Appendix 1 Additional Information Related to Chapter 5

Table A1.1 Estimation of annual growth rates of PFPs of individual inputs of grain farms[a], 1976-1989

	Coefficients	Standard Error	t-Stat	P-value	Lower 95%	Upper 95%	Lower 95%	Upper 95%
Land:								
Intercept	6.40	0.14	44.452	0.000	6.090	6.717	6.090	6.717
T-variable	0.0531	0.0169	3.141	0.009	0.016	0.090	0.016	0.090
Labour:								
Intercept	5.5731	0.113	49.216	0.000	5.326	5.820	5.326	5.820
T-variable	0.0301	0.013	2.263	0.043	0.001	0.059	0.001	0.059
Fertiliser:								
Intercept	3.4690	0.177	19.594	0.000	3.083	3.855	3.083	3.855
T-variable	0.0121	0.021	0.584	0.570	-0.033	0.057	-0.033	0.057
Capital								
Intercept	1.3864	0.120	11.516	0.000	1.124	1.649	1.124	1.649
T-variable	0.0292	0.014	2.067	0.061	-0.002	0.060	-0.002	0.060
Other Cost								
Intercept	3.9212	0.116	33.700	0.000	3.668	4.175	3.668	4.175
T-variable	-0.0610	0.014	-4.465	0.001	-0.091	-0.031	-0.091	-0.031

[a] Coefficients of T-variables indicate the annual growth rates of PFPs of individual inputs.

Table A1.2 Regression statistics of annual growth rates of PFPs of individual inputs of grain farms, 1976-1989

	Multiple R	R-Square	Adjusted R-Square	Standard Error	Observations
Land	0.67	0.45	0.41	0.26	14
Labour	0.55	0.30	0.24	0.20	14
Fertiliser	0.17	0.03	-0.05	0.31	14
Capital	0.51	0.26	0.20	0.21	14
Other Cost	0.79	0.62	0.59	0.21	14

Table A1.3 Maximum-likelihood estimates for the parameters of the SFPFs with time-varying inefficiency effects for grain farms, translog form[i], 1976-1989

Variables		1976-1989
Constant	β_0	0.047
		(0.041)
Land	β_1	0.322
		(0.065)
Labour	β_2	0.22
		(0.39)
Fertiliser	β_3	0.0426
		(0.0301)
Capital	β_4	0.473
		(0.053)
Other costs	β_5	0.076
		(0.022)
Time	β_6	0.0264
		(0.0074)
$(\text{Land})^2$	β_7	0.0294
		(0.0101)
$(\text{Labour})^2$	β_8	0.010
		(0.012)
$(\text{Fert.})^2$	β_9	0.018
		(0.011)
$(\text{Capital})^2$	β_{10}	-0.020
		(0.054)
$(\text{Other costs})^2$	β_{11}	0.005
		(0.011)
$(\text{Time})^2$	β_{12}	0.0060
		(0.0013)
(Land x Labour)	β_{13}	0.149
		(0.059)
(Land x Fert.)	β_{14}	0.004
		(0.062)
(Land x Capital)	β_{15}	-0.066
		(0.067)
(Land x Other costs)	β_{16}	-0.025
		(0.039)
(Land x Time)	β_{17}	0.031
		(0.015)

(Labour x Fert.)	β_{18}	-0.056
		(0.033)
(Labour x Capital)	β_{19}	0.007
		(0.088)
(Labour x Other costs)	β_{20}	-0.022
		(0.024)
(Labour x Time)	β_{21}	0.0223
		(0.0099)
(Fert. x Capital)	β_{22}	0.025
		(0.058)
(Fert. x Other costs)	β_{23}	-0.025
		(0.017)
(Fert. x Time)	β_{24}	-0.0026
		(0.0066)
(Capital x Other costs)	β_{25}	0.034
		(0.043)
(Capital x Time)	β_{26}	-0.040
		(0.014)
(Other costs x Time)	β_{27}	0.0067
		(0.0059)
$\sigma^2_s = \sigma^2_v + \sigma^2$		0.77
		(0.26)
$\gamma = \sigma^2/\sigma^2_s$		0.830
		(0.056)
μ		-1.60
		(0.35)
η		-0.010
		(0.021)
Returns to scale		1.13

[a] Estimated standard errors are presented below the corresponding parameter estimates.

Chow test to establish the presence/absence of structural change in data sets: Grain farms

A Chow test was conducted to establish the presence of the structural change in the data the following way:

$$\chi 2 = -2 \times \{(Ln[L(Ho)]^1 + Ln[L(Ho)]^2 + Ln[L(Ho)]^3\} - Ln[L(Ho)]^T = -278.98$$

df= (No. of parameters x 2) = 60

where: $Ln[L(Ho)]^1$ log-likelihood function of the first sub-period (-35.40)
$Ln[L(Ho)]^2$ log-likelihood function of the second sub-period (-76.49)
$Ln[L(Ho)]^3$ log-likelihood function of the third sub-period (13.41)
$Ln[L(Ho)]^T$ log-likelihood function of the overall period (-237.97)
$\chi^2_{60,0.95} = 79.08$
As $\chi 2$- value > $\chi^2_{60,0.95}$ Ho: is rejected.

Hence, the result suggests that the three sub-periods divided according to five year plans are statistically preferred options against a single 14-year period.

Table A1.4 Maximum-likelihood estimates for the parameters of the SFPFs with time-varying inefficiency effects for grain farms under different functional forms[a], 1976-1980

Variables		Translog	Cobb-Douglas
Constant	β_0	0.40	0.46
		(0.13)	(0.23)
Land	β_1	0.20	0.306
		(0.11)	(0.087)
Labour	β_2	0 061	0.083
		(0 051)	(0.031)
Fertiliser	β_3	0 095	0.020
		(0 039)	(0.025)
Capital	β_4	0.64	0.635
		(0.10)	(0.092)
Other costs	β_5	0 014	0.046
		(0 030)	(0.027)
Time	β_6	-0.027	0.024
		(0 066)	(0.076)
(Land)^2	β_7	-0.46	-
		(0.15)	-
(Labour)^2	β_8	0 031	-
		(0 020)	-
(Fert.)^2	β_9	0 018	-
		(0 012)	-
(Capital)^2	β_{10}	0.27	-
		(0.20)	-
(Other costs)^2	β_{11}	0 018	-
		(0 013)	-
(Time)^2	β_{12}	0.0004	-
		(0.0231)	-
(Land x Labour)	β_{13}	0.16	-
		(0.13)	-
(Land x Fert.)	β_{14}	0.15	-
		(0.10)	-
(Land x Capital)	β_{15}	0.10	-
		(0.32)	-
(Land x Other costs)	β_{16}	0.212	-
		(0.060)	-
(Land x Time)	β_{17}	-0.314	-
		(0.078)	-
(Labour x Fert.)	β_{18}	-0.066	-

		(0.043)	-
(Labour x Capital)	β_{19}	-0.17	-
		(0.14)	-
(Labour x Other costs)	β_{20}	-0.016	-
		(0.030)	-
(Labour x Time)	β_{21}	0.066	-
		(0.045)	-
(Fert. x Capital)	β_{22}	-0.080	-
		(0.091)	-
(Fert. x Other costs)	β_{23}	-0.028	-
		(0.022)	-
(Fert. x Time)	β_{24}	0.0001	-
		(0.0256)	-
(Capital x Other costs)	β_{25}	-0.214	-
		(0 070)	-
(Capital x Time)	β_{26}	0 204	-
		(0 078)	-
(Other costs x Time)	β_{27}	0 023	-
		(.018)	-
$\sigma^2_s = \sigma^2_v + \sigma^2$		0 230	0.27
		(0 098)	(0.11)
$\gamma = \sigma^2/\sigma^2_s$		0.72	0.64
		(0.12)	(0.14)
μ		0.69	0.83
		(0.40)	(0.49)
η		-0.50	-0.41
		(0.13)	(0.11)
Returns to scale		1.01	1.09

[a] Estimated standard errors are presented below the corresponding parameter estimates

Table A1.5 Maximum-likelihood estimates for the parameters of the SFPFs with time-varying inefficiency effects for grain farms under different functional forms[a], 1981-1985

Variables		Translog	Cobb-Douglas
Constant	β_0	0.045	0.133
		(0.069)	(0.052)
Land	β_1	0.36	0.561
		(0.11)	(0.078)
Labour	β_2	0.427	0.378
		(0.077)	(0.074)
Fertiliser	β_3	-0.054	-0.032
		(0.053)	(0.046)
Capital	β_4	0.327	0.201
		(0.096)	(0.069)
Other costs	β_5	0.068	0.008
		(0.041)	(0.035)
Time	β_6	0.133	0.160
		(0.031)	(0.038)
(Land)$^{2)}$	β_7	-0.210	-
		(0.084)	-
(Labour)^2	β_8	0.169	-
		(0.072)	-
(Fert.)^2	β_9	-0.002	-
		(0.034)	-
(Capital)^2	β_{10}	-0.027	-
		(0.088)	-
(Other costs)^2	β_{11}	0.025	-
		(0.019)	-
(Time)^2	β_{12}	0.027	-
		(0.018)	-
(Land x Labour)	β_{13}	-0.09	-
		(0.18)	-
(Land x Fert.)	β_{14}	0.29	-
		(0.14)	-
(Land x Capital)	β_{15}	0.20	-
		(0.16)	-
(Land x Other costs)	β_{16}	-0.07	-
		(0.11)	-
(Land x Time)	β_{17}	0.210	-
		(0.083)	-

