An Econometric Analysis of the Effects of Global Warming and Economic Factors to the Yield and Area Sown of Wheat and Barley in Adana and Konya Provinces in Turkey

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Abstract

Wheat and barley are first two important cereals in Turkey. They occupy about 70% and 30% of the total cereals production in Turkey. Barley can tolerate salinity, drought, and lower tempetature better than wheat. But these crops are affected by heat damage and drought considerably. GCM and RCM predict that global warming will increase temperature and decrease rainfall in Turkey during the later part of the 21st century, and thus area sown and yield of wheat and barley will be reduced.

First, multiple regression analyses of the effects of heat damage and drought and of the product prices to wheat and barley yield, and of the effects of cumulative monthly rainfall and product prices to area sown of wheat and barley for Adana and Konya were done in this paper. The monthly data (1959 to 2002) of rainfall, temperature, and prices(annual data) were regressed with yield and area sown of wheat and barley for Adana and Konya. Then, the estimated results regarding heat damage and drought were used to predict yield, area sown and production of wheat and barley for the year 2070 assuming that Dr. Kimura's pseudo-warming second run N2 revised will occur.

Our econometric estimation has shown generally significantly that heat damage occurred in the yield of both wheat and barley in April, May, and June(for Konya wheat yield only) in Adana and Konya. Drought affected significantly to the yield of wheat in May in Adana, in April in Konya, and to the yield of barley in December in Adana and in May in Konya. We have obtained some significant effects of cumulative monthly rainfall variables and real product prices, relative prices, and nominal prices to the area sown for wheat and barley in Adana and Konya. For wheat, September to October cumulative rainfall in Adana and June to September cumulative rainfall in the previous year increased significantly area sown in Adana and Konya respectively. For Barley, cumulative rainfall from January to October in the previous year in Adana, and from October in two years before to September in the previous year increased area sown in Konya to some extent.

Then, the estimated effects of heat damage, drought, cumulative rainfall, and prices to yield and area sown of wheat and barley were used to predict yield, area sown and production of wheat and barley for the year 2070 in both Adana and Konya provinces assuming that Dr. Kimura's pseudo-warming second run N2(revised)will occur. It was found that wheat yield will decrease by 29.3% from the average yield of 1959-2002 to 2070 in Adana and by 39.9% in Konya. The predicted decrease in wheat area sown in Adana was 24.3%, but wheat area sown in Konya was predicted to increase by 8.4%. Consequently, the total wheat production in Adana was predicted to decrease drastically by 54% in 2070. But in Konya wheat production in 2070 was predicted to decrease only by 32% in 2070. Our prediction seems to show that the global warming decreased Adana wheat production more than Konya because of greater heat damage in Adana than Konya.

For barley, yield in Adana was predicted to decrease by 29.8%, and by 46.3% in Konya. Barley area sown was predicted to increase by 80.3% in Adana, and to decrease by 20.1% in Konya. This difference in predicted area sown is caused by slight increase in the predicted rainfall in Adana, and considerable decrease in the predicted Konya rainfall. Consequently, barley production in Adana was predicted to

increase by 50% by 2070, but in Konya it was predicted to decrease by 66%.

We can conclude that heat damage and drought effects identified to wheat and barley production in Adana and Konya from our econometric study suing past monthly weather data and production data have very strong negative effects to future wheat and barley production in these provinces under global warming situation, and regional differences in the predicted monthly temperature and rainfall for the year 2070 affect very much the predicted differences in wheat and barley production in these provinces.

1. Introduction

Wheat and barley are first two important cereals in Turkey. They occupy about 70% and 30% of the total cereals production in Turkey recently. Barley can tolerate salinity, drought, and lower temperature better than wheat. But these crops are affected by heat damage and drought considerably. GCM and RCM predict that global warming will increase temperature and decrease rainfall in Turkey during the later part of the 21st century, and thus area sown and yield of wheat and barley will be reduced.

First, multiple regression analyses of the effects of heat damage and drought to wheat and barley in Adana and Konya, and of economic factors are done in this paper. The monthly data (1959 to 2002) of rainfall, temperature, and prices(annual data) are regressed with yield and area sown of wheat and barley for Adana and Konya. Then, the estimated results regarding heat damage and drought are used to predict yield, area sown and production of wheat and barley for the year 2070 assuming that Dr. Kimura's pseudo-warming second run N2 revised will occur.

2. Material and Methods

Two main agricultural regions (Adana and Konya) within Turkey were chosen (Figure 1) as study areas.

Adana is located on Mediterranean coast, and very important agricultural province. It has vast irrigated plain on the coast, and very productive and important regarding Turkish agriculture. Osmaniye was separated from Adana province and became a new province in 1997. Thus the Osmaniye's data was added to Adana's data after the year 1997 for our econometric study.

