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# Supply Response of Cereals in Iran: An Auto-Regressive Distributed Lag Approach

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**Abstract:** Supply response to commodity price is a core issue of agricultural economics. This study quantifies the responsiveness of Iranian producers of wheat, barley and corn to incentives using an Auto-Regressive Distributed Lag (ARDL) approach. This method simultaneously estimates the long-run and short-run patterns and removes the resulted problems of variables elimination and autocorrelation. It is found that: Firstly, there is insignificant long-run and short-run guaranteed own price elasticity for all crop types. Secondly, 1% increase in yield risk will decrease the wheat, barley and corn's planted area 5.92, 4.98 and 6.09%, respectively. Finally, the wheat and barley planters supply response to 1% increase in amount of rain in millimeters during the early months of the season is 4.76 and 3.79%, respectively.

**Key words:** Supply response, cereals, guaranteed price, planted area, auto-regressive distributed lag approach

## INTRODUCTION

The agricultural products represent the main alimentary source for 6.7 billion people. Therefore agriculture represents that fundamental sector of the world economy that has to supply food for all mankind. According to FAO prospects from 2007, the agricultural production increased annually by 2.2% in the past decade and a half. This growth is due mainly to the developing countries which increased output by almost 3.4% per year, compared to the mere 0.2% increase per year in the developed countries. The developing countries produce now 67% of the world agricultural production, while 25 years ago the proportion was only 50% (FAO United Nations, 2009). Cereal crops are the most important of food crops gross production and extend over 55% of total arable land (0.7 billion hectares). The developing countries contribute with 57% to the world cereal production, while the developed countries contribute with 43% (FAO United Nations, 2009). Similarly, agriculture is one of the most important sectors of the Iranian economy in order that since 1979 commercial farming has replaced subsistence farming as the dominant mode of agricultural production. The 1979 Revolution sought self-sufficiency in foodstuffs as part of its overall goal of decreased economic dependence on the other countries. Higher government subsidies for grain and other staples and expanded short-term credit and tax exemptions for farmers complying with government quotas were intended by the new regime to promote self-sufficiency. But by early 1987, Iran was actually more dependent on agricultural imports than in the 1970s. By 1997, the gross value of products in Iran's agricultural sector had reached $25 billion. In 2003, a quarter of Iran's non-oil exports were agricultural based. Iran's agricultural sector contributed 11% of the GDP in 2004 and employed a third of the labor force. Benefiting from 123,580 $km^2$ of land suitable for agriculture, the agricultural sector is one of the major contributors to Iran's economy. It accounts for almost 13% of Iran's GDP, 20% of the employed population, 23% of non-oil exports, 82% of domestically consumed foodstuffs and 90% of raw materials used in the food processing industry (Iran's Ministry of Agricultural Jihad, 2009). Beside cereals are of great importance in Iranian agriculture. In 2007, cereal production was nearly 23.5 million tones. Wheat takes the most important place in cereals with a share of 42.6%, barley ranks second with 3.2 million tones 25.5% and is followed by corn with a share of 7.5%. The remaining 2.5% consists of the production of other crops (Iran's Ministry of Agricultural Jihad, 2009).

According to the above table the average growth rate of wheat, barley and corn guaranteed prices during the 1991-2009, are 20.57, 19.28 and 18.51%, respectively. In addition, the average growth rate of wheat, barley and corn planted area during the 1991-2009, are 1.05, -1.32 and 17.07%, respectively. Therefore, Table 1 conclude that the price incentives couldn't work well in long-run.

On the other hand, roughly one-third of Iran's total surface area is suited for farmland, but because of poor soil and lack of adequate water distribution in many areas, most of it is not under cultivation. Only 12% of the total land area is under cultivation but less than one-third of

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the cultivated area is irrigated; the rest is devoted to dry farming (Iran's Ministry of Agricultural Jihad, 2009). Therefore, according to the key role of cereals in food security and lack of suited farmland in Iran, studying the factors which affect the supply response of Iran's cereal is unavoidably. This study estimates the responsiveness of producers of wheat, barley and corn to incentives in Iran. Supply response to commodity price is a core issue of agricultural economics. Assessing supply response is fundamental to analysis of farm programs. Also, Supply response is used as a tool to evaluate the effectiveness of price policies in the allocation of farmer's resource and estimates of supply responsiveness provides useful guidelines to the formulation of economic policy (Huq and Arshad, 2010).