(Labour x Fert.)	β_{18}	-0.07	-
		(0.11)	-
(Labour x Capital)	β_{19}	0.08	-
		(0.17)	-
(Labour x Other costs)	β_{20}	-0.200	-
		(0.088)	-
(Labour x Time)	β_{21}	-0.109	-
		(0.063)	-
(Fert. x Capital)	β_{22}	-0.10	-
		(0.14)	-
(Fert. x Other costs)	β_{23}	-0.095	-
		(0.039)	-
(Fert. x Time)	β_{24}	0.010	-
		(0.038)	-
(Capital x Other costs)	β_{25}	0.176	-
		(0.089)	-
(Capital x Time)	β_{26}	-0.061	-
		(0.077)	-
(Other costs x Time)	β_{27}	-0.037	-
		(.024)	-
$\sigma^2_s = \sigma^2_v + \sigma^2$		0.56	0.54
		(0.22)	(0.28)
$\gamma = \sigma^2/\sigma^2_s$		0.792	0.68
		(0.098)	(0.18)
μ		-1.33	-1.21
		(0.52)	(0.86)
η		-0.27	-0.30
		(0.16)	(0.25)
Returns to scale		1.13	1.12

[a] Estimated standard errors are presented below the corresponding parameter estimates

Table A1.6 Maximum-likelihood estimates for the parameters of the SFPFs with time-varying inefficiency effects for grain farms under different functional forms[a], 1986-1989

Variables		Translog	Cobb-Douglas
Constant	β_0	0.32	0.191
		(0.23)	(0.041)
Land	β_1	0.329	0.397
		(0.088)	(0.061)
Labour	β_2	0.232	0.145
		(0.059)	(0.049)
Fertiliser	β_3	0.080	0.0240
		(0.040)	(0.0304)
Capital	β_4	0.415	0.430
		(0.076)	(0.056)
Other costs	β_5	0.054	0.085
		(0.027)	(0.023)
Time	β_6	-0.003	-0.033
		(0.063)	(0.024)
(Land)^2	β_7	-0.33	-
		(0.11)	-
(Labour)^2	β_8	-0.047	-
		(0.060)	-
(Fert.)^2	β_9	0.023	-
		(0.023)	-
(Capital)^2	β_{10}	-0.197	-
		(0.085)	-
(Other costs)^2	β_{11}	0.023	-
		(0.021)	-
(Time)^2	β_{12}	0.001	-
		(0.020)	-
(Land x Labour)	β_{13}	-0.23	-
		(0.11)	-
(Land x Fert.)	β_{14}	0.22	-
		(0.12)	-
(Land x Capital)	β_{15}	0.46	-
		(0.15)	-
(Land x Other costs)	β_{16}	0.047	-
		(0.072)	-
(Land x Time)	β_{17}	-0.042	-
		(0.066)	-

(Labour x Fert.)	β_{18}	0.09	-
		(0.11)	-
(Labour x Capital)	β_{19}	0.26	-
		(0.15)	-
(Labour x Other costs)	β_{20}	0.071	-
		(0.075)	-
(Labour x Time)	β_{21}	-0.111	-
		(0.058)	-
(Fert. x Capital)	β_{22}	-0.23	-
		(0.11)	-
(Fert. x Other costs)	β_{23}	-0.036	-
		(0.036)	-
(Fert. x Time)	β_{24}	0.021	-
		(0.031)	-
(Capital x Other costs)	β_{25}	-0.112	-
		(0.083)	-
(Capital x Time)	β_{26}	0.074	-
		(0.061)	-
(Other costs x Time)	β_{27}	-0.0004	-
		(.0227)	-
$\sigma^2_s = \sigma^2_v + \sigma^2$		0.049	0.122
		(0.012)	(0.034)
$\gamma = \sigma^2/\sigma^2_s$		0.26	0.61
		(0.16)	(0.12)
μ		0.23	-0.55
		(0.20)	(0.41)
η		0.18	0.411
		(0.12)	(0.083)
Returns to scale		1.11	1.08

[a] Estimated standard errors are presented below the corresponding parameter estimates

Table A1.7 Returns-to-scale statistics of grain farms, 1986-1989

Farms	No.	Returns to scale			
		1986	1987	1988	1989
Tuvshruuleh	1	1.182	1.272	1.076	1.095
Bayannuur	2	1.121	1.096	1.090	1.052
Ingettolgoi	3	1.001	1.027	1.006	1.063
Magsarjav	4	1.130	1.027	1.055	1.067
Onon	5	1.059	1.023	1.108	1.141
Halhgol	6	1.070	1.127	0.948	0.946
Herlen	7	1.056	1.200	1.153	1.263
Ereentsav	8	1.137	1.195	1.152	-
Harhorin	9	1.050	1.000	1.032	1.050
Tumentsogt	10	1.036	1.098	1.087	0.940
Altanbulag	11	1.073	1.127	1.021	0.631
Baruunharaa	12	0.917	1.134	1.038	0.923
Burgaltai	13	0.961	1.031	1.188	1.077
Yuruu	14	1.071	1.048	1.036	1.095
Zuunburen	15	1.144	1.073	1.105	1.150
Zuunharaa	16	1.072	1.143	1.158	1.107
Orhon	17	1.113	1.127	1.012	1.032
Orhontuul	18	1.127	1.190	1.213	1.133
Tsagaantolgoi	19	1.060	1.044	1.032	1.067
Zelter	20	1.081	0.962	1.016	0.851
Bayanharaat	21	1.105	1.075	1.163	1.010
Nomgon	22	1.097	1.173	1.119	1.065
Nairamdal	23	-	0.985	0.931	0.715
Enkhtal	24	0.608	1.264	1.097	1.147
Batsumber	25	1.158	1.109	1.066	1.020
Bayantsogt	26	1.057	1.027	0.991	1.019
Bornuur	27	1.177	1.231	1.107	1.105
Jargalant	28	1.108	1.029	1.040	0.987
Ugtaal	29	1.076	1.060	1.076	1.049
Oktyabr	30	1.109	1.099	1.093	1.165
Zaluuchuud	31	1.051	1.099	1.018	1.084
Bayanchandmana	32	1.123	0.882	1.131	1.111
Baruunturuun	33	1.076	0.956	0.991	1.034
Tarialan	34	1.043	1.040	1.020	1.050
Eguur	35	0.916	1.119	1.103	0.915
Hurh	36	1.054	1.060	1.098	0.980
Undurhaan	37	1.184	1.167	1.051	1.003
Chandgana	38	1.017	0.977	0.911	1.073
Darhan	39	-	-	-	1.162
Ulaantolgoi (ET)	40	1.249	-	-	0.759
mean		1.070	1.087	1.067	1.029
std. d		0.103	0.087	0.069	0.125
max		1.249	1.272	1.213	1.263
min		0.608	0.882	0.911	0.631

[a] The cells containing '-" indicate the missing observations where efficiency scores are not calculated.

Table A1.8 Efficiency scores of grain farms[a], 1976-1980

Farms	No.	Efficiency scores				
		1976	1977	1978	1979	1980
Tuvshruuleh	1	0.915	0.863	0.782	0.665	0.510
Baidrag	2	0.849	0.762	-	0.474	-
Ingettolgoi	3	0.988	0.980	0.967	0.947	0.913
Magsarjav	4	-	-	0.950	0.919	0.870
Onon	5	0.882	0.811	0.705	0.559	0.381
Halhgol	6	0.963	0.939	0.900	0.841	0.753
Herlen	7	0.853	0.767	0.643	0.479	0.295
Ereentsav	8	0.890	0.824	0.724	0.584	0.410
Harhorin	9	0.969	0.949	0.917	0.867	0.791
Tumentsogt	10	0.916	0.864	0.785	0.669	0.514
Altanbulag	11	0.904	0.844	0.754	0.626	0.461
Baruunharaa	12	0.914	0.860	0.778	0.660	0.503
Burgaltai	13	-	0.956	0.927	0.883	0.815
Yuruu	14	0.930	0.886	0.817	0.715	0.576
Zuunburen	15	0.955	0.926	0.880	0.810	0.707
Zuunharaa	16	0.976	0.960	0.935	0.895	0.834
Orhon	17	0.975	0.959	0.933	0.891	0.828
Orhontuul	18	0.967	0.946	0.911	0.858	0.777
Tsagaantolgoi	19	0.887	0.818	0.715	0.573	0.397
Zelter	20	0.971	0.953	0.923	0.876	0.805
Bayanharaat	21	-	0.856	0.772	0.651	0.492
Nomgon	22	-	0.836	0.743	0.610	0.441
Nairamdal	23	-	0.967	0.946	0.912	0.860
Batsumber	24	0.986	0.978	0.963	0.939	0.902
Bayantsogt	25	0.875	0.801	0.690	0.540	0.360
Bornuur	26	0.934	0.893	0.828	0.731	0.597
Jargalant	27	0.956	0.928	0.883	0.814	0.714
Ugtaal	28	0.890	0.823	0.722	0.582	0.408
Oktyabr	29	-	0.872	0.796	0.684	0.534
Zaluuchuud	30	-	0.916	0.864	0.785	0.671
Bayanchandmana	31	-	-	-	0.897	0.837
Baruunturuun	32	0.949	0.916	0.865	0.787	0.674
Tarialan	33	0.968	0.948	0.915	0.863	0.785
Undurhaan	34	0.970	0.950	0.919	0.869	0.794
Chandgana	35	-	-	0.832	0.737	0.605
Darhan	36	0.897	0.834	0.740	0.606	0.436
Ulaantolgoi (ET)	37	-	0.825	0.725	0.586	0.413
mean		0.931	0.889	0.833	0.740	0.630
std. d		0.042	0.064	0.093	0.142	0.186
max		0.988	0.980	0.967	0.947	0.913
min		0.849	0.762	0.643	0.474	0.295

[a] The cells containing "-" indicate the missing observations where efficiency scores are not calculated.