Konya is located on the Anatoria plateau of Turkey with average altitude of about 1000meters above sea level. Konya agriculture has vast area of rainfall-fed cereals field such as wheat and barley. It also has some irrigated agriculture for sugar beat, maize, etc. in closed basins using near fossil underground water. Depletion of this

Figure 1. The study area, Konya (including Karaman) and Adana (including Osmaniye)

underground water by the irrigated agriculture is a serious problem there. Karaman was separated from Konya province in 1989. In our econometric analysis, we added Karaman's data to Konya's data after the year 1989.

Monthly observations of temperature (in degrees centigrade) and monthly precipitation (in millimeters per month) from 1950 to 2004 were obtained from Turkish State Meteorological Service and used in our econometric analysis for Adana and Konya. Annual yield and area sown of wheat and barley were obtained from State Institute of Statistics (SIS) for the period from 1959 to 2002. In addition, necessary information (such as cropping pattern, planting and harvesting times of crops) was obtained from Agricultural Services in each province of our study.

Annual farm gate prices of wheat and barley in each province were obtained from SIS, and they were deflated if necessary by whole sale price index (1938=100).

First, multiple regression analyses of the effects of heat damage and drought to wheat and barley yield, and of the prices, and of the effects of cumulative monthly rainfall and prices to area sown of wheat and barley for Adana and Konya were done in this paper. The monthly data (1959 to 2002) of rainfall, temperature, and prices (annual data) are regressed with yield and area sown of wheat and barley for Adana and Konya, that are the dependent variables. Then, the estimated results regarding heat damage and drought are used to predict yield, area sown and production of wheat and barley for the year 2070 assuming that Dr. Kimura's pseudo-warming second run N2 (revised) will occur.

In order to identify heat damage effect to yield of wheat and barley, we consulted some Cukurova University wheat specialists and our farm survey results in Turkey, then checked simple relations between high monthly average temperature and low wheat and barley yield in the time series data, and identified probable heat damage months, i.e. April and May for barley, and April, May, and June for wheat. Then we defined monthly heat damage dummy variables for these months, that take the value 1 when the monthly average temperature became above certain threshold level temperature that we thought relevant to test heat damage to the yield, and 0 otherwise. We created many heat damage dummies by changing this threshold temperature by 0.1 degree centigrade in the temperature band that we judged relevant for each month, each province, and wheat and barley, and estimated yield response functions with each heat dummy variable. These bands are shown in foot note 1). At most a few most influential heat damage dummies if any were then selected for each wheat and barley yield function in Adana and Konya.

In order to identify drought effect to yield of wheat and barley, we consulted some Cukurova University wheat specialists and our farm survey results in Turkey, then we checked simple relations between low monthly rainfall and low wheat and barley yield in the time series data, and identified probable drought months. Then we defined monthly drought dummy variable, that takes the value 1 when the monthly rainfall became below certain threshold percentage level of the sample average monthly rainfall, 0 otherwise. We created many drought dummies by changing this threshold percentage by one percentage point in the rainfall band that we judged relevant for each month, each province, and wheat and barley, and estimated yield response functions with each drought dummy variable. These bands are shown in footnote 2). The statistically best drought dummy if any was then selected for each wheat and barley yield function in Adana and Konya.

Consulting Cukurova University agronomists and our farm survey results, it was assumed that past cumulative monthly rainfall must affect positively the yield of wheat and barley in both Adana and Konya. After the consultation we estimated yield effects of the cumulative rainfall for many monthly durations, for wheat and barley, both in Adana and Konya. The monthly durations tested are shown in footnote 3).

Farmer's yield response by changing levels of input to a crop is done after the areas own to the crop had been determined before. Thus crop's price change from previous year must be relevant for farmer's decision about input level to the crop that had been sown already. We assume that it is very difficult for a farmer to calculate the change in the real price of the crop he already sowed from previous year because inflation in Turkey had been very serious during the 90's and early 2000's. Consequently, as an economic factor affecting wheat and barley yield, we assumed that nominal farm gate price change from previous year to current year for whet and barley for both Adana and Konya was the relevant price to which the farmer responded their input levels to these two crops.

Area sown of wheat and barley in Adana and Konya were assumed to be affected by past monthly cumulative rainfall and real crop prices as assumed in most of the past supply response studies in the world. We assumed that the farmers in these provinces choose either wheat or barley to sow on the plot they manage. Thus they make this decision based on the real prices in the previous year, such as relative farm gate price between wheat and barley or real crop prices deflated by WPI in the previous year. In rain-fed area in Konya especially, farmers can sow either wheat or barley on the field that they manage. Thus we assume the relative price between these crops in the previous year must be the critical price by which they decide which crop to sow. Consulting Cukurova University agronomists and our farm survey results, it was assumed that past cumulative monthly rainfall must affect positively the area sown for wheat and barley in both Adana and Konya. We tried many monthly cumulative rainfall periods in our econometric estimations as listed in food note 4), and chose the most significant period with a positive coefficient in each area sown response function. In Adana and Konya farmers can plant either wheat or barley on the same rainfall-fed field, and thus we assumed area sown to these crops responded to the relative price in the previous year.