This study quantifies the responsiveness of producers of wheat, barley and corn to incentives in Iran. Several studies have been carried out to analyze the planter's effectiveness to incentives. Alwan and El-Habbab (2002) estimated the Jordan's wheat supply response function and concluded that holding fragmentation is the major factor that negatively affects wheat production. Also, the partial adjustment coefficient was low (i.e., less than one), which means that the farmers need more than one year to change their producing habits. Begum *et al.* (2002) determined the wheat supply response to selected factors and to analyze the short run and long run supply responses of wheat in Bangladesh. They found that the implementation of a farm price support policy could be used to manipulate wheat supply in Bangladesh. If the government would follow a price stabilization policy, it would reduce price risk and would produce a positive impact on wheat supply situation in Bangladesh. Alemu *et al.* (2003) quantified the responsiveness of producers of teff, wheat, maize and sorghum to incentives using an Error-Correction Model (ECM). They found that planned supply of these crops is positively affected by own price, negatively by prices of substitute crops and variously by structural breaks related to policy changes and the occurrence of natural calamities. Edet *et al.* (2007) studied the maize supply response to changes in real prices in Nigeria. They stated that the response of maize farmers to real maize price is very high and among other interventions, their study recommends a policy package that would boost the demand for maize by stimulating its utilization by small and medium enterprises and large scale industries. Muchapondwa (2008) estimated the supply response of Zimbabwean agriculture during 1970-1999. He found that the agricultural price policy is a somewhat blunt instrument for effecting growth in aggregate agricultural supply. The provision of non-price incentives must play a key role in reviving the agricultural sector in Zimbabwe. Huq and Arshad (2010) estimated the supply response of potato in Bangladesh. They reported that the price policies are effective in obtaining the desired level of output for potato. If intervention in the market is necessity, it must be implemented during the harvest season for altering expectations. According to the key role of cereals in food security, in this research we quantify the supply response function of cereals in Iran using new Auto-Regressive Distributed Lag (ARDL) approach which simultaneously estimates the long-run and short-run patterns and removes the resulted problems of variables elimination and autocorrelation.

## MATERIALS AND METHODS

**Supply response function of cereals:** In our research, the supply response function will be estimated. This function takes care of lagged affects such as the price of the product and substitute product in the previous period. Sadoulet and de Janvry (1995) noted that central problem in the estimation of this function is that producers respond to expected as opposed to actual prices. The Lagged Model includes Auto-Regressive Distributed Lag, will be used to estimate this function for wheat, barley and corn produced in Iran. This model enables us to estimate the speed of farmers' response to changes in prices. This will help decision makers to choose the best policy that could increase these crops production. In our study, the planted area is taken as the dependent variable. The rationale for this is that farmers planting decisions follow two steps. In the first step they decide on the planted area and then they decide on the level of input application (Houck and Ghallagher, 1976). In addition, the use of area as proxy to production depends on the fact that the farmer has full control on the planted area decision. The expected production however, depends on factors that cannot be predicted such as weather. The direct relationship between planted area and production can be explained through Fig. 1a-c, which states the wheat, barley and corns guaranted price, planted are and yield in Iran during 1991-2009. A movement through guaranteed prices causes an increase in the planted area of the crops and this will be followed by an increase in yield (Ghatak and Ingerent, 1984).

The general supply response function is given by:

$$ha_{j,\,t} = f(P^*_{j,\,t-1},\ Po^*_{k(\neq j),\,t-1},\ Risk_{j,\,t},\ R_L)\ \ ;\ j = \text{wheat,barley,corn} \quad (1)$$

where, $ha_{j,t}$ is planted area of $j^{th}$ product in current year, $P^*_{j,\,t-1}$ is expected price of $j^{th}$ product in previous year, $Po^*_{k(\neq j),\,t-1}$ is expected price of substitute product (k) with