Table A1.9 Efficiency scores of grain farms[a], 1981-1985

Farm	No.	No. of observations	Efficiency scores
Tuvshruuleh	1	5	0.853
Baidrag	2	1	0.746
Ingettolgoi	3	5	0.840
Magsarjav	4	5	0.858
Onon	5	5	0.524
Halhgol	6	5	0.888
Herlen	7	5	0.639
Ereentsav	8	5	0.648
Harhorin	9	5	0.876
Tumentsogt	10	5	0.803
Altanbulag	11	5	0.875
Baruunharaa	12	5	0.910
Burgaltai	13	5	0.798
Yuruu	14	5	0.901
Zuunburen	15	5	0.885
Zuunharaa	16	5	0.903
Orhon	17	5	0.881
Orhontuul	18	5	0.913
Tsagaantolgoi	19	5	0.805
Zelter	20	5	0.898
Bayanharaat	21	5	0.868
Nomgon	22	5	0.819
Nairamdal	23	5	0.843
Batsumber	24	5	0.827
Bayantsogt	25	5	0.900
Bornuur	26	5	0.937
Jargalant	27	5	0.751
Ugtaal	28	5	0.748
Oktyabr	29	5	0.808
Zaluuchuud	30	5	0.790
Baruunturuun	31	5	0.871
Ulaantolgoi (Uvs)	32	3	0.879
Tarialan	33	5	0.841
Eguur	34	2	0.882
Hurh	35	4	0.780
Undurhaan	36	5	0.796
Chandgana	37	5	0.850
Darhan	38	5	0.763
Ulaantolgoi (ET)	39	5	0.936
mean			0.829
std. d			0.085
max			0.937
min			0.524

[a] The cells containing "-" indicate the missing observations where efficiency scores are not calculated.

Table A1.10 Efficiency scores of grain farms[a], 1986-1989

Farms	No.	Efficiency scores			
		1986	1987	1988	1989
Tuvshruuleh	1	0.709	0.754	0.794	0.827
Bayannuur	2	0.743	-	-	0.848
Ingettolgoi	3	0.859	0.883	0.902	0.919
Magsarjav	4	0.818	0.848	0.873	0.895
Onon	5	0.443	0.513	0.579	0.640
Halhgol	6	0.569	0.630	0.685	0.734
Herlen	7	0.490	0.558	0.620	0.676
Ereentsav	8	0.724	0.767	0.804	0.836
Harhorin	9	0.728	0.770	0.807	-
Tumentsogt	10	0.803	0.835	0.863	0.886
Altanbulag	11	0.818	0.848	0.874	0.895
Baruunharaa	12	0.904	0.920	0.934	0.945
Burgaltai	13	0.871	0.893	0.911	0.926
Yuruu	14	0.808	0.839	0.866	0.888
Zuunburen	15	0.703	0.749	0.789	0.823
Zuunharaa	16	0.766	0.804	0.836	0.863
Orhon	17	0.883	0.903	0.920	0.933
Orhontuul	18	0.929	0.942	0.952	0.960
Tsagaantolgoi	19	0.827	0.856	0.880	0.900
Zelter	20	0.918	0.932	0.944	0.954
Bayanharaat	21	0.746	0.786	0.821	0.850
Nomgon	22	0.794	0.828	0.856	0.880
Nairamdal	23	0.927	0.940	0.950	0.959
Enkhtal	24	-	0.769	0.806	0.838
Batsumber	25	0.824	0.853	0.877	0.898
Bayantsogt	26	0.683	0.731	0.774	0.810
Bornuur	27	0.848	0.874	0.895	0.913
Jargalant	28	0.718	0.762	0.800	0.833
Ugtaal	29	0.891	0.909	0.925	0.938
Oktyabr	30	0.540	0.603	0.661	0.712
Zaluuchuud	31	0.849	0.874	0.895	0.913
Bayanchandmana	32	-	-	-	0.937
Baruunturuun	33	0.635	0.689	0.737	0.779
Tarialan	34	0.926	0.939	0.949	0.958
Eguur	35	0.904	0.920	0.934	0.946
Hurh	36	0.727	0.769	0.807	0.838
Undurhaan	37	0.801	0.833	0.861	0.884
Chandgana	38	0.656	0.708	0.754	0.793
Darhan	39	0.800	0.832	0.860	0.884
Ulaantolgoi (ET)	40	0.947	0.956	0.964	0.970
mean		0.777	0.811	0.841	0.869
std. d		0.124	0.108	0.093	0.080
max		0.947	0.956	0.964	0.970
min		0.443	0.513	0.579	0.640

[a] The cells containing "-" indicate the missing observations where efficiency scores are not calculate l.

Table A1.11 Maximum-likelihood estimates for the parameters of the SFPFs for grain farms using Aigner *et al.* (1977) model[a], 1976-1989

Variables		1976-1989
Constant	β_0	0.469
		(0.028)
Land	β_1	0.339
		(0.058)
Labour	β_2	0.159
		(0.033)
Fertiliser	β_3	0.033
		(0.024)
Capital	β_4	0.4310
		(0.0501)
Other costs	β_5	0.106
		(0.017)
Time	β_6	-
		-
$(\text{Land})^2$	β_7	0.02084
		(0.00902)
$(\text{Labour})^2$	β_8	-0.001
		(0.013)
$(\text{Fert.})^2$	β_9	0.0081
		(0.0079)
$(\text{Capital})^2$	β_{10}	-0.078
		(0.056)
$(\text{Other costs})^2$	β_{11}	0.0117
		(0.0082)
$(\text{Time})^2$	β_{12}	-
		-
(Land x Labour)	β_{13}	0.1319
		(0.0504)
(Land x Fert.)	β_{14}	-0.043
		(0.059)
(Land x Capital)	β_{15}	-0.018
		(0.066)
(Land x Other costs)	β_{16}	-0.052
		(0.031)
(Land x Time)	β_{17}	-
		-
(Labour x Fert.)	β_{18}	-0.063
		(0.031)

(Labour x Capital)	β_{19}	0.080
		(0.077)
(Labour x Other costs)	β_{20}	-0.032
		(0.021)
(Labour x Time)	β_{21}	-
		-
(Fert. x Capital)	β_{22}	0.069
		(0.055)
(Fert. x Other costs)	β_{23}	-0.003
		(0.014)
(Fert. x Time)	β_{24}	-
		-
(Capital x Other costs)	β_{25}	0.022
		(0.036)
(Capital x Time)	β_{26}	-
		-
(Other costs x Time)	β_{27}	-
		-
$\sigma^2_s = \sigma^2_v + \sigma^2$		0.472
		(0.037)
$\gamma = \sigma^2/\sigma^2_s$		0.957
		(0.013)
Returns to scale		1.07

[a] Estimated standard errors are presented below the corresponding parameter estimates

Table A1.12 Efficiency sco·es of grain farms using Aigner *et al.* (1977) model, 1976-1989

1976-1980		1981-1985		1986-1989	
Year	Efficiency score	Year	Efficiency score	Year	Efficiency score
1976	0.644	1981	0.517	1986	0.665
1977	0.681	1982	0.579	1987	0.716
1978	0.585	1983	0.706	1988	0.728
1979	0.59	1984	0.602	1989	0.712
1980	0.419	1985	0.768		
mean	0.584		0.634		0.705
std. d	0.100		0.101		0.028
max	0.681		0.768		0.728
min	0.419		0.517		0.665

Table A1.13 Efficiency scores of grain farms[a], 1987-1989; (SFPF with technical inefficiency effects model)