SPSS 11.0 software computer package program was used for our estimation.
After getting the most significant coefficients for the heat damage dummies, drought dummies, monthly cumulative rainfall variables, and price variables for our yield and area sown equations for wheat and barley, we combined these coefficients with the adjusted monthly rainfall and temperature prediction by Dr. Kimura's RCM pseudo-warming 2nd run case (N2 revised) for the period of 2070-2079, and obtained future yield, area sown, and production of wheat and barley for Adana and Konya for the year of 2070.

3. The Estimated Yield and Area Sown Functions for Wheat and Barley

Multiple regression analyses of the effects of heat damage and drought and of the product prices to wheat and barley yield, and of the effects of cumulative monthly rainfall and product prices to area sown of wheat and barley for Adana and Konya were done in this paper. The monthly data (1959 to 2002) of rainfall, temperature, and annual prices were regressed with yield and area sown of wheat and barley for Adana and Konya. Linear functional form was used for all estimations. For wheat estimated yield and area sown functions for Adana and Konya are shown in the following tables.

Estimated parameters were generally significant and had theoretically expected signs in both Adana and Konya. But there were some estimation problems regarding low explanatory power of some estimated functions as shown by some low R^2 values, and serial correlation problem as shown by Durbin Watson statistics. Heat damage and drought effect to yield of wheat were found for both Adana and Konya. The heat damage were found in April and May in both provinces, and in June only in Konya.

Comparing the estimated heat damage coefficients, wheat yield in Adana was affected more by heat damage than in Konya.

ADANA WHEAT (AREA SOWN)

Period of Analysis; from 1959 to 2002
Type of Function; Linear function

Dependent Variable	
ARSWADA(t)	Area Sown in Adana (sown in November, year (t-1), & listed in year (t))
Explanatory Variables	
NPC(t-1)/(t-2)	Nominal Farm Gate Price Change from year (t-1) to year (t-2)
CRSEP(t-1)OCT(t-1)	Cumulative monthly rainfall from September in year (t-1) to October in year (t-1)
DASI	Area sown increase dummy (1980, if year > 1979, 0, otherwise)

Variables	MODEL 1			MODEL 2		
	R^2= 0,640	AR^2= 0,614	DW= 0,928	R^2= 0,467	AR^2= 0,441	DW= 1,058
	Coefficient	**t-value**	**Significant**	**Coefficient**	**t-value**	**Significant**
CONSTANT	193225,49	11,79	0,00	199932,10	10,19	0,00
NPC(t-1)/(t-2)	464,84	1,35	0,18	1531,91	5,24	0,00
CRSEP(t-1)OCT(t-1)	369,82	1,74	0,09	535,42	2,12	0,04
DASI	54,53	4,40	0,00			

Price; Relative Price P_{wheat} / P_{barley} (-1,75), Real Price (-3,95)
Cumulative Rainfal; Total 6 different possibilities. CRASjun(t-1)-sep(t-1) CRASsep(t-1)-nov(t-1) CRASsep(t-1)-oct(t-1) CRASaug(t-1)-oct(t-1) CRASsep(t-1)-Dec(t-1) CRASsep(t-2)-nov(t-1)

ADANA WHEAT (YIELD)

Period of Analysis; from 1959 to 2002
Type of Function; Linear function

Dependent Variable	
YIELADA(t)	Average wheat yield in Adana in year (t)
Explanatory Variables	
NPC	Nominal Farm Gate Price Change
DDMA(t)10	Dummy for drought in May, year (t) (1 if rain <= 10%, 0, otherwise)
DHDAA(t)162	Dummy for heat damage in April in year (t) (1 if temperature >= 16.2 °C, 0, otherwise)
DHDMA(t)235	Dummy for heat damage in May in year (t) (1 if temperature >= 23.5 °C, 0, otherwise)
DYSA	Yield stagnation dummy after 1982, (1983, if year > 1982, current year, otherwise)

Variables	MODEL 1			MODEL 1		
	R^2= 0,752	AR^2= 0,727	DW= 1,757	R^2= 0,261	AR^2= 0,186	DW= 0,758
	Coefficient	**t-value**	**Significant**	**Coefficient**	**t-value**	**Significant**
CONSTANT	-165180,79	-10,39	0,00	2417,33	6,84	0,00
NPC				11,60	3,41	0,00
DDMA(t)10	-75,92	-0,30	0,77	-286,29	-0,61	0,54
DHDAA(t)162	-109,40	-0,54	0,60	-179,24	-0,52	0,61
DHDMA(t)235	-155,62	-0,36	0,72	-409,09	-0,55	0,59
DYSA	85,00	10,58	0,00			