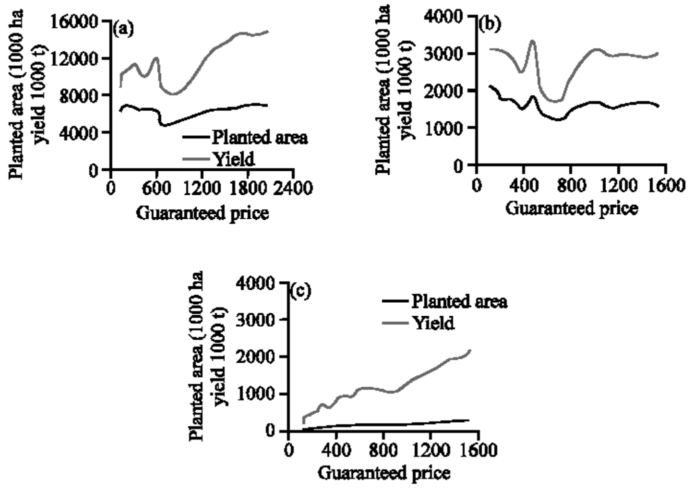


Fig. 1: Direct relationship between planted area and production; (a) Wheat , (b) Baeley and (c) Corn

jth product in previous year, $Risk_{j,t}$ is productivity risk of jth product in current year and $R_L$ is the amount of rain in millimeters during the early months of the season. The rationale for choosing the guaranteed price and yield risk in Eq. 1 is explained in the following sections:

- **Guaranteed price:** According to economic theory, prices play an important role in deciding what to produce, i.e. how to produce and for whom to produce. Also, the Cobbweb model which is used to explain the unstable performance of many agricultural commodity markets the solution of this model gives the time path of current prices as a function of time and market equilibrium is achieved if the follow equation be obtained (Sandoulet and de Janvry, 1995):

$$P_t = P_{t-1} \Rightarrow P_t^* = P_{t-1} \quad (2)$$

where, $P^*_t$ is the expected price in the current year which in our study the guaranteed price of previous year is it's suitable proxy.

- **Yield risk:** The agricultural sector is characterized by risk in production and prices. This is mainly due to the effect of climate on the production of crops grown in rain-fed areas. This kind of risk is called "Yield Risk". The risk variable can be calculated according to the "Gallagher Method" (Gallagher, 1978):

$$Risk_{j,t} = \frac{[Y_{j,t-1} - 0.5(Y_{j,t-2} + Y_{j,t-3})]^2}{0.5(Y_{j,t-2} + Y_{j,t-3})} \; ; \; j = w, b, c \quad (3)$$

where, $Risk_{j,t}$ is the productivity risk; $Y_{j,t-1}$ is the yield of $j^{th}$ product in the previous year; yield of $j^{th}$ product before two years and $Y_{j,t-3}$ is the yield of $j^{th}$ product before three years. Simply, this variable states that the expected yield risk for current period (t) is the difference between the real yield of current period (t) and the average yield of the previous periods (t-2 and t-3).

- **Statistical hypotheses:** We expect that "own guaranteed price" and "amount of rain during the last seasons" have positive effect on Iranian cereals farmer response while the "price of substitute crop" and "yield risk negatively" affect it.

Finally, all of the required data was gathered from the Iran's Jihad Ministry of Agriculture and the project was conducted during the period February to October 2010 in Mashhad-Iran.

**Auto-Regressive Integrated Moving Average (ARDL) Approach:** In this research, in order to study the long-run and short-run relationship between depended and independent variables, we apply the ARDL approach. In this model, the equality of variables co-integration degree is not essential while in Engel-Granger method, it is necessary (Greene, 2002). Other advantages of ARDL are the simultaneously estimation of long-run and short-run patterns and removing the resulted problems of variables elimination and autocorrelation.

The long-run supply response functions of wheat, barley and corn based on dynamic ARDL model have been presented in Eq. 4-6:

$$\ln haw_{(t)} = \delta_0 + \delta_{Pw(t-1)} \ln Pw_{(t-1)} + \delta_r \ln R_t + \delta_{Pb(t-1)} Pb_{(t-1)} + \delta_{Risk} \ln Risk_{wt} + u_{1t} \quad (4)$$

$$\ln hab_{(t)} = \delta_0 + \delta_{Pb(t-1)} \ln Pb_{(t-1)} + \delta_r \ln R_t + \delta_{Pw(t-1)} Pw_{(t-1)} + \delta_{Risk} \ln Risk_{bt} + u_{2t} \quad (5)$$

$$\ln hac_{(t)} = \delta_0 + \delta_{Pc(t-1)} \ln P_{c(t-1)} + \delta_r \ln R_t + \delta_{Ps(t-1)} \ln Ps_{(t-1)} + \delta_{Risk} \ln Risk_{ct} + u_{3t} \quad (6)$$

where, lnhaw, lnhab, lnhac, lnPw, lnPb, lnPc ,lnPs , lnR and lnRisk are the natural logarithm of wheat planted area, barley, corn, wheat guaranteed price, barley guaranteed price, corn guaranteed price, sugar beef- as the corn substitute product- guaranteed price, rain and yield risk, respectively.