Farms	No.	Efficiency scores		
		1987	1988	1989
Tuvshruuleh	1	0.941	0.792	0.946
Ingettolgoi	2	0.725	0.783	0.904
Magsarjav	3	0.998	0.969	0.874
Onon	4	0.573	0.558	0.384
Halhgol	5	0.612	0.980	0.906
Herlen	6	0.668	0.374	0.701
Ereentsav	7	0.982	0.930	0.962
Harhorin	8	0.762	0.502	-
Tumentsogt	9	0.995	0.885	0.948
Altanbulag	10	0.949	0.906	0.904
Baruunharaa	11	0.927	0.937	0.909
Burgaltai	12	0.938	0.838	0.534
Yuruu	13	0.999	0.417	0.806
Zuunburen	14	0.681	0.759	0.661
Zuunharaa	15	0.945	0.569	0.980
Orhon	16	0.949	0.688	0.943
Orhontuul	17	0.946	0.815	1.000
Tsagaantolgoi	18	0.860	0.970	0.763
Zelter	19	0.956	1.000	0.801
Bayanharaat	20	0.833	0.987	0.683
Nomgon	21	0.788	0.956	0.568
Nairamdal	22	0.722	0.992	0.769
Enkhtal	23	0.581	0.710	0.888
Batsumber	24	0.931	0.593	0.461
Bayantsogt	25	0.737	0.375	0.708
Bornuur	26	0.935	0.523	0.954
Jargalant	27	0.780	0.669	0.488
Ugtaal	28	0.919	0.444	0.551
Oktyabr	29	0.673	0.431	0.413
Zaluuchuud	30	0.955	0.574	0.671
Baruunturuun	31	0.341	0.538	0.538
Tarialan	32	0.974	0.840	0.671
Eguur	33	0.970	0.914	0.942
Hurh	34	0.799	0.502	0.766
Undurhaan	35	0.749	0.561	0.960
Chandgana	36	0.575	0.682	0.735
Darhan	37	0.577	0.672	0.944
Ulaantolgoi (ET)	38	0.712	0.553	0.888
Bayanchandmana	39	-	-	1.000
Bayannuur	40	-	-	0.917
mean		0.815	0.715	0.781
std. d		0.162	0.202	0.181
max		0.999	1.000	1.000
min		0.341	0.374	0.384

[a] The cells containing "-" indicate the missing observations where efficiency scores are not calculated.

Appendix 2 Additic nal Information Related to Chapter 6

Table A2.1 The estimation of annual growth rates of PFPs of individual inputs of potato farms[a], 1976-1989

	Coefficients	Standard Error	t-stat	P-value	Lower 95%	Upper 95%	Lower 95%	Upper 95%
Land:								
Intercept	4.607	0.131	35.071	0.000	4.321	4.893	4.321	4.893
T-variable	0.034	0.017	1.999	0.069	-0.003	0.072	-0.003	0.072
Labour:								
Intercept	4.782	0.089	53.754	0.000	4.589	4.976	4.589	4.976
T-variable	0.026	0.012	2.223	0.046	0.001	0.051	0.001	0.051
Fertiliser:								
Intercept	4.245	0.136	31.177	0.000	3.948	4.541	3.948	4.541
T-variable	0.018	0.018	0.999	0.337	-0.021	0.057	-0.021	0.057
Capital								
Intercept	4.580	0.073	62.525	0.000	4.420	4.739	4.420	4.739
T-variable	0.000	0.010	0.047	0.963	-0.020	0.021	-0.020	0.021
Other Cost								
Intercept	4.516	0.087	51.771	0.000	4.326	4.706	4.326	4.706
T-variable	-0.057	0.011	-5.015	0.000	-0.082	-0.032	-0.082	-0.032

[a] Coefficients of T-variables indicate the annual growth rates of PFPs of individual inputs.

Table A2.2 Regression statistics of annual growth rates of PFPs of individual inputs on potato farms, 1976-1989

	Multiple R	R Square	Adjusted R Square	Standard Error	Observations
Land	0.500	0.250	0.187	0.259	14
Labour	0.540	0.292	0.233	0.175	14
Fertiliser	0.277	0.077	0.000	0.268	14
Capital	0.014	0.000	-0.083	0.144	14
Other Cost	0.823	0.677	0.650	0.172	14

Table A2.3 Maximum-likelihood estimates for the parameters of the SFPFs with time-varying inefficiency effects for potato farms, translog form, 1976-1989

Variables		1976-1989
Constant	β_0	0.19
		(0.12)
Land	β_1	0.643
		(0.049)
Labour	β_2	0.210
		(0.039)
Fertiliser	β_3	0.004
		(0.025)
Capital	β_4	0.224
		(0.037)
Other costs	β_5	0.073
		(0.021)
Time	β_6	0.020
		(0.015)
$(\text{Land})^2$	β_7	-0.066
		(0.036)
$(\text{Labour})^2$	β_8	0.010
		(0.025)
$(\text{Fert.})^2$	β_9	0.009
		(0.015)
$(\text{Capital})^2$	β_{10}	0.042
		(0.019)
$(\text{Other costs})^2$	β_{11}	0.019
		(0.011)
$(\text{Time})^2$	β_{12}	0.0013
		(0.0019)
(Land x Labour)	β_{13}	0.136
		(0.049)
(Land x Fert.)	β_{14}	-0.067
		(0.039)
(Land x Capital)	β_{15}	0.001
		(0.045)
(Land x Other costs)	β_{16}	0.049
		(0.034)
(Land x Time)	β_{17}	-0.017
		(0.011)
(Labour x Fert.)	β_{18}	0.037
		(0.025)

(Labour x Capital)	β_{19}	-0.119
		(0.035)
(Labour x Other costs)	β_{20}	-0.049
		(0.023)
(Labour x Time)	β_{21}	0.0089
		(0.0077)
(Fert. x Capital)	β_{22}	0.041
		(0.028)
(Fert. x Other costs)	β_{23}	0.003
		(0.014)
(Fert. x Time)	β_{24}	0.000
		(0.006)
(Capital x Other costs)	β_{25}	-0.037
		(0.024)
(Capital x Time)	β_{26}	-0.0040
		(0.0088)
(Other costs x Time)	β_{27}	0.0029
		(0.0052)
$\sigma^2_s = \sigma^2_v + \sigma^2$		0.406
		(0.079)
$\gamma = \sigma^2/\sigma^2_s$		0.16
		(0.16)
μ		0.12
		(0.32)
η		0.021
		(0.046)
Returns to scale		1.15

[a] Estimated standard errors are presented below the corresponding parameter estimates

Chow test to establish the presence/absence of structural change in data sets: Potato farms

A Chow test was conducted to establish the presence/absence of the structural change in the data the following way:

$$\chi 2 = -2 \times \{(Ln[L(Ho)]^1 + Ln[L(Ho)]^2 + Ln[L(Ho)]^3\} - Ln[L(Ho)]^T = 137.21$$

df= (No. of parameters x 2) = 60

where: $Ln[L(Ho)]^1$ log-likelihood function of the first sub-period (-157.40)
$Ln[L(Ho)]^2$ log-likelihood function of the second sub-period (-160.84)
$Ln[L(Ho)]^3$ log-likelihood function of the third sub-period (-115.60)
$Ln[L(Ho)]^T$ log-likelihood function of the overall period (-502.449)
$\chi^2_{60, 0.95} = 79.08$

As $\chi 2$- value > $\chi^2_{60, 0.95}$ Ho: is rejected.

Hence, the result suggests that the three sub-periods divided according to five year plans are the statistically preferred option against a single 15-year period.

Table A2.4 Maximum-likelihood estimates for the parameters of the SFPFs with time-varying inefficiency effects for potato farms under different functional forms[a], 1976-1980

Variables		Translog	Cobb-Douglas
Constant	β_0	0.31	0.66
		(0.17)	(0.28)
Land	β_1	0.803	0.795
		(0.072)	(0.075)
Labour	β_2	0.180	0.170
		(0.058)	(0.057)
Fertiliser	β_3	0.068	0.008
		(0.047)	(0.043)
Capital	β_4	0.156	0.216
		(0.059)	(0.055)
Other costs	β_5	0.112	0.074
		(0.039)	(0.041)
Time	β_6	-0.107	-0.066
		(0.056)	(0.063)
$(\text{Land})^2$	β_7	-0.02828	-
		(0.06001)	-
$(\text{Labour})^2$	β_8	0.054	-
		(0.035)	-
$(\text{Fert.})^2$	β_9	0.037	-
		(0.026)	-
$(\text{Capital})^2$	β_{10}	0.062	-
		(0.029)	-
$(\text{Other costs})^2$	β_{11}	0.040	-
		(0.023)	-
$(\text{Time})^2$	β_{12}	-0.013	-
		(0.027)	-
(Land x Labour)	β_{13}	0.250	-
		(0.077)	-
(Land x Fert.)	β_{14}	-0.118	-
		(0.065)	-
(Land x Capital)	β_{15}	-0.106	-
		(0.072)	-
(Land x Other costs)	β_{16}	0.073	-
		(0.065)	-
(Land x Time)	β_{17}	-0.094	-
		(0.046)	-
(Labour x Fert.)	β_{18}	-0.011	-
		(0.045)	-
(Labour x Capital)	β_{19}	-0.252	-