Price; Relative Price P_{wheat} / P_{barley} (-0,70), Nominal Price Change (-1,08), Real Price (-1,32)
Heat Damage; Best result from simple correlation between (March 12,0 °C to 15,2 °C), (April 15,6 °C to 19,0 °C), (May 20,8 °C to 24,0 °C) by each 0,1 °C increase, total 101 different trials.
Drought; Best result from simple correlation between (March 7% to 25%), (April 7% to 25%), (May 7% to 25%), by each 1% increase, total 57 different trials.
Cumulative Rainfal; Total 9 different possibilities but all negative. CRYLsep(t-1)-feb(t) CRYLdec(t-1)-may(t) CRYLdec(t-1)-apr(t) CRYLnov(t-1)-may(t) CRYLnov(t-1)-apr(t) CRYLfeb(t)-apr(t) CRYLjan(t)-may(t) CRYLmar(t)-may(t) CRYLsep(t-1)-may(t)

We think warmer climate in Adana than Konya is the reason for this difference. Heat damage to wheat yield in Adana was identified when monthly average temperature became higher than 16.2 degrees centigrade in April and 23.5 degrees centigrade in May. Heat damage in Konya was identified when monthly average temperature became higher than 12.8 degrees centigrade in April, 16.3 degrees centigrade in May, and 20.7 degrees centigrade in June. Drought effect to wheat yield was identified in different months and at different levels, in May and less than 10%

KONYA WHEAT (YIELD)

Period of Analysis; from 1959 to 2002
Type of Function; Linear function

Dependent Variable	
YIELKON(t)	Average wheat yield in Konya
Explanatory Variables	
NPC	Nominal Farm Gate Price Change
CROCT(t-1)MAY(t)	Cumulative monthly rainfall from October in year (t-1) to May in year (t)
DDAK(t)20	Dummy for drought in April, year (t) (1 if rain <= 20%, 0, otherwise)
DHDAK(t)128	Dummy for heat damage in April, year (t) (1 if temperature >= 12.8 °C, 0, otherwise)
DHDMK(t)163	Dummy for heat damage in May, year (t) (1 if temperature >= 16.3 °C, 0, otherwise)
DHDJK(t)207	Dummy for heat damage in june, year (t) (1 if temperature >= 20.7 °C, 0, otherwise)
DYSK	Yield stagnation dummy after 1978, (1979, if year > 1978, current year, otherwise)

Variables	**MODEL 1**			**MODEL 2**		
	R^2= 0,721	AR^2= 0,667	DW= 1,652	R^2= 0,526	AR^2= 0,449	DW= 1,185
	Coefficient	**t-value**	**Significant**	**Coefficient**	**t-value**	**Significant**
CONSTANT	-89071,73	-4,96	0,00	1085,76	4,24	0,00
NPC	0,10	0,06	0,95	5,63	3,53	0,00
CROCT(t-1)MAY(t)	1,50	2,36	0,02	1,98	2,46	0,02
DDAK(t)20	-78,98	-0,52	0,61	-263,68	-1,38	0,18
DHDAK(t)128	-239,56	-2,02	0,05	-164,48	-1,09	0,28
DHDMK(t)163	-123,23	-1,35	0,19	-210,83	-1,83	0,08
DHDJK(t)207	-166,87	-1,56	0,13	-279,61	-2,08	0,04
DYSK	45,80	5,02	0,00			

Price; Relative Price P_{wheat} / P_{barley} (-2,25), Real Price (-4,40)
Heat Damage; Best result from simple correlation between (April 10,5 °C to 13,2 °C), (May 15,5 °C to 17,5 °C), (June 18,6 °C to 21,0 °C) by each 0,1 °C increase, total 74 different trials.
Drought; Best result from simple correlation between (April 7% to 25%), (May 7% to 25%), (June 7% to 25%), by each 1% increase, total 57 different trials.
Cumulative Rainfal; Total 11 different possibilities. CRYLoct(t-1)-may(t) CRYLjan(t)-may(t) CRYLfeb(t)-apr(t) CRYLfeb(t)-may(t) CRYLsep(t-1)-feb(t) CRYLdec(t-1)-may(t) CRYLdec(t-1)-apr(t) CRYLnov(t-1)-may(t) CRYLnov(t-1)-apr(t) CRYLfeb(t)-apr(t) CRYLmar(t)-may(t)

KONYA WHEAT (AREA SOWN)

Period of Analysis; from 1959 to 2002
Type of Function; Linear function

Dependent Variable	
ARSWKON(t)	Area Sown in Konya (sown in October, year (t-1), & listed in year (t))
Explanatory Variables	
RPWB(t-1)	Relative farm gate price between wheat and barley in year (t-1)
CRJUN(t-1)SEP(t-1)	Cummulative monthly rainfall from June in year (t-1) to September in year (t-1)
DASD	Area sown decline dummy before 1979, (1978, if year < 1979, current year, otherwise)

