Fertiliser subsidies are one of the most popular forms of agricultural policies in developing countries (Ellis 1996). Many governments of third world nations, including Cambodia, still implement formal fertiliser subsidy schemes in the agricultural sector. Recent prices for subsidised fertiliser in Cambodia have been calculated based on 75 per cent of the free-on-board (f.o.b.) Japanese price. In addition, the prices of transportation and storage are added to the prices of fertilisers. Consequently, the prices of fertilisers are always 5-15 per cent lower than market prices[7].

The main objective of the fertiliser subsidy is to make the fertilisers affordable for farmers in order to encourage the use of fertilisers in production and, hence, increase output. Timmer and Falcon (1975) argue that an increase in output prices or, equivalently a decrease in fertiliser prices as a result of a fertiliser subsidy,

---

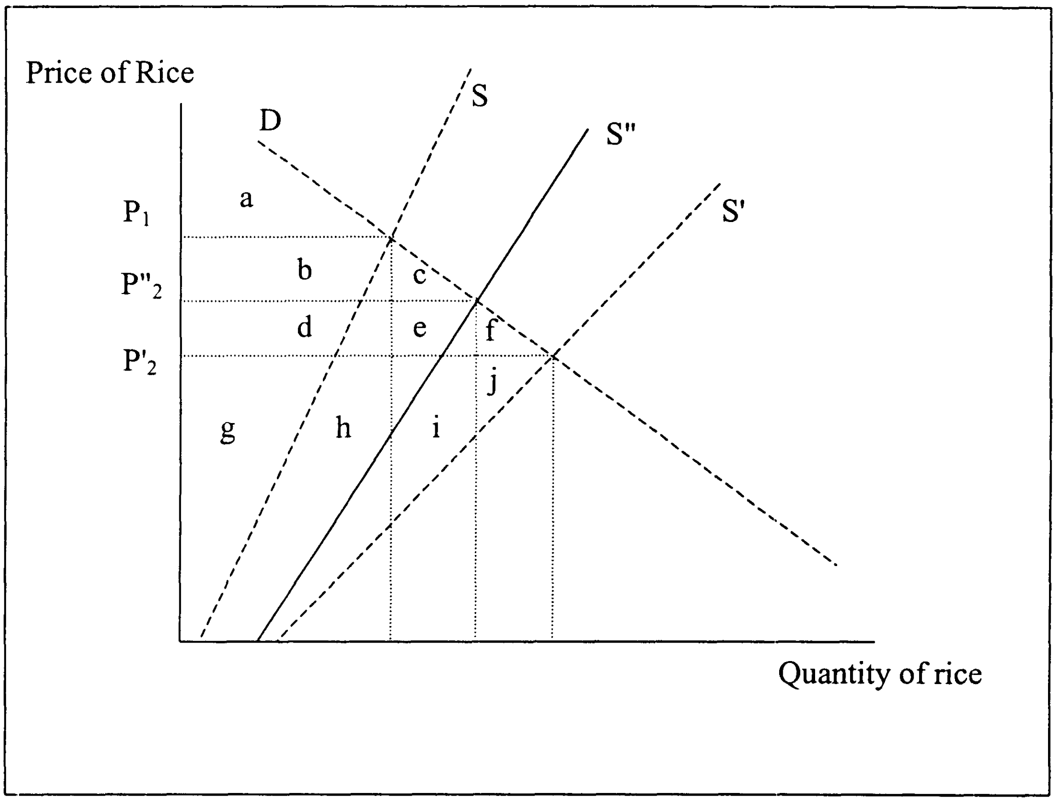
[7] This information was obtained from an interview with Mr. Kith Seng (currently Vice Director of the Department of Planning and Statistics, Ministry of Agriculture, Forestry and Fisheries) on 18th August 1998 during a field trip to Cambodia.

will bring about rapid agricultural development. Furthermore, Ellis (1996) adds that the main objective of governments in introducing fertiliser subsidies is to accelerate the adoption of new technology, especially fertiliser use. In other words, the government is mainly concerned with increasing agricultural output, rather than with income distribution or other social objectives.

The effectiveness of the fertiliser subsidy on the rice market is illustrated in Figure 6.2. A fertiliser subsidy decreases marginal costs of production, thereby shifting the supply curve to the right. The horizontal shift from S to S' measures the response of rice output to a fertiliser subsidy. For a given price of rice and fertiliser subsidy level, the greater is the elasticity of rice output with respect to the ratio of rice-to-fertiliser prices, the greater the horizontal shift in the rice supply function. In Figure 6.2, the shift of supply from S to S' represents a greater responsiveness of rice output to a given level of fertiliser subsidy than does the shift in supply from S to S".