		(0.064)	-
(Labour x Other costs)	β_{20}	-0.059	-
		(0.041)	-
(Labour x Time)	β_{21}	-0.001	-
		(0.033)	-
(Fert. x Capital)	β_{22}	0.110	-
		(0.051)	-
(Fert. x Other costs)	β_{23}	-0.020	-
		(0.031)	-
(Fert. x Time)	β_{24}	0.030	-
		(0.028)	-
(Capital x Other costs)	β_{25}	-0.071	-
		(0.043)	-
(Capital x Time)	β_{26}	-0.005	-
		(0.034)	-
(Other costs x Time)	β_{27}	0.062	-
		(0.031)	-
$\sigma^2_s = \sigma^2_v + \sigma^2$		0.79	0.519
		(1.32)	(0.103)
$\gamma = \sigma^2/\sigma^2_s$		0.64	0.27
		(0.61)	(0.13)
μ		-0.72	0.75
		(3.88)	(0.41)
η		-0.10	-0.085
		(0.14)	(0.095)
Returns to scale		1.32	1.26

[a] Estimated standard errors are presented below the corresponding parameter estimates

Table A2.5 Maximum-likelihood estimates for the parameters of the SFPFs with time-varying inefficiency effects for potato farms under different functional forms[a], 1981-1985

Variables		Translog	Cobb-Douglas
Constant	β_0	0.13	0.321
		(0.11)	(0.074)
Land	β_1	0.5958	0.6915
		(0.0901)	(0.0804)
Labour	β_2	0.280	0.251
		(0.061)	(0.059)
Fertiliser	β_3	-0.001	0.007
		(0.037)	(0.029)
Capital	β_4	0.238	0.179
		(0.057)	(0.042)
Other costs	β_5	0.033	0.032
		(0.029)	(0.029)
Time	β_6	0.010	0.022
		(0.054)	(0.047)
$(\text{Land})^2$	β_7	-0.057	-
		(0.104)	-
$(\text{Labour})^2$	β_8	0.119	-
		(0.059)	-
$(\text{Fert.})^2$	β_9	0.0129	-
		(0.0198)	-
$(\text{Capital})^2$	β_{10}	0.049	-
		(0.029)	-
$(\text{Other costs})^2$	β_{11}	0.015	-
		(0.016)	-
$(\text{Time})^2$	β_{12}	-0.009	-
		(0.025)	-
(Land x Labour)	β_{13}	-0.03	-
		(0.12)	-
(Land x Fert.)	β_{14}	0.030	-
		(0.072)	-
(Land x Capital)	β_{15}	0.091	-
		(0 093)	-
(Land x Other costs)	β_{16}	0 020	-
		(0 053)	-
(Land x Time)	β_{17}	-0.016	-
		(0.058)	-
(Labour x Fert.)	β_{18}	-0.015	-
		(0.045)	-

(Labour x Capital)	β_{19}	-0.106	-
		(0.059)	-
(Labour x Other costs)	β_{20}	-0.006	-
		(0.038)	-
(Labour x Time)	β_{21}	0.000	-
		(0.044)	-
(Fert. x Capital)	β_{22}	-0.047	-
		(0.042)	-
(Fert. x Other costs)	β_{23}	0.012	-
		(0.021)	-
(Fert. x Time)	β_{24}	-0.029	-
		(0.025)	-
(Capital x Other costs)	β_{25}	-0.048	-
		(0.031)	-
(Capital x Time)	β_{26}	0.016	-
		(0.032)	-
(Other costs x Time)	β_{27}	-0.00094	-
		(0.02004)	-
$\sigma^2_s = \sigma^2_v + \sigma^2$		0.39	0.46
		(0.27)	(0.18)
$\gamma = \sigma^2/\sigma^2_s$		0.40	0.42
		(0.43)	(0.27)
μ		-0.7943	-0.88
		(1.6004)	(0.98)
η		0.34	0.30
		(0.14)	(0.12)
Returns to scale		1.15	1.16

[a] Estimated standard e rors are presented below the corresponding parameter estimates

Table A2.6 Maximum-likelihood estimates for the parameters of the SFPFs with time-varying inefficiency effects for potato farms under different functional forms[a], 1986-1989

Variables		Translog	Cobb-Douglas
Constant	β_0	0.19	0.41
		(0.17)	(0.13)
Land	β_1	0.635	0.636
		(0.086)	(0.075)
Labour	β_2	0.190	0.217
		(0.064)	(0.063)
Fertiliser	β_3	0.041	0.030
		(0.047)	(0.039)
Capital	β_4	0.178	0.174
		(0.072)	(0.065)
Other costs	β_5	0.072	0.080588
		(0.033)	(0.030005)
Time	β_6	-0.118	-0.091
		(0.054)	(0.066)
$(\text{Land})^2$	β_7	0.09	-
		(0.11)	-
$(\text{Labour})^2$	β_8	-0.031	-
		(0.041)	-
$(\text{Fert.})^2$	β_9	-0.025	-
		(0.033)	-
$(\text{Capital})^2$	β_{10}	-0.045	-
		(0.068)	-
$(\text{Other costs})^2$	β_{11}	-0.014	-
		(0.017)	-
$(\text{Time})^2$	β_{12}	0.109	-
		(0.051)	-
(Land x Labour)	β_{13}	-0.040	-
		(0.099)	-
(Land x Fert.)	β_{14}	0.001	-
		(0.077)	-
(Land x Capital)	β_{15}	-0.15	-
		(0.13)	-
(Land x Other costs)	β_{16}	-0.039	-
		(0 059)	-
(Land x Time)	β_{17}	0 086	-
		(0 073)	-
(Labour x Fert.)	β_{18}	0 053	-
		(0 041)	-

(Labour x Capital)	β_{19}	0.050	-
		(0.081)	-
(Labour x Other costs)	β_{20}	-0.038	-
		(0.039)	-
(Labour x Time)	β_{21}	0.027	-
		(0.054)	-
(Fert. x Capital)	β_{22}	0.088	-
		(0.059)	-
(Fert. x Other costs)	β_{23}	-0.030	-
		(0.027)	-
(Fert. x Time)	β_{24}	0.031	-
		(0.036)	-
(Capital x Other costs)	β_{25}	0.115	-
		(0.051)	-
(Capital x Time)	β_{26}	-0.145	-
		(0.062)	-
(Other costs x Time)	β_{27}	0.030	-
		(0.026)	-
$\sigma^2_s = \sigma^2_v + \sigma^2$		0.205	0.278
		(0.027)	(0.064)
$\gamma = \sigma^2/\sigma^2_s$		0.118	0.20
		(0.066)	(0.18)
μ		-0.31	0.10
		(0.26)	(0.31)
η		0.79	0.34
		(0.28)	(0.17)
Returns to scale		1.12	1.14

[a] Estimated standard errors are presented below the corresponding parameter estimates

Table A2.7 Efficiency scores of potato farms[a], 1976-1980

Farms	No.	Efficiency scores				
		1976	1977	1978	1979	1980
Tuvshruuleh	1	0.944	0.922	0.893	0.855	0.806
Bayannuur	2	0.919	0.888	0.848	0.796	0.730
Baidrag	3	0.864	0.815	0.754	0.678	-
Ingettolgoi	4	0.920	0.890	0.851	0.800	0.735
Magsarjav	5	-	-	-	0.608	0.505
Sumber	6	0.945	0.924	-	0.859	-
Onon	7	0.913	0.881	0.839	0.784	0.716
Halhgol	8	0.861	0.811	0.748	0.669	0.575
Herlen	9	0.692	0.597	0.486	0.365	0.247
Ereentsav	10	0.878	0.834	0.777	0.706	0.619
Harhorin	11	0.926	0.898	0.861	0.813	0.752
Tumentsogt	12	0.832	0.774	0.700	0.610	0.506
Altanbulag	13	0.919	0.889	0.849	0.797	0.732
Baruunharaa	14	0.837	0.780	0.708	0.620	0.518
Burgaltai	15	-	0.801	0.735	0.653	0.556
Yuruu	16	0.874	0.828	0.770	0.696	0.608
Zuunburen	17	0.796	0.727	0.641	0.539	0.426
Zuunharaa	18	0.903	0.868	0.821	0.761	0.688
Orhon	19	0.910	0.876	0.832	0.776	0.706
Orhontuul	20	-	0.633	0.528	0.411	0.291
Tsagaantolgoi	21	0.778	0.704	0.612	0.506	0.390
Zelter	22	0.834	0.776	0.702	0.612	0.509
Bayanharaat	23	-	0.816	0.753	0.676	0.584
Nomgon	24	-	0.740	0.657	0.558	0.448
Nairamdal	25	-	0.764	0.688	0.595	0.490
Batsumber	26	0.855	0.803	0.738	0.656	0.560
Bayantsogt	27	0.648	0.544	0.427	0.304	0.191
Bornuur	28	0.933	0.907	0.873	0.829	0.772
Jargalant	29	0.780	0.707	0.616	0.511	0.395
Ugtaal	30	0.913	0.881	0.839	0.784	0.715
Oktyabr	31	-	0.796	0.728	0.644	0.546
Zaluuchuud	32	-	0.882	0.839	0.785	0.717
Bayanchandmana	33	-	-	-	-	0.660
Baruunturuun	34	0.809	-	0.662	0.564	0.455
Tarialan	35	0.938	0.914	0.882	0.841	0.788
Undurhaan	36	0.783	0.710	0.621	0.516	0.400
Chandgana	37	-	-	0.904	0.869	0.824
Darhan	38	0.887	0.845	0.792	0.724	0.642
Sharyin gol	39	0.933	0.908	0.875	0.831	0.774
Partisan	40	-	-	0.656	-	-
Ulaantolgoi (ET)	41	-	0.811	0.748	0.669	0.575
mean		0.863	0.810	0.743	0.674	0.583
std. d		0.075	0.093	0.116	0.141	0.161
max.		0.945	0.924	0.904	0.869	0.824
min		0.648	0.544	0.427	0.304	0.191

[a] The cells containing "-" indicate the missing observations where efficiency scores are not calculated.