Variables	**MODEL 1**			**MODEL 2**		
	R^2= 0,619	AR^2= 0,600	DW= 0,580	R^2= 0,134	AR^2= 0,092	DW= 0,453
	Coefficient	**t-value**	**Significant**	**Coefficient**	**t-value**	**Significant**
CONSTANT	15793614,49	7,76	0,00	623466,10	4,28	0,00
RPWB(t-1)	92994,68	1,33	0,19	277925,50	2,52	0,02
CRJUN(t-1)SEP(t-1)				507,84	1,12	0,27
DASD	-7516,76	-7,42	0,00			

Price; Nominal Price Change (-5,81), Real Price (3,21) but rainfall has – sign
Cumulative Rainfal; Total 5 different possibilities. CRASjun(t-1)-sep(t-1) CRASapr(t-1)-sep(t-1) CRASoct(t-2)-sep(t-1) CRASsep(t-1)-oct(t-1) CRASaug(t-1)-oct(t-1)

of the sample average monthly rainfall in Adana, and in April and less than 20% of the sample average monthly rainfall in Konya. The positive effects of nominal wheat price change to its yield was very significant statistically, and the effect in Adana was about twice as large as the effect in Konya. The positive effect of past cumulative rainfall was fount to be very significant only in Adana, and the period was from October previous year to May in current year. This may be caused by the fact that annual rainfall in Adana is about three times more than it in Konya, and most rainfall occurs from October to May in Adana, while monthly rainfall is more evenly distribute in Konya than in Adana.The variable description for Adana barley yield function is as follows.

The R^2 value was very low, but the Durbin Watson test tells us that there was no autocorrelation. Most of the estimated parameters are significant and have theoretically expected signs. This result also showed that heat damage and drought affected Adana barley yield negatively. Although statistically not very significant, it was found that if average monthly temperature became higher than 18.9 degree centigrade in April and 23.4 degree centigrade in May barley yield was found to decrease considerably. Drought effect to Adana barley yield was found that the yield declined significantly when December rainfall became less than 23% of sample average. Adana farmers were also found significantly to respond to the increase in the barley nominal price.

The variable description for Konya barley yield function is as follows.

The estimated result for Konya yield is much better than it for Adana as is shown by the levels of R^2. And the Durbin Watson test tells us that there was no autocorrelation. Most of the estimated parameters for Konya barley yield function are generally more significant than those for Adana barley yield. In both Adana and Konya barley yield functions, the heat damage dummies for April and May were identified to be significant. Although their threshold temperature levels were much lower in Konya than in Adana. In other words, Konya barley was identified to belong to the class of barley the yield of which was reduced by heat damage at much lower temperature than Adana barley in April and May. Drought damage to barley yield was identified to occur by the drought dummy in December in Adana and in May in Konya. These months were the highest rainfall month in Adana and Konya respectively. Farmers' barley yield response to nominal barley price change form previous year to current year was found to be very significant both in Adana and Konya. This was also the case for wheat yield response in both provinces as was shown just above. This consistent result seems to show that farmers in Adana and Konya adjusted their input level not to real price change or relative price between wheat and barley, but to nominal price change of these crops probably because of the spiral inflation especially during the 90's and early 2000's. We call this inflation yield response hypothesis. Cumulative rainfall from October to June was found to be highly significant for Konya barley yield. This period is the high rainfall months in Konya, and thus the rainfall in this period has a strong positive effect to the barley yield in rain-short and dry Konya area.

Next we shall show variable descriptions and our estimation results for barley yield and area sown functions for Adana and Konya in the following tables.

TABLE Description of the Variables for the Barley Yield Function for Adana

NPC	:	Nominal Price Change
DDDA(t)23	:	Drought Effect in December in year (t) (1 if rainfall <= 23%, 0, otherwise)
DHDAA(t)18.9	:	Heat damage in April in year (t) (1 if temperature >= 18.9 °C, 0, otherwise)
DHDMA(t)23.4	:	Heat damage in May in year (t) (1 if temperature >= 23.4 °C, 0, otherwise)

TABLE The Estimated Barley Yield Function for Adana

	R^2= 0.254	AR^2= 0.178	DW= 1.342
Variables	**Coefficient**	**t-value**	**Significant**
CONSTANT	2128.75	31.18	0.00
NPC	1.95	1.84	0.07
DDDA(t)23	-423.78	-1.90	0.07
DHDAA(t)18.9	-135.45	-0.84	0.41
DHDMA(t)23.4	-375.13	-1.42	0.16