The size of the shift in rice supply (as determined by the elasticity of rice output with respect to the rice-fertiliser price ratio) is crucial in determining the welfare effects in the *rice market* resulting from the fertiliser subsidy (there are also welfare effects in the fertiliser market). Because of the functional forms used in the models in this study, the rightward shift in the supply curve resulting from a fertiliser subsidy is not parallel but is divergent. As a result of the fertiliser subsidy, the increase in consumer surplus is equal to area (b+c) in the case of the less elastic supply response (S to S") and area (b+c+d+e+f) in the case of the more elastic supply response (S to S'). Producer surplus increases by area (e+h) minus area b in the case of the less elastic supply response, and by area (h+i+j) minus area (b+d) in the case of the more elastic supply response. Given the low value for rice supply response to the rice:fertiliser price ratio obtained in this study, these welfare effects may be relatively small when compared to, say, the government cost of the fertiliser subsidy. However, empirical evidence on other market parameter such as the price elasticity of rice demand is needed before stronger statement can be made.

Figure 6.2 Effects of Fertiliser Subsidy on Rice Market



6.4 Marketed Surplus of Rice Outputs

"Considerable debate about the sign and the magnitude of the price elasticity of the marketed surplus of a subsistence crop has occurred over many years. The elasticity is important because some current and proposed government interventions and policies may adversely affect the magnitude of the rural domestic food surpluses that are available to the urban areas and upon which the rate of overall economic development may be partially dependent" (Behrman 1968, pp. 185-186).

The marketed surplus of subsistence crop can be estimated using several obvious hypotheses (Lim 1975)[8]. As an example, it may be the case that subsistence farmers market only that proportion of their output necessary to fulfil cash requirements. They are most likely to be indebted because of social obligations, unexpected droughts and floods in the past, or input expenses. To pay off the debts, farmers have to sell some of their rice output. Additionally, Cambodian subsistence farmers tend to keep some of their output to ensure that there is enough for home consumption, seeds and feed requirements, and payments in kind. In accordance with this hypothesis, the quantity of rice marketed may actually vary inversely with the price of rice since a decrease in the price would necessitate a larger quantity of rice being marketed to obtain the same cash returns (Lim 1975).

The results from the current study allow some comments to be made about the marketed surplus for rice in Cambodia. The marketed surplus of rice production in Cambodia can be derived as:

$$MS = Q^T - H_d \tag{6.1}$$

where:

MS = marketed surplus,

Q^T = $A^W \cdot Y^W + A^D \cdot Y^D$ = quantity of rice produced in a year;

H_d = home demand for output;

Then

$$MS = \left(A^W \cdot Y^W + A^D \cdot Y^D\right) - H_d \tag{6.2}$$

---

[8] The brief discussions of the alternative hypotheses to test the marketed surplus of subsistent crops can be obtained from Lim, 1975, *Supply Responses of Primary Producers*, pp. 148-150.

Since the elasticity of supply with respect to the rice:fertiliser price ratio was already calculated in Chapter 5, the elasticity of the marketed surplus of rice can be written as:

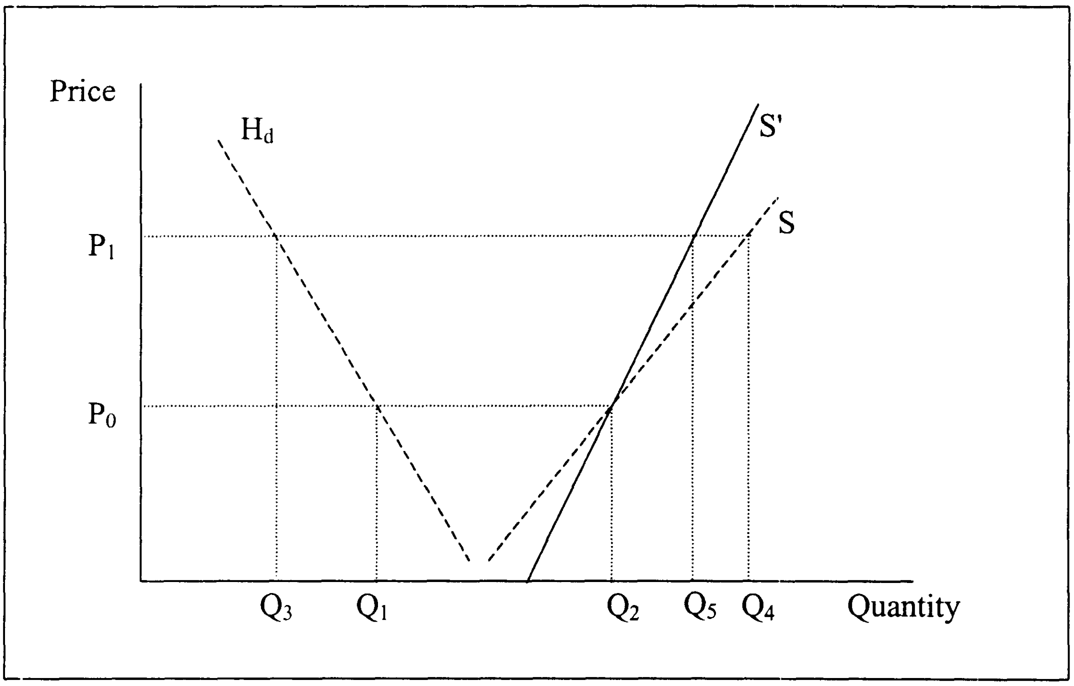
$$\frac{\partial MS}{\partial PRF}\cdot\frac{\overline{PRF}}{\overline{MS}} = \left[\xi^{WQ}_{PRF}\left(\frac{\overline{A}^{W}\cdot\overline{Y}^{W}}{\overline{A}^{W}\cdot\overline{Y}^{W}+\overline{A}^{D}\cdot\overline{Y}^{D}}\right) + \xi^{DQ}_{PRF}\cdot\left(\frac{\overline{A}^{D}\cdot\overline{Y}^{D}}{\overline{A}^{W}\cdot\overline{Y}^{W}+\overline{A}^{D}\cdot\overline{Y}^{D}}\right)\right] - \left[\left(\frac{\partial H_d}{\partial PRF}\cdot\frac{\overline{PRF}}{\overline{H_d}}\right)\cdot\left(\frac{\overline{H_d}}{\overline{MS}}\right)\right] \tag{6.3}$$

The elasticity cannot be estimated in this study since the elasticity of home demand is unknown. This study provides estimates of only the elasticity of supply and the elasticity of home demand is a subject of future study.

The impact of the degree of price responsiveness of rice output on marketed surplus if demonstrated in Figure 6.3. The supply function S shows how total rice output responds to rice prices and H_d is the home demand for rice on the part of rice producers. The marketed surplus at any price level is equal to the horizontal difference between S and H_d. Clearly, the marketed surplus is more responsive to price the greater is the price responsiveness of S. For example, if price increases from P_0 to P_1, marketed surplus increases less if the supply function is given by S' than it does when the supply function is given by S. The results from the study suggest that a positive price policy for rice (meaning a policy which increases the rice price received by farmers) may do little in the way of achieving self-sufficiency goals or greater rice surplus.

In Figure 6.3 it has been assumed that there is a home demand for rice which is negatively related to price. Given a positive response of rice output (or production) to prices, the marketed surplus (identically equal to the horizontal difference between output and home demand at any price level) is necessarily positively related to price. How then does one obtain a marketed surplus which responds negatively to price consistent with the hypothesis described earlier? One possibility would be if the response of output to price is sufficiently negative that the horizontal difference between the supply of output and home demand becomes smaller at high prices. This might be the case if Cambodian rice farmers are truly subsistence farmers who produce some rice beyond home consumption needs as a source of cash. However, the results of this study suggest that rice output does respond positively to price, albeit only a slight response.

Figure 6.3 Rice Marketed Surplus



Another possibility would be a home demand function which is positively slope. Krishna (1967) addresses the possibility in terms of the nature of substitution and income effects of rice changes.

5.6 Summary

This chapter has demonstrated how a knowledge of the price responsiveness of rice output can be used in policy analysis. While definitive answers to price policy questions would require knowledge of other market parameters, the degree of price responsiveness of rice output is clearly important in determining policy outcomes. The main generalisation that can be made based on the results of this study is that policies aimed at increasing the ratio of rice price to fertiliser prices may well be ineffective in achieving greater rice output and marketed surplus.