Table A2.8 Efficiency scores of potato farms[a], 1981-1985

Farms	No.	Efficiency scores				
		1981	1982	1983	1984	1985
Tuvshruuleh	1	0.734	0.794	0.842	0.881	0.911
Bayannuur	2	0.732	0.792	0.841	0.880	0.910
Baidrag	3	0.287	0.396	0.505	-	0.690
Ingettolgoi	4	0.761	0.815	0.859	0.894	0.921
Magsarjav	5	-	0.290	0.400	0.509	0.608
Sumber	6	-	0.674	0.745	0.804	0.851
Onon	7	0.276	0.386	0.495	0.596	0.683
Halhgol	8	0.293	0.403	0.511	0.610	0.695
Herlen	9	0.234	0.341	0.453	0.558	0.651
Ereentsav	10	0.137	0.231	0.340	0.453	0.559
Harhorin	11	0.637	0.714	0.778	0.831	0.872
Tumentsogt	12	0.523	0.616	0.698	0.767	0.822
Altanbulag	13	0.765	0.819	0.862	0.896	0.922
Baruunharaa	14	0.731	0.792	0.840	0.879	0.909
Burgaltai	15	0.318	0.427	0.534	0.629	0.711
Yuruu	16	0.748	0.805	0.851	0.887	0.915
Zuunburen	17	0.720	0.782	0.833	0.873	0.905
Zuunharaa	18	0.707	0.772	0.825	0.867	0.900
Orhon	19	0.519	0.613	0.695	0.764	0.820
Orhontuul	20	0.484	0.582	0.669	0.743	0.803
Tsagaantolgoi	21	0.669	0.740	0.800	0.847	0.885
Zelter	22	0.574	0.660	0.735	0.796	0.845
Bayanharaat	23	0.707	0.772	0.825	0.867	0.900
Nomgon	24	-	0.616	0.697	0.764	0.820
Nairamdal	25	0.470	0.570	0.659	0.735	0.797
Batsumber	26	0.596	0.679	0.750	0.808	0.855
Bayantsogt	27	-	0.834	0.874	0.905	0.929
Bornuur	28	0.740	0.798	0.846	0.883	0.913
Jargalant	29	0.656	0.730	0.791	0.841	0.880
Ugtaal	30	0.635	0.712	0.777	0.829	0.871
Oktyabr	31	0.594	0.677	0.748	0.807	0.854
Zaluuchuud	32	0.639	0.716	0.780	0.832	0.873
Baruunturuun	33	0.641	0.718	0.781	0.833	0.874
Ulaantolgoi (Uvs)	34	0.793	0.841	0.879	0.909	0.932
Tarialan	35	0.620	0.699	0.766	-	0.865
Hurh	36	-	-	0.794	0.842	0.880
Undurhaan	37	0.417	0.522	0.618	0.701	0.770
Chandgana	38	0.552	0.642	0.719	0.784	0.835
Darhan	39	0.595	0.678	0.749	-	0.854
Sharyin gol	40	0.761	0.816	0.860	-	0.921
Partisan	41	0.869	0.901	0.926	0.945	0.959
Gachuurt	42	-	-	-	-	0.859
Ulaantolgoi (ET)	43	0.681	0.759	0.807	-	0.890
mean		0.590	0.661	0.732	0.790	0.840
std. d		0.178	0.165	0.141	0.119	0.093
max.		0.869	0.901	0.926	0.945	0.959
min		0.137	0.231	0.340	0.453	0.559

[a] The cells containing "-" indicate the missing observations where efficiency scores are not calculated.

Table A2.9 Efficiency scores of potato farms[a], 1986-1989

Farms	No.	Efficiency scores			
		1986	1987	1988	1989
Tuvshruuleh	1	0.607	0.691	0.761	0.818
Bayannuur	2	0.751	0.809	0.855	0.892
Baidrag	3	0.466	0.569	0.661	0.738
Ingettolgoi	4	0.783	0.834	0.875	0.906
Magsarjav	5	0.394	0.504	0.604	0.692
Sumber	6	0.399	0.508	0.608	0.695
Onon	7	0.635	0.714	0.780	0.833
Halhgol	8	0.344	0.456	0.562	0.656
Herlen	9	0.506	0.604	0.690	0.762
Ereentsav	10	0.514	0.612	0.697	0.767
Harhorin	11	0.833	0.874	0.905	-
Tumentsogt	12	0.871	0.903	0.928	0.947
Altanbulag	13	0.811	0.856	0.892	0.920
Baruunharaa	14	0.741	0.800	0.849	0.886
Burgaltai	15	0.808	0.854	0.890	0.918
Yuruu	16	0.750	0.808	0.855	0.891
Zuunburen	17	0.799	0.847	0.885	0.914
Zuunharaa	18	0.750	0.808	0.855	0.891
Orhon	19	0.458	0.562	0.655	0.733
Orhontuul	20	0.443	0.548	0.643	0.724
Tsagaantolgoi	21	0.746	0.805	0.852	0.889
Zelter	22	0.409	0.518	0.617	0.702
Bayanharaat	23	0.820	0.864	0.898	0.924
Nomgon	24	0.620	0.702	0.770	0.825
Nairamdal	25	0.655	0.731	0.794	0.844
Enkhtal	26	-	0.822	0.865	0.899
Batsumber	27	0.641	0.720	0.785	0.837
Bayantsogt	28	0.824	0.867	0.900	0.925
Bornuur	29	0.809	0.855	0.891	0.919
Jargalant	30	0.773	0.827	0.869	0.902
Ugtaal	31	0.872	0.904	0.928	0.947
Oktyabr	32	0.591	0.677	0.750	0.810
Zaluuchuud	33	0.733	0.794	0.844	0.883
Bayanchandmana	34	-	-	-	0.862
Baruunturuun	35	0.682	0.753	0.811	0.857
Ulaantolgoi (Uvs)	36	0.690	-	-	-
Tarialan	37	-	0.488	0.589	0.678
Eguur	38	-	0.828	0.870	0.903
Hurh	39	0.827	0.869	0.902	0.927
Undurhaan	40	0.351	0.463	0.569	0.662
Chandgana	41	0.637	0.716	0.782	0.834
Darhan	42	0.428	0.535	0.632	0.714
Sharyin gol	43	0.701	-	-	-
Partisan	44	0.816	0.860	0.895	-
Gachuurt	45	-	0.713	0.778	-
Ulaantolgoi (ET)	46	0.699	0.767	0.822	0.866
mean		0.658	0.727	0.788	0.834
std. d		0.160	0.138	0.112	0.089
max.		0.872	0.904	0.928	0.947
min		0.344	0.456	0.562	0.656

Table A2.10 Maximum-likelihood estimates for the parameters of the SFPFs for potato farms using Aigner *et al.* (1977) model[a], 1976-1989

Variables		1976-1989
Constant	β_0	1.31
		(0.76)
Land	β_1	0.05
		(0.28)
Labour	β_2	0.27
		(0.25)
Fertiliser	β_3	-0.14
		(0.14)
Capital	β_4	0.65
		(0.18)
Other costs	β_5	0.19
		(0.12)
Time	β_6	-
		-
$(\text{Land})^2$	β_7	0.013
		(0.033)
$(\text{Labour})^2$	β_8	-0.002
		(0.023)
$(\text{Fert.})^2$	β_9	0.011
		(0.013)
$(\text{Capital})^2$	β_{10}	0.029
		(0.016)
$(\text{Other costs})^2$	β_{11}	0.0179
		(0.0092)
$(\text{Time})^2$	β_{12}	-
		-
(Land x Labour)	β_{13}	0.079
		(0.047)
(Land x Fert.)	β_{14}	-0.058
		(0.036)
(Land x Capital)	β_{15}	-0.004
		(0.034)
(Land x Other costs)	β_{16}	-0.009
		(0.029)
(Land x Time)	β_{17}	-
		-
(Labour x Fert.)	β_{18}	0.025
		(0.023)

(Labour x Capital)	β_{19}	-0.089
		(0.029)
(Labour x Other costs)	β_{20}	-0.019
		(0.021)
(Labour x Time)	β_{21}	-
		-
(Fert. x Capital)	β_{22}	0.036
		(0.024)
(Fert. x Other costs)	β_{23}	-0.007
		(0.013)
(Fert. x Time)	β_{24}	-
		-
(Capital x Other costs)	β_{25}	-0.004
		(0.019)
(Capital x Time)	β_{26}	-
		-
(Other costs x Time)	β_{27}	-
$\sigma^2_s = \sigma^2_v + \sigma^2$		0.988
		(0.087)
$\gamma = \sigma^2/\sigma^2_s$		0.934
		(0.021)
Returns to scale		1.02