TABLE Description of the Variables for Barley Yield Function for Konya

NPC	Nominal Price Change
CROCT(t-1)JUN(t)	Cumulative monthly rainfall from October in year (t-1) to June in year (t)
DDMK(t)17	Dummy for drought in May, year (t) (1 if rainfall <= 17%, 0, otherwise)
DHDAK(t)13.7	Dummy for heat damage in April, year (t) (1 if temperature >= 13.7 °C, 0, otherwise)
DHDMK(t)16.3	Dummy for heat damage in May, year (t) (1 if temperature >= 16.3 °C, 0, otherwise)

TABLE The Estimated Barley Yield function for Konya

	R^2= 0.533	AR^2= 0.472	DW= 1.384
Variables	**Coefficient**	**t-value**	**Significant**
CONSTANT	858.22	3.04	0.00
NPC	4.69	3.22	0.00
CROCT(t-1)JUN(t)	3.43	3.96	0.00
DDMK(t)17	-579.05	-1.34	0.19
DHDAK(t)13.7	-505.21	-1.71	0.09
DHDMK(t)16.3	-309.10	-2.34	0.02

TABLE. Description of the Variables for Barley Area Sown in Adana

RPBARLEY(t-1)	Real Farm Gate Price for Barley deflated by Whole Sale Price Index, 1938=100
CRJAN(t-1)OCT(t-1)	Cumulative monthly rainfall from January in year (t-1) to October in year (t-1)

TABLE The Estimated Barley Area Sown Function for Adana

	R^2= 0.208	AR^2= 0.170	DW= 0.347
Variables	**Coefficient**	**t-value**	**Significant**
CONSTANT	-9912.30	-0.84	0.41
RPBARLEY(t-1)	0.13	3.18	0.00
CRJAN(t-1)OCT(t-1)	15.44	1.11	0.28

TABLE Description of the Variables for Barley Area Sown in Konya

RPBW(t-1)	Relative farm gate price between barley and wheat in year (t-1)
CROCT(t-2)SEP(t-1)	Cumulative monthly rainfall from October in year (t-1) to September in year (t-1)

TABLE The Estimated Function for Barley Area Sown in Konya

	R^2= 0.114	AR^2= 0.070	DW= 0.277
Variables	**Coefficient**	**t-value**	**Significant**
CONSTANT	208247.40	1.67	0.10
RPBW(t-1)	290201.00	2.20	0.03
CROCT(t-2)SEP(t-1)	105.62	0.51	0.61

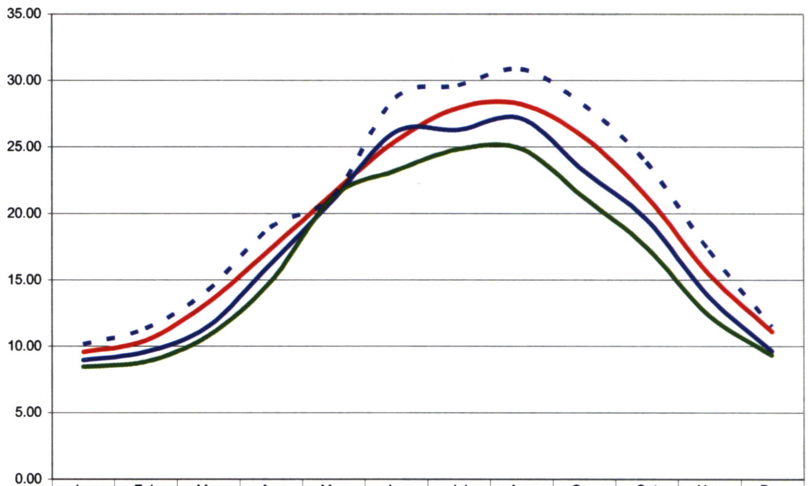
The explanatory power of the estimated area sown functions was low as shown by low R2 values. But the expected signs of the estimated coefficients met with the theoretical hypothesis presented above. The durations of monthly cumulative rainfall identified to be positively correlated with area sown were from January to October in the previous year for Adana and form October in two years ago to September in the previous year for Kese correlations were low as shown by the low t-values, this results seemed to indicate that more cumulative rainfall for long monthly periods increased soil moisture level which made framers to be able to plant barley for wider area.

As we assumed above, the coefficient to the real farm gate price of barley in previous year was positive and very significant for Adana barley area sown function and the coefficient to the relative farm gate price between barley and wheat was also positive and very significant for Konya barley area sown function. This results are consistent with many past supply response studies in the world.