Also, the existence of co-integration among a set of economic variables provides the application of error correction models. In this research, the error correction model can be written like this:

$$\Delta \ln ha_{i(t)} = \Delta\alpha_0 + \sum_{n=1}^{o} \hat{\beta}_i \Delta \ln ha_{i(t-n)} + \sum_{n=1}^{p} \hat{\gamma}_i \Delta \ln P_{i(t-n)} + \sum_{n=1}^{q} \hat{\lambda}_i \Delta \ln R_{(t)} + \sum_{n=1}^{r} \hat{\omega}_i \Delta \ln P_{j(t-n)} + \sum_{n=1}^{s} \hat{\varphi}_i \Delta \ln Risk_{i(t)} + \theta ECT_{t-1} + u_{4t} \quad (7)$$

And the error correction term $ECT_{t-1}$ is as follow:

$$ECT_{t-1} = \ln ha_{i(t)} - \hat{\alpha}_0 - \hat{\gamma}_1 \ln P_{i(t-1)} - \hat{\lambda}_1 \ln R_{(t)} - \hat{\omega}_1 \ln P_{j(t-1)} - \hat{\varphi}_1 \ln Risk_{i(t)} \quad (8)$$

In relations 7 and 8, $\Delta$ is the first order difference factor and $\hat{\beta}_i$, $\hat{\gamma}_i$, $\hat{\lambda}_i$, $\hat{\omega}_i$ and $\hat{\varphi}_i$ are, respectively the estimated coefficients. Also, $\theta$ is the coefficient of error correction term which, measures the modify rate. So that o, p, q, r and s are numbers of the best lags for the variables $lnha_i$, $lnP_i$, lnR, $lnP_j$ and lnRisk, respectively.

## RESULTS AND DISCUSSION

**Estimation long-run supply response function of cereals:** Here, we estimate the long-run supply response function of wheat, barley and corn. In order to studying the existence of long-run relations between variables of supply response functions, the required t statistic for wheat, barley and corn's long-run response functions was calculated equal to -4.93, -5.75 and -4.62, respectively which are more than the absolute of offered critical quantity by Banerjee *et al*. (2002) in 5% significance level. Therefore we can't reject the existence of long-run relationship among the model variables. Table 1 show

Table 1: Results of estimations of long-run supply response function

| Variable | Coefficient | Standard error | t-statistic |
|---|---|---|---|
| **Wheat** | | | |
| Wheat guaranteed price | 0.7792 | 0.5035 | 1.5475 |
| Rain | 4.7565 | 0.9734 | 4.8865* |
| Barley guaranteed price | -0.4012 | 1.2547 | -0.3198 |
| Yield risk | -5.9194 | 0.9995 | -5.9224* |
| Intercept | 3.7185 | 0.5031 | 7.3907* |
| Trend | -13.1106 | 38.1943 | -0.3433 |
| Test statistics | | | LM version |
| Serial Correlation | | | 25.94 (0.11) |
| Functional Form | | | 8.53 (0.18) |
| Heteroscedasticity | | | 43.76 (0.09) |
| * Significant at 1% level | | | |
| Variable | Coefficient | Standard error | t-statistic |
| **Barley** | | | |
| Barley guaranteed price | 0.7675 | 0.4853 | 1.5815 |
| Rain | 3.7866 | 0.9505 | 3.9838* |
| Wheat guaranteed price | -0.8999 | 0.4801 | -1.8744*** |
| Yield risk | -4.9784 | 0.8712 | -5.7144* |
| Intercept | 3.4837 | 0.5615 | 6.2043* |
| Trend | 15.3019 | 3.8753 | 3.9486* |
| Test statistics | | | LM version |
| Serial Correlation | | | 14.89 (0.13) |
| Functional Form | | | 7.41 (0.15) |
| Heteroscedasticity | | | 37.69 (0.08) |
| *Significant at 1% level. ***Significant at 10% level | | | |
| Variable | Coefficient | Standard error | t-statistic |
| **Corn** | | | |
| Corn guaranteed price | 0.7886 | 0.4911 | 1.6058 |
| Rain | 1.6003 | 0.9989 | 1.6021 |
| Sugar beet guaranteed price | -0.7022 | 0.4924 | -1.4261 |
| Yield risk | -6.0893 | 1.5502 | -3.9281* |
| Intercept | 3.7512 | 1.0232 | 3.6661* |
| Test statistics | | | LM version |
| Serial correlation | | | 16.91 (0.17) |
| Functional form | | | 10.37 (0.19) |
| Heteroscedasticity | | | 41.83 (0.11) |
| *Significant at 1% level | | | |

the coefficient of estimated long-run response functions using ARDL approach and Schwartz-Bayesian criterion:

Table 1 shows that according to LM version of test statistics, functional form of wheat, barley and corn long-run supply response function is acceptable. Also, the existence of serial correlation and heteroscedasticity hypothesizes will be rejected. In addition, Table 1 indicates that: wheat and barley guaranteed prices have no significant effects on wheat long-run supply response function in this mean that wheat planters don't show significant response to own and substitute product price incentives in long-run. Yield risk has the greatest share in wheat planters long-run supply response in order that 1% increases in yield risk will decrease the wheat planted area equal to 5.92%. Beside amount of rain during the early months of the season has the significant effect on wheat long-run supply response function in order that 1% increases in rain will increase the wheat planters supply response equal to 4.76%. Also, results show that barley guaranteed price has no significant effect on barley long-run supply response function this mean that like wheat planters barley planters don't show significant response

Table 2: Error correction model estimations of cereals supply response function

| | Coefficient of supply response | | | Error term of supply response | | | t statistic of supply response | | |
|---|---|---|---|---|---|---|---|---|---|
| Variable | Wheat | Barley | Corn | Wheat | Barley | Corn | Wheat | Barley | Corn |
| Wheat guaranteed price | 0.55 | -0.79 | ... | 0.46 | 0.45 | ... | 1.21 | -1.75*** | ... |
| Barley guaranteed price | -0.39 | 0.54 | ... | 1.17 | 0.46 | ... | -0.33 | 1.19 | ... |
| Sugar beet guaranteed price | ... | ... | -0.63 | ... | ... | 0.46 | ... | ... | -1.37 |
| Corn guaranteed price | ... | ... | 0.56 | ... | ... | 0.46 | ... | ... | 1.22 |
| Rain | 3.74 | 2.96 | 1.21 | 0.90 | 0.91 | 0.96 | 4.13* | 3.25* | 1.26 |
| Yield risk | -4.81 | -4.05 | -4.94 | 0.93 | 0.83 | 1.50 | -5.17* | -4.86* | -3.30* |
| Intercept | 2.90 | 2.72 | 2.93 | 0.46 | 0.53 | 0.98 | 6.34* | 5.12* | 2.98* |
| Trend | -10.56 | 12.17 | ... | 36.26 | 3.78 | ... | -0.29 | 3.22* | ... |
| Error Correction Term | -0.39 | -0.24 | -0.49 | 1.26 | 0.80 | 1.54 | 3.22* | 3.35* | 3.14* |

*Significant at 1% level. ***Significant at 10% level

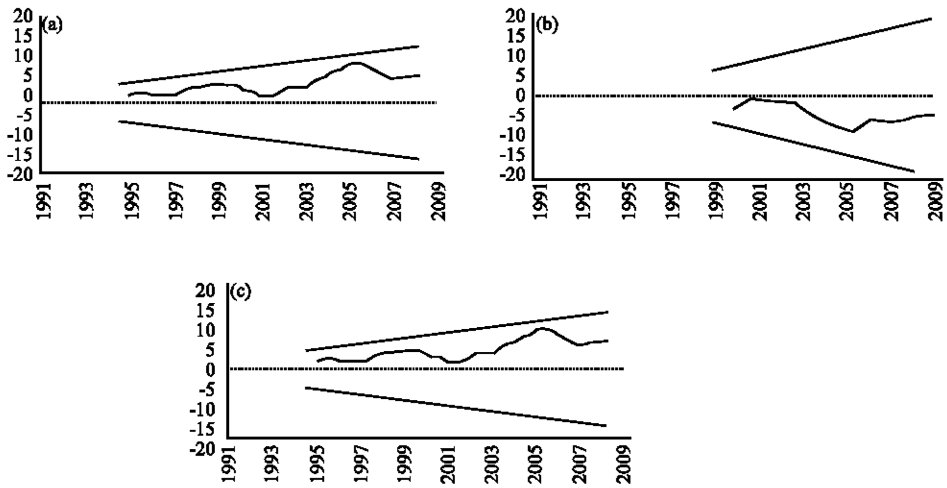


Fig. 2: Plot of Cusum of Iran's selected cereals planted area; (a) Wheat, (b) Corn and (c) Barley

to own price in long-run, too. Wheat guaranteed price, has significant effect on barley long-run supply response function with the -0.9 of elasticity. Therefore, in long-run 1% increase in wheat guaranteed price will decrease the barley planted area equal to 0.9%. Similarly, amount of rain during the early months of the season and yield risk have the significant effect on barley long-run supply response function in order that 1% increscent in amount of rain will increase the barley planters supply response equal to 3.79 and 1% increase in yield risk will decrease the barley planted area equal to 4.98%. Finally, corn and sugar beet guaranteed prices have no significant effect on corn long-run supply response. In this mean that like wheat planters, corn planters don't show significant response to own and substitute product price incentives in long-run. In addition because the corn is an irrigated crop, the amount of rain during the early months of the season doesn't affect the corn planters supply response in long-run. Beside the yield risk have the significant effect on corn long-run supply response function in order that in long-run 1% increscent in yield risk will decrease the corn planted area equal to 6.09%.

**Estimation short-run supply response function of cereals:** Generally, the error correction model engages the short-run fluctuations in their long-run quantities. Table 2 illustrates the short-run wheat, barley and corn supply response functions.

The results of Table 2, error correction model estimations of cereals supply response function indicate that firstly, the wheat short-run supply response is the significant function of amount of rain during the early months of the season and yield risk. In order that 1% increase in amount of rain will increase the wheat planted area equal to 3.74% in short-run and 1% increase in yield risk will decrease the wheat planted area equal to 4.81% in short-run. Also, like long-run supply response, wheat planters don't show significant response to price incentives in short-run. Secondly, barley short-run supply response is the significant function of amount of rain during the early months of the season, yield risk and wheat guaranteed price (at 10% significant level). In order that 1% increase in amount of rain will increase the barley planted area equal to 2.96% in short-run and 1% increase in yield risk will decrease the barley planted area equal to

4.05% in short-run. Beside, like long-run supply response, barley planters don't significant response to own guaranteed price in short-run. But barley planters will response to wheat guaranteed price with the elasticity of -0.8 in short-run. Finally, corn short-run supply response is only the significant function of yield risk. In order that 1% increases in yield risk will decrease the corn planted area equal to 4.94% in short-run. Also that like long-run supply response, corn planters don't show significant response to price incentives in short-run. In addition, the coefficient of error correction term ($ecm_{t-1}$) for wheat, barley and corn are significant and equal to -0.39, -0.24 and -0.49, respectively. In this mean that respectively 39, 24 and 49%, respectively of inequality of depended variable (wheat, barley and corn supply response) will adjust to long-run relation after one period.

Beside, the stability of estimated coefficients during the studied period has tested by Cumulative sum of recursive residuals (Cusum) test. Figure 2a-c illustrate the results of this test.

According Fig. 2, the coefficients of estimated models are stable. Because their Cusum are located between the two up and down straight lines (In above figures the straight lines represent critical bounds at 5% significance level).

## CONCLUSION

In this study, we evaluated the factors which affect cereals supply response using new Auto-Regressive Distributed Lag (ARDL) approach. We found that there is insignificant long-run and short-run guaranteed own price elasticity for all crop types. But the long-run elasticity of barley supply response for wheat guaranteed price is -0.90 (significant at 10% level). Beside, the elasticity of wheat, barley and corn supply response for yield risk is -5.92, -4.98 and -6.09%, respectively. In addition, wheat and barley planters supply response to 1% increase in amount of rain in millimeters during the early months of the season is 4.76 and 3.79%, respectively and because the corn is an irrigated crop, the amount of rain during the early months of the season doesn't affect the corn planters supply response in long-run. Also, the results of error correction model estimations of cereals supply response function showed that 39, 24 and 49% of inequality of wheat, barley and corn supply response function will adjust to long-run relation after one period. The paper concludes that farmers don't respond to price incentive changes. Thus, attempt to introduce the non-price incentives to the farmers' decision making is unavoidably.

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