[a] Estimated standard errors are presented below the corresponding parameter estimates

Table A2.11 Efficiency sco·es of potato farms using Aigner *et al.* (1977) model, 1976-1989

1976-1980		1981-1985		1986-1989	
Year	Efficiency score	Year	Efficiency score	Year	Efficiency score
1976	0.540	1981	0.459	1986	0.551
1977	0.525	1982	0.577	1987	0.573
1978	0.428	1983	0.588	1988	0.520
1979	0.554	1984	0.619	1989	0.617
1980	0.356	1985	0.644		
mean	0.481		0.578		0.565
std. d	0.086		0.071		0.040
max	0.554		0.644		0.617
min	0.356		0.459		0.520

Appendix 3 Calculation of the Rate of Technical Change in Grain Farming

Calculation of the rate of technical change in grain farming for the years 1980/1981 and 1985/1986 (Shazam output file):

```
UNIT  6 IS NOW ASSIGNED TO: join2aa.out
|_sample 1 28
|_* read in the mle betas:
|_file 33 betaa.txt
UNIT 33 IS NOW ASSIGNED TO: betaa.txt
|_read(33) d b1
  2 VARIABLES AND      28 OBSERVATIONS STARTING AT OBS      1

|_read(33) d b2
  2 VARIABLES AND      28 OBSERVATIONS STARTING AT OBS      1

|_read(33) d b3
  2 VARIABLES AND      28 OBSERVATIONS STARTING AT OBS      1

|_copy b1 b2 b3 b
|_* read in the sample means for each sub-panel - in original units (x1-x5,y)
|_file 33 mean2aa.txt
UNIT 33 IS NOW ASSIGNED TO: mean2aa.txt
|_sample 1 3
|_read(33) a1-a6/byvar
  6 VARIABLES AND       3 OBSERVATIONS STARTING AT OBS      1
|_copy a1-a5 a
|_sample 1 14
|_* read in the sample means for each year - mean-corrected logged data (y,x1-x5)
|_file 33 mean14aa.txt
UNIT 33 IS NOW ASSIGNED TO: mean14aa.txt
|_read(33) mt6 mt1-mt5
  6 VARIABLES AND      14 OBSERVATIONS STARTING AT OBS      1

|_copy mt1-mt5 m1
|_print m1
   M1
  14 BY     5 MATRIX
 -0.4401000E-01  0.3220700    -0.4951500    -0.1464000E-01 -0.1180400
 -0.7159000E-01  0.2916510    -0.4907600     0.9831700E-01  0.2915500E-01
  0.1007730      0.2923470     0.2978680    -0.1217000E-01  0.2007440
  0.8700000E-03 -0.6407100     0.3063140    -0.5324000E-01 -0.1376100
  0.1746000E-02 -0.1427200     0.2304340    -0.1532000E-01  0.7261000E-02
 -0.6288000E-01 -0.3572600    -0.4619600    -0.2633700     -0.5708300
 -0.6248000E-01 -0.1590000E-02  0.1928200    -0.7102000E-01 -0.1838000
  0.2965700E-01  0.1045110     0.4884600E-01  0.1485960      0.5676700E-01
 -0.6250000E-02  0.1087870     0.7302400E-01  0.8398100E-01  0.1351820
  0.1019580      0.1455470     0.1472690      0.1018110      0.5626820
 -0.2687000E-01  0.9610800E-01 -0.4935000E-01  0.1532100E-01  0.1822290
  0.4182000E-01  0.4450500E-01  0.1007740     -0.2039200     -0.1857300
  0.8594900E-01  0.5876900E-01  0.1190250      0.1726180      0.2670060
 -0.9832000E-01 -0.1942700    -0.1660800      0.1557300E-01 -0.2567500
|_matrix a=log(a)
```

```
|_print a
   A
   3 BY     5 MATRIX
  9.368839      10.23520      5.469746      7.496097      5.191845
  9.339683      10.40970      5.850189      7.728680      5.982172
  9.334150      10.44432      5.783825      7.717841      6.333280
|_sample 1 8
|_dim x 28 8 t 8 1 m 8 5
|_read t
  1 VARIABLES AND       8 OBSERVATIONS STARTING AT OBS       1

|_matrix m(1,0)=m1(5,0)
|_matrix m(2,0)=m1(6,0)+a(2,0)-a(1,0)
|_matrix m(3,0)=m1(5,0)+a(1,0)-a(2,0)
|_matrix m(4,0)=m1(6,0)
|_matrix m(5,0)=m1(10,0)
|_matrix m(6,0)=m1(11,0)+a(3,0)-a(2,0)
|_matrix m(7,0)=m1(10,0)+a(2,0)-a(3,0)
|_matrix m(8,0)=m1(11,0)
|_set nodoecho
|_do #=1,8
|_matrix x(1,#)=1
|_matrix x(2,#)=m(#,1)
|_matrix x(3,#)=m(#,2)
|_matrix x(4,#)=m(#,3)
|_matrix x(5,#)=m(#,4)
|_matrix x(6,#)=m(#,5)
|_matrix x(7,#)=t(#)
|_matrix x(8,#)=m(#,1)**2
|_matrix x(9,#)=m(#,2)**2
|_matrix x(10,#)=m(#,3)**2
|_matrix x(11,#)=m(#,4)**2
|_matrix x(12,#)=m(#,5)**2
|_matrix x(13,#)=t(#)**2
|_matrix x(14,#)=m(#,1)*m(#,2)
|_matrix x(15,#)=m(#,1)*m(#,3)
|_matrix x(16,#)=m(#,1)*m(#,4)
|_matrix x(17,#)=m(#,1)*m(#,5)
|_matrix x(18,#)=m(#,1)*t(#)
|_matrix x(19,#)=m(#,2)*m(#,3)
|_matrix x(20,#)=m(#,2)*m(#,4)
|_matrix x(21,#)=m(#,2)*m(#,5)
|_matrix x(22,#)=m(#,2)*t(#)
|_matrix x(23,#)=m(#,3)*m(#,4)
|_matrix x(24,#)=m(#,3)*m(#,5)
|_matrix x(25,#)=m(#,3)*t(#)
|_matrix x(26,#)=m(#,4)*m(#,5)
|_matrix x(27,#)=m(#,4)*t(#)
|_matrix x(28,#)=m(#,5)*t(#)
|_endo
****** EXECUTION BEGINNING FOR DO LOOP # =       1
|_sample 1 28
|_matrix p=b'x
|_print p
```

```
   P
   3 BY     8 MATRIX
 0.1516990     0.1477458     0.3673883     0.2645415     0.3100721
 0.2396989     0.5193324     0.3738933
 0.3361728     0.2758002    -0.4004127    -0.3974614     0.5032604
 0.3903518     0.1475494     0.1111148
 0.2145986     0.1637275     0.8115349E-02 -0.4081895E-01  0.3923115
 0.2901107     0.3671827     0.2614493
|_sample 1 3
|_copy a6 a6 a6 a6 a6 a6 a6 a6 aa6
|_matrix pp=exp(p+log(aa6))
|_print pp
   PP
   3 BY     8 MATRIX
  9242.629     9206.163     11467.49     10346.71     10828.69
  10092.84     13349.24     11542.32
  16117.29     15173.04     7716.086     7738.893     19048.35
  17014.60     13346.70     12869.17
  16655.69     15829.59     13548.41     12901.38     19894.93
  17962.10     19401.23     17454.59
|_sample 1 28
|_matrix c1=pp(2,3)/pp(1,1)
|_matrix c2=pp(2,4)/pp(1,2)
|_matrix c3=pp(3,7)/pp(2,5)
|_matrix c4=pp(3,8)/pp(2,6)
|_gen1 j1=sqrt(abs(c1*c2))
|_gen1 j2=sqrt(abs(c3*c4))
|_print c1-c4
   C1
 0.8348368
   C2
 0.8406209
   C3
  1.018525
   C4
  1.025860
|_print j1 j2
   J1
 0.8377238
   J2
  1.022186
|_stop
```

Appendix 4 Calculation of the Rate of Technical Change in Potato Farming

Calculation of the rate of techn cal change in potato farming for the years 1980/1981 and 1985/1986 (Shazam output file):

```
UNIT  6 IS NOW ASSIGNED TO: join2p1.out
|_sample 1 28
|_* read in the mle betas:
|_file 33 betap1.txt
UNIT 33 IS NOW ASSIGNED TO: betap1.txt
|_read(33) d b1
  2 VARIABLES AND      28 OBSERVATIC NS STARTING AT OBS      1

|_read(33) d b2
  2 VARIABLES AND      28 OBSERVATIC NS STARTING AT OBS      1

|_read(33) d b3
  2 VARIABLES AND      28 OBSERVATIC NS STARTING AT OBS      1

|_copy b1 b2 b3 b
|_print b
   B
  28 BY    3 MATRIX
 0.3654880     0.3740090     0.3167380
 0.7916040     0.6937350     0.6206850
 0.1841370     0.2551330     0.1914740
 0.5325700E-01  0.6040000E-02  0.69124001-01
 0.1772180     0.1766140     0.1573830
 0.1092040     0.3343100E-01  0.8327000E-( 1
 0.0000000E+00  0.0000000E+00  0.000000( E+00
-0.6262000E-01  0.0000000E+00  0.9305300E-01
 0.5597900E-01  0.0000000E+00 -0.2360500E-01
 0.2771100E-01  0.0000000E+00 -0.720500(E-02
 0.6252300E-01  0.0000000E+00 -0.157790(E-01
 0.4175700E-01  0.0000000E+00 -0.895900(E-02
 0.0000000E+00  0.0000000E+00  0.000000( E+00
 0.2647070     0.0000000E+00  0.3076000E-)2
-0.9117800E-01  0.0000000E+00 -0.519100( E-02
-0.9567200E-01  0.0000000E+00 -0.166012(
 0.4584900E-01  0.0000000E+00 -0.439380( E-01
 0.0000000E+00  0.0000000E+00  0.000000(E+00
-0.1717200E-01  0.0000000E+00  0.687330( E-01
-0.2502970     0.0000000E+00 -0.7418000E 02
-0.5706200E-01  0.0000000E+00 -0.427400( E-01
 0.0000000E+00  0.0000000E+00  0.000000(E+00
 0.9559000E-01  0.0000000E+00  0.640170( E-01
-0.1078200E-01  0.0000000E+00 -0.325200(E-01
 0.0000000E+00  0.0000000E+00  0.000000(E+00
-0.5587600E-01  0.0000000E+00  0.120545(
 0.0000000E+00  0.0000000E+00  0.000000(E+00
 0.0000000E+00  0.0000000E+00  0.000000(E+00
|_* read in the sample means for each sub-pa el - in or ginal units (x1-x5,y)
|_file 33 mean2p.txt
UNIT 33 IS NOW ASSIGNED TO: mean2p.txt
```

```
|_sample 1 3
|_read(33) a1-a6/byvar
  6 VARIABLES AND       3 OBSERVATIONS STARTING AT OBS      1
|_copy a1-a5 a
|_sample 1 14
|_* read in the sample means for each year - mean-corrected logged data (y,x1-x5)
|_file 33 mean14p.txt
UNIT 33 IS NOW ASSIGNED TO: mean14p.txt
|_read(33) mt6 mt1-mt5
  6 VARIABLES AND      14 OBSERVATIONS STARTING AT OBS      1

|_copy mt1-mt5 m1
|_print m1
   M1
  14 BY     5 MATRIX
 -0.2181130     0.2896700E-01 -0.3740780     -0.1977200     -0.4413930
 -0.9704700E-01 -0.7299800E-01 -0.7780900E-01 -0.7141100E-01  0.4680400E-01
 -0.6327200E-01  0.4947100E-01  0.9475600E-01  0.1385460     -0.4903000E-01
  0.8365800E-01  0.1265270      0.2480000E-01  0.2652380      0.2627330
  0.2358070     -0.1322770      0.2389860     -0.1922200      0.7189600E-01
 -0.4108320     -0.2597440     -0.3247880     -0.3215740     -0.3151550
 -0.8322200E-01 -0.4867500E-01 -0.1205930      0.2093470     -0.3168000E-02
  0.1573380      0.4170200E-01  0.8246300E-01  0.1122200E-01  0.8082600E-01
  0.1903790      0.1430580      0.1827730      0.2977320      0.1648970
  0.1153640      0.1060830      0.1566370     -0.1900560      0.5336600E-01
  0.3338800E-01  0.3148000E-01  0.2325010     -0.1210120     -0.2581750
 -0.1200260     -0.1587590     -0.1761900     -0.9860300E-01 -0.5121700E-01
 -0.2177200E-01 -0.1013920     -0.5669200E-01 -0.5112600E-01 -0.2053900E-01
  0.1153270      0.2413610      0.1174100E-01  0.2780450      0.3334310
|_matrix a=log(a)
|_print a
   A
   3 BY     5 MATRIX
  4.755341      8.754771      3.346761      5.088042      3.325236
  4.735558      8.875239      3.572416      5.234054      3.922745
  5.022509      9.112716      3.633649      5.713647      4.490909
|_sample 1 8
|_dim x 28 8 t 8 1 m 8 5
|_read t
  1 VARIABLES AND       8 OBSERVATIONS STARTING AT OBS      1

|_matrix m(1,0)=m1(5,0)
|_matrix m(2,0)=m1(6,0)+a(2,0)-a(1,0)
|_matrix m(3,0)=m1(5,0)+a(1,0)-a(2,0)
|_matrix m(4,0)=m1(6,0)
|_matrix m(5,0)=m1(10,0)
|_matrix m(6,0)=m1(11,0)+a(3,0)-a(2,0)
|_matrix m(7,0)=m1(10,0)+a(2,0)-a(3,0)
|_matrix m(8,0)=m1(11,0)
|_set nodoecho
|_do #=1,8
|_matrix x(1,#)=1
|_matrix x(2,#)=m(#,1)
|_matrix x(3,#)=m(#,2)
```

```
|_matrix x(4,#)=m(#,3)
|_matrix x(5,#)=m(#,4)
|_matrix x(6,#)=m(#,5)
|_matrix x(7,#)=t(#)
|_matrix x(8,#)=m(#,1)**2
|_matrix x(9,#)=m(#,2)**2
|_matrix x(10,#)=m(#,3)**2
|_matrix x(11,#)=m(#,4)**2
|_matrix x(12,#)=m(#,5)**2
|_matrix x(13,#)=t(#)**2
|_matrix x(14,#)=m(#,1)*m(#,2)
|_matrix x(15,#)=m(#,1)*m(#,3)
|_matrix x(16,#)=m(#,1)*m(#,4)
|_matrix x(17,#)=m(#,1)*m(#,5)
|_matrix x(18,#)=m(#,1)*t(#)
|_matrix x(19,#)=m(#,2)*m(#,3)
|_matrix x(20,#)=m(#,2)*m(#,4)
|_matrix x(21,#)=m(#,2)*m(#,5)
|_matrix x(22,#)=m(#,2)*t(#)
|_matrix x(23,#)=m(#,3)*m(#,4)
|_matrix x(24,#)=m(#,3)*m(#,5)
|_matrix x(25,#)=m(#,3)*t(#)
|_matrix x(26,#)=m(#,4)*m(#,5)
|_matrix x(27,#)=m(#,4)*t(#)
|_matrix x(28,#)=m(#,5)*t(#)
|_endo
****** EXECUTION BEGINNING FOR DC LOOP #= 1
|_sample 1 28
|_matrix p=b'x
|_print p
  P
  3 BY  8 MATRIX
 0.4985530  0.9440140E-02  0.3485036  -0.1239454  0.4657274
 0.7612564  0.4283409E-01  0.3627056
 0.4737466  0.3523741E-01  0.3919483  -0.4656094E-01  0.4502699
 0.7226659  0.1042079  0.3766039
 0.4330179  0.4475546E-01  0.3594029  -0.8719706E-01  0.3951777
 0.6537596  0.6313113E-01  0.3236877
|_sample 1 3
|_copy a6 a6 a6 a6 a6 a6 a6 a6 aa6
|_matrix pp=exp(p+log(aa6))
|_print pp
  PP
  3 BY  8 MATRIX
  1712.206  1049.873  1473.636  913.7723  1656.914
  2226.622  1085.525  1494.714
  2317.691  1494.904  2135.654  1377.491  2263.913
  2972.759  1601.647  2103.134
  2975.614  2018.163  2764.432  1758.683  2865.120
  3710.594  2055.591  2667.443
|_sample 1 28
|_matrix c1=pp(2,3)/pp(1,1)
|_matrix c2=pp(2,4)/pp(1,2)
|_matrix c3=pp(3,7)/pp(2,5)
```

```
|_matrix c4=pp(3,8)/pp(2,6)
|_gen1 j1=sqrt(abs(c1*c2))
|_gen1 j2=sqrt(abs(c3*c4))
|_print c1-c4
   C1
  1.247312
   C2
  1.312055
   C3
 0.9079816
   C4
 0.8972951
|_print j1 j2
   J1
  1.279274
   J2
 0.9026226
|_stop
```

Appendix 5 List of Acronyms

List of Acronyms

1. AE- Allocative efficiency
2. C-D- Cobb-Douglas
3. COLS- Corrected ordinary least squares
4. CPF- Combined factor productivity
5. CRS- Constant returns to scale
6. DEA- Data envelopment analysis
7. DRS- Decreasing returns to scale
8. Kg- Kilogram
9. LLF- Log-likelihood function
10. MLE- Maximum-likelihood estimates
11. MOLS- Modified ordinary least squares
12. NIRS- Non-increasing returns to scale
13. OLS- Ordinary least squares
14. PE- Productive efficiency
15. PFP- Partial factor productivity
16. SFPF- Stochastic frontier production function
17. t- Tonnes
18. TE- Technical efficiency
19. TFP- Total factor productivity
20. Tg(s)- Tugrig(s) – Mongolian currency unit
21. Translog- Translogarithmic function
22. VRS- Variable returns to scale

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