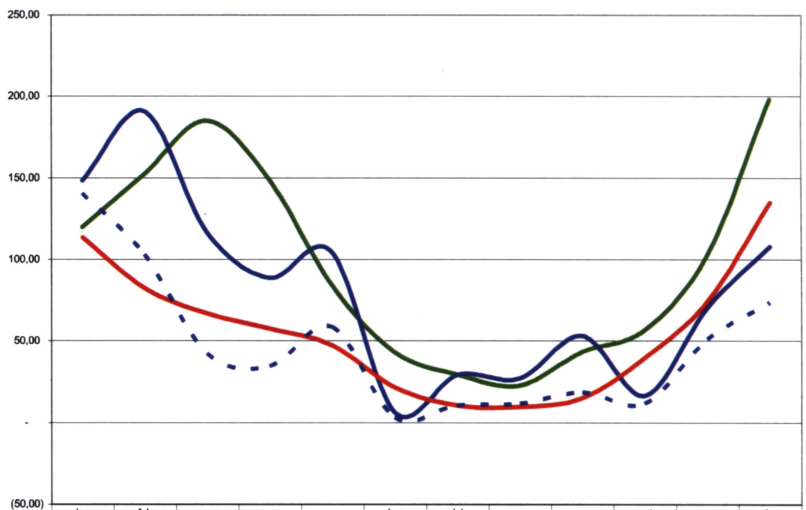
4. Biases in the Pseudo Warming RCM Calculation and Their Revisions

Dr. Kimura's pseudo-warming second run N2 RCM prediction revised from 2070 to 2080 has model biases. These biases were revised by subtracting these biases from the RCM prediction of monthly rainfall and temperature for the ten year period form 2070, and revised weather data was used to predict area sown, yield, and production of

ADANA temperature and rainfall bias revision



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Real (1950-2004) ADANA	9.60	10.48	13.34	17.35	21.52	25.47	27.95	28.23	25.74	21.29	15.46	11.14
ADANA (future estimation)	8.99	9.60	11.52	16.21	21.03	26.13	26.28	27.17	23.21	19.60	13.76	9.68
ADANA (present estimation)	8.48	8.87	10.80	14.85	21.26	23.19	24.82	24.86	21.22	17.50	12.35	9.35
Adjusted ADANA	10.19	11.35	14.23	18.94	21.30	28.70	29.59	30.85	28.15	23.85	17.22	11.53



	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
ADANA rain (present estimation)	120,09	152,54	185,35	149,27	84,46	43,34	29,44	22,83	43,51	57,00	102,70	198,26
ADANA rain (future estimation)	148,51	190,87	117,08	88,86	104,88	6,49	29,23	27,19	53,39	16,76	70,58	108,31
Real (1950-2004) ADANA	113,83	82,45	67,15	57,79	47,42	21,78	10,70	9,91	15,32	40,22	74,71	135,31
Adjusted ADANA	140,77	103,16	42,41	34,40	58,88	3,26	10,63	11,80	18,79	11,83	51,35	73,92

wheat and barley in Adana and Konya for 2070 when global warming will occur. Revisions of model biases are shown in the figures listed in two attached Word files.

5. Predictions of Wheat and Barley Production in Adana and Konya by Integrating Our Estimation Results and Bias Revised Pseudo-warming RCM Prediction

Predictions of wheat and barley production in Adana and Konya was done by integrating our estimation results and bias revised pseudo-warming RCM prediction. The results are shown in the following table.

It was found that wheat yield will decrease by 29.3% from the average yield of 1959-2002 to 2070 in Adana and by 39.9% in Konya. The predicted decrease in wheat area sown in Adana was 24.3%, but wheat area sown in Konya was predicted to increase by 8.4%. Consequently, the total wheat production in Adana was predicted to decrease drastically by 54% in 2070. But in Konya wheat production in 2070 was predicted to decrease only by 32% in 2070. Our prediction seems to show that the global warming decreased Adana wheat production more than Konya because of greater heat damage in Adana than Konya.

For barley, yield in Adana was predicted to decrease by 29.8%, and by 46.3% in Konya. Barley area sown was predicted to increase by 80.3% in Adana, and to decrease by 20.1% in Konya. This difference in predicted area sown is caused by slight increase in the predicted rainfall in Adana, and considerable decrease in the predicted Konya rainfall. Consequently, barley production in Adana was predicted to increase by 50% by 2070, but in Konya it was predicted to decrease by 66%.

We can conclude that heat damage and drought effects identified to wheat and barley production in Adana and Konya from our econometric study suing past monthly weather data and production data have very strong negative effects to future wheat and barley production in these provinces under global warming situation, and regional differences in predicted monthly temperature

FUTURE ESTIMATION ON BARLEY AND WHEAT

BARLEY

ADANA YIELD	Coefficient		2070-2079	1959-2002		%	
CONSTANT	2128.75	1	2128.75				
Nominal price change	1.95	32.8	63.96				
DDDecember(t)23	-423.78	1	-423.78				
DHDApril(t)18,9	-135.45	1	-135.45				
DHDMay(t)23,4	-375.13	0	0.00				
			1,633	2,328	-	29.8	decrease

ADANA AREA SOWN	Coefficient		2070-2079	1959-2002		%	
CONSTANT	-9912.3	1	-9912.30				
Real PriceBARLEY(t-1)	0.13	241048.00	31336.24				
CRJAN(t-1)OCT(t-1)	15.44	338.0787	5219.93				
			26,644	14,779		80.3	increase

KONYA YIELD	Coefficient		2070-2079	1959-2002		%	
CONSTANT	858.22	1	858.22				
Nominal price change	4.69	32.8	153.83				
CROCT(t-1)JUN(t)	3.43	214.8864	737.06				
DDMay(t)17	-579.05	1	-579.05				
DHDApril(t)137	-505.21	0	0.00				
DHDMay(t)163	-309.10	0	0.00				
			1,170	2,178	-	46.3	decrease

KONYA AREA SOWN	Coefficient		2070-2079	1959-2002		%	
CONSTANT	208247.40	1	208247.40				
RelativePriceBW(t-1)	290201.00	0.79	229258.79				
CROCT(t-2)SEP(t-1)	105.62	297.4769	31419.51				
			468,926	587,142	-	20.1	decrease

in the equation, average price (1935-2002) was used for all price estimation

WHEAT

ADANA YIELD	Coefficient		2070-2079	1959-2002		%	
CONSTANT	2417.33	1	2417.33				
Nominal price change	11.6	31.2	361.92				
DDMay(t)10	-286.29	1	-286.29				
DHDApril(t)162	-179.24	1	-179.24				
DHDMay(t)235	-409.09	0	0				
			2,314	3,274	-	29.3	decrease

ADANA AREA SOWN	Coefficient		2070-2079	1959-2002		%	
CONSTANT	199932.10	1	199932.10				
Nominal price change	1531.91	31.2	47795.59				
CRSEP(t-1)OCT(t-1)	535.42	43.7	23386.87				
			271,115	357,941	-	24.3	decrease

KONYA YIELD	Coefficient		2070-2079	1959-2002		%	
CONSTANT	1085.76	1	1085.76				
Nominal price change	5.63	31.2	175.66				
CROCT(t-1)MAY(t)	1.98	215	424.98				
DDApril(t)20	-263.68	1	-263.68				
DHDApril(t)128	-164.48	0	0.00				
DHDMay(t)163	-210.83	0	0.00				
DHDJune(t)207	-279.61	1	-279.61				
			1,143	1,903	-	39.9	decrease

KONYA AREA SOWN	Coefficient		2070-2079	1959-2002		%	
CONSTANT	623466.10	1	623466.10				
RelativePriceWB(t-1)	277925.50	1.3	361303.15				
CRJUN(t-1)SEP(t-1)	507.84	56.56	28722.00				
			1,013,491	934,822		8.4	increase

and rainfall for year 2070 also affect very much the predicted differences in wheat and barley production between these provinces.

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Notes:

1) For Barley for example the heat damage bands for Adana Province were (March 12.7 °C to 15.7 °C), (April 15.5 °C to 19.0 °C), (May 20.5 °C to 23.6 °C). For Konya the heat damage bands were (March 5.1 °C to 8.5 °C), (April 10.5 °C to 13.8 °C), (May 14.5 °C to 17.8 °C), (June 19.5 °C to 22.2 °C).
2) For barley for example drought damage bands were (December 7% to 25%); (January 7% to 25%); (February 7% to 25%); (March 7% to 25%), (April 7% to 25%), (May 7% to 25%) for Adana.For Konya, the drought damage bands were (Mach 7% to 25%), (April 7% to 25%), (May 7% to 25%), (June 7% to 25%).
3) For the test of the effect of monthly periods of cumulative rainfall to barley yield for example, the periods tested for Adana were sep(t-1)-feb(t), dec(t-1)-may(t), dec(t-1)-apr(t), nov(t-1)-may(t), nov(t-1)-apr(t), feb(t)-apr(t), jan(t)-may(t), mar(t)-may(t). The periods tested for Konya were oct(t-1)-may(t), nov(t-1)-may(t), oct(t-1)-jun(t), nov(t-1)-jun(t), jan(t)-may(t), mar(t)-may(t), mar(t)-jun(t), apr(t)-jun(t), may(t)-jun(t)
4) For the test of the effect of monthly periods of cumulative rainfall to barley area sown for example, the periods tested for Adana were jun(t-1)-sep(t-1), sep(t-1)-nov(t-1), sep(t-1)-oct(t-1), aug(t-1)-oct(t-1), may(t-1)-nov(t-1), jun(t-1)-aug(t-1), aug(t-1)-oct(t-1), jan(t-1)-oct(t-1), mar(t-1)-oct(t-1), feb(t-1)-oct(t-1). For Konya these periods were jun(t-1)-sep(t-1) apr(t-1)-sep(t-1) oct(t-2)-sep(t-1) jan(t-1)-sep(t-1) mar(t-1)-sep(t-1) may(t-1)-sep(t-1)

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