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Wheat Production Response to the Shocks of some Economic Variables in Iran (Vector Autoregression Model Framework)

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Abstract: Recognizing response of economic variables consciously and based on scientific theories results in intelligent decision making. In the past years, Iran has been considered as an agricultural section and particularly wheat has been considered as a strategic product in the upstream documents such as Iran 20- year vision plan and the Five-Year Economic Development Program rules. So, in this paper, Phillips-Perron, Johanssen, impulse response function, variance decomposition and vector autoregressive model are used following studying response of wheat and important effective variables in this part. The results indicate that response of wheat production to shocks applied by variables of added value in agricultural division and wheat cultivation area is positive, increasing and the standard deviation which has been created in production of wheat in the first period has been explained completely by wheat production.

JEL Classification: C32, C52, Q11

Keywords: Impulse response function, Johanssen test, variance decomposition, vector autoregressive model and wheat

I. Introduction

Agriculture section is of high importance in development programs as a critical section in economic growth, development and strategic section in fulfillment of food requirements of Iran's growing population. This section comprises about 15% of GDP and one fifth of total employees of the country and supplies 80% of the required local food products.

After Islamic Revolution, attention was increasingly paid to agriculture section, but study of development programs shows that although the obtained yield was more than the determined goal in some agricultural subsections, the gap between yield and goal was very large in some subsections and the measures taken in the framework of programs could not realize the desired goals. This case mainly originates from structural limitations and weaknesses of this section (Hakimipour, 2004). In this study, the effect of wheat cultivated area, value added of agricultural division and price of wheat have been studied among all potential variables affecting wheat production.

Based on organization of the paper issues, theoretical fundamentals and review of literature are given in the first section, Materials and methods are given in the second section and the applied model is presented in the third section. Finally, the results of the model have been studied and analyzed.

A. Assumed causal relationships between variables

Since the mid-1970s, numbers of studies have used vector autoregressive (VAR) models to evaluate the magnitude and timing of macroeconomic impacts on agriculture. Use of the VAR method has been viewed as a way to obtain empirical evidence about these impacts that might not emerge from more traditional over identified and less dynamic econometric models. It is hoped that by placing minimal restrictions on VAR models, the true structure of the economic relationships under investigation can be observed.

While the aim is laudable, critics of VAR models have argued that it has had the unfortunate consequence of obscuring some important structural identification issues and seeming to promise that something can be obtained for nothing (Cooley and et al). They point out that identifying restrictions are required to give economically interpretable meaning to the results of any simultaneous equation model (SEM). In standard practice, identification of VAR models is obtained implicitly by choice of a Choleski decomposition of the covariance matrix of one-step-ahead forecast errors, which is equivalent to imposing a recursive structure may not be believable. Further, as Bernanke observed, examination of ad hoc variant of the recursive order implies a strange set of prior beliefs in which the analyst holds strongly that the system is recursive but is not sure in what order the variables should be arranged.

In response to these concerns, several recent papers have mentioned that identification of VAR models does not have to rely on the assumption that the contemporaneous structure is recursive (Bernanke, Sims). Rather, the distinguishing features of a VAR model are, first, that identification rests on the assumption that distinct,

mutually orthogonal Behavior shocks drive the economy, and, second, that lagged relationships among the endogenous and exogenous variables (If any) are left entirely unrestricted. Given these features, a VAR models must be identified solely by restrictions placed on the contemporaneous interactions among the variables, the identifying restrictions do not have to preclude simultaneity.

B. Review of Literature

Abrishami and Mohseni (2005), following Feder's model (1982), studied the effect of instability of export income on agricultural growth during 1971-2001. The results indicated the presence of a unique long-term relationship between the modeled variables. Because production growth depends on factors such as population and technology improvement in long term, the effect of export instability on agricultural value added is considered exogenous and effective only in short term, so this effect is assessed positive in this research.

Karbasi and Piri (2008) studied factors affecting price level of agricultural products by emphasizing on inflation and inflation uncertainty as one of the macroeconomic variables and using time series data for years 1971-2004. In this regard, GARCH technique was used to model and calculate inflation uncertainty. The obtained results indicate the presence of long-term relationship and co-integration among the variables included in the model.

Julietta, Philip (2010) highly fluctuating agricultural prices have rekindled questions regarding the influence of volatile oil and exchange rates markets on dynamic behavior. Using weekly cash data from 1998 to 2009 and VAR and VECM procedures, they estimate the linkages among several agricultural grain and livestock commodities, oil, and exchange rates. They identify a structural break in mid 2006, and perform the analysis for each period. In the first period, agricultural commodity prices are most influenced by idiosyncratic factors as reflected in own lagged prices, and exchange rates and crude oil have limited effect on agricultural markets. In the second period the effect of own lags in the agricultural markets are smaller and the effect of the exchange rate and crude oil are more pronounced, especially in the corn market. In recent years, agricultural commodity markets appear more dependent on exchange rates and to a lesser extent on oil prices.

Goodwin, Smith (2009) studied dynamic relationships among three classes of wheat by investigated using threshold VAR models that incorporate the effects of protein availability. Changes in the stock of protein are found to generate significant responses in the prices of hard red spring wheat and hard red winter wheat, but not soft red wheat. The responses to identical changes in protein stocks are larger when the magnitudes of deviations of protein stocks from normal levels are large. Shocks to the prices of individual classes of wheat result in complex responses in the prices of the other wheat classes. Notably, however, a shock to the price of hard red winter wheat appears to result in little or no response in the price of hard spring wheat, though importantly, the opposite is not true.

Babula, Bessler (1989) use of time series techniques (vector autoregression or VAR) to employed the model a three-price dynamic system of the farm gate, processor, and consumer prices of wheat-related goods an increase (presumably drought-induced) in farm gate wheat price is simulated to determine impacts on processor and consumer prices in the wheat sector several findings emerge First, the increase in farm wheat price (PF-increase) may be expected to immediately generate processor price increases which are statistically significant for almost a year. Second, the PF-increase is expected to generate wheat-related consumer price increases, which are mostly significant for 22-month consumer price increases of wheat-related goods are expected to peak in strength at about the 8-month point following the PF-increase and third, the consumer price increases are expected to be more gradual, less acute, but of longer duration than the processor price rises.

Considering the above facts, the main goal of this study was to study the response of wheat production to the shocks applied in Iran. For this purpose, first, the presence of structural break of variables was studied and then stationary of variables was tested by Philips Perron test, optimal rank of VAR model was extracted and variables affecting wheat production were studied using autoregressive vector model. In case of co-integration vector based on Johansen-Juselius co-integration test, long-term relationship between variables was also estimated. At the end, impulse response function (IRF) and variance decomposition (VD) were studied as a criterion for dynamicity performance.

Statistics and information of all variables have been extracted annually as time series for 1978-2011 from time-series databank of Central Bank of the Islamic Republic of Iran and Iran Statistics Center.

II. Materials and Methods

A. Introduction of model

The main goal of this study is to investigate response of wheat production to the shocks applied in Iran using a vector autoregressive model (VAR). The applied variables are described in the following Table (1).

Table (1)- Introduction of Model Variables

Variable title	Used sign
Wheat cultivation area	S
Price of wheat	PW
Production of wheat	POW
Value Added Of Agricultural Division	VADD

Based on the VAR equations, including K-lag with a t-interval, the model is presented as follows:

$$Y_t = A_1 Y_{t-1} + \dots + A_p Y_{t-p} + B_0 X_t + \dots + B_q X_t + CD_t + U_t$$

Where:

Y_t is a vector of K observable endogenous variable:

$$Y_t = (Y_{1t}, \dots, Y_{Kt})'$$

X_t is a vector of M observable exogenous variable :

$$X_t = (X_{1t}, \dots, X_{Mt})' \quad (1)$$

D_t contains all deterministic variables, which may consist of constant:

$$D_t$$

U_t is a K-dimensional unobservable zero mean:

$$U_t$$

B. Structural break test

If a change occurs in the trend of variables along with the change of the model's parameters considering conditions and circumstances governing economic variables or if there is a disturbance in stability of parameters of a model, these changes will be called structural break. Structural break test was first performed in linear regression models by Quant (1958) and Chow (1960) and then by Brown, Durbin and Evans (1975). In these studies, structural break test is performed endogenously in a predetermined point, but other methods have been used for testing structural break since 1990s. In these methods, the desired test is performed endogenously in an indefinite point or points. These methods have been presented by Andrews (1993), Andrews and Ploberger (1996) for single-break state and Andrews (1993), Andrews and Ploberger (1996), Liu, Wu and Zidek (1997) and Bai and Perron (1998, 2003) in multiple break state.

In the present research, the method of Andrews (1993) was used to estimate the number and place of break endogenously using a linear regression model.

$$Y_t = X_t' \beta_1 + \varepsilon_t, t = 1, \dots, \tau$$

$$Y_t = X_t' \beta_2 + \varepsilon_t, t = \tau + 1, \dots, T \quad (2)$$

β_1 , β_2 and X_t are $k \times 1$ matrices. There is a single break point, τ . Assume that X 's are stationary as well as weakly exogenous and ε 's are serially uncorrelated and homoscedastic.

If τ is specified, Assume that $H_0: \beta_1 = \beta_2$ and the F statistic asymptotically under the null hypothesis of χ^2 is:

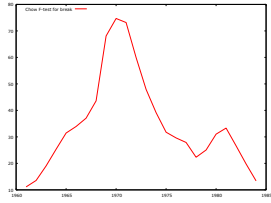
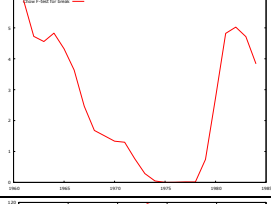
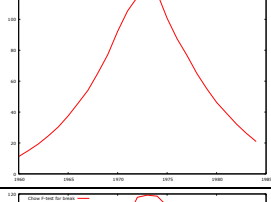
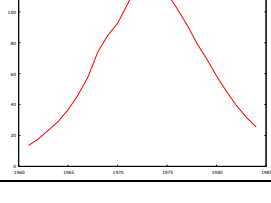
$$F_T(\tau) = (T - 2K)[SSR_{1:T} - (SSR_{1:\tau} + SSR_{\tau+1:T})]/(SSR_{1:T} + SSR_{\tau+1:T}) \quad (3)$$

Quant (1960) showed that if ε 's are normally distributed and X 's are strictly exogenous, then $F_T(\tau)$ is a likelihood ratio statistic and is exactly χ^2 under the null hypothesis.

When τ is unspecified, Quant (1960) showed that the likelihood ratio statistic under the hypothesis of $H_0: \beta_1 = \beta_2$ is equal to:

$$QLR_T = \max_{\tau \in \{\tau_{\min}, \dots, \tau_{\max}\}} F_T(\tau) \quad (4)$$

Table 2 – The results of structural break test

Variables	Hypothesis Test	Test Statistic	Break year	Break Figure
LPOW		$\chi^2 = 74.6959$ P-value = 4.0338e-016	1992	
LS		$\chi^2 = 5.8837$ P-value = 0.1633	1982	
LV		$\chi^2 = 119.2$ P-value = 5.514e-026	1994	
LPW		$\chi^2 = 119.248$ P-value = 8.728e-026	1994	
Ref: Research Finding				

C. Phillips-Perron (PP) test

Following criticisms of Phillips-Perron (1988), Dickey Fuller, and in case of structural changes in time series, Perron unit root test should be used. Such changes seem reasonable in political and economic changes of Iran in recent years and considering that changes have created considerable effects on macroeconomic variables of society. So, it is necessary to compare Phillips-Perron unit root test to ensure statics of variables (table 3).

Table 3- The results obtained from Phillips-Perron test

Test statistic value PP			Variable
PP (Level) 5% - None	PP (Level) 5% - Trend and Intercept	PP (Level) 5% - Intercept	
5.89(-1.95)	-1.89(-3.55)	-0.94(-2.95)	LPOW
0.59(-1.95)	-3.36(-3.55)	-3.32(-2.95)	LS
7.36(-1.95)	-2.04(-3.55)	-1.42(-2.95)	LV
1.99(-1.95)	-4.02(-3.55)	-1.91(-2.95)	LPW
PP (1 st) 5% - None	PP (1 st) 5% - Trend and Intercept	PP (1 st) 5% - Intercept	
-3.50(-1.95)	-7.43(-3.55)	-7.53(-2.95)	D(LPOW)
-7.89(-1.95)	-7.78(-3.55)	-7.87(-2.95)	D(LS)
-1.53(-1.95)	-5.30(-3.56)	-5.19(-2.96)	D(LV)
-8.57(-1.95)	-12.90(-3.55)	-12.00(-2.95)	D(LPW)

Ref: Research Finding

() MacKinnon statistic values

In estimation of vector autoregressive model, optimal rank of VAR model is determined using AIC: Akaike information criterion, SC: Schwarz information criterion and HQ: Hannan-Quinn information criterion. Based on these tests, it was found that both had the minimum value of between lags 2, 3 and 4 in lag of three criteria of Akaike and Schwarz. As a result, length of lag 1 has been selected for the desired model.

III. Results and Discussion

A. Vector Autoregression (VAR) Model Estimation

When we want to study behavior of some time series variables, it is necessary to pay attention to interaction of these variables as a model of equations system-lags of variables. In this case, we call it dynamic simultaneous equations system model. In such a model, some variables are regarded endogenous and some are regarded exogenous, so, before estimating such a model, it is necessary to ensure that equations are identifiable. The important point is that it is optional to classify variables into two endogenous and exogenous groups. For this reason, two issues were criticized by Sims (1980). He said that if there was simultaneity between variables of the model, all variables should be regarded equally and it is not proper to prejudge about what are endogenous and exogenous. He introduced VAR models in this case. This model has no exogenous variable and all variables of the model are endogenous. Vector Autoregression Models are almost used to predict, summarize interdependencies of data, exogenous test, Granger Causality, sensitivity analysis and other cases. In analysis of VAR models, the role of shocks (innovations) is very distinctive and the results of impulse response or variance decomposition have been formed based on the role of innovations.

In this stage, the number of convergence vectors between variables of the model is determined using the second method (Intercept (no trend) in CE-no intercept in VAR) and with Unrestricted Cointegration Rank Test (Trace) and Unrestricted Cointegration Rank Test (Maximum Eigen value). Considering results in table 3, the number of vectors which have been obtained by Unrestricted Cointegration Rank Test (Trace) and Unrestricted Cointegration Rank Test (Maximum Eigen value) are regarded as criteria of selection.

Table 4- The results of Unrestricted Cointegration Rank Test (Trace) and Unrestricted Cointegration Rank Test (Maximum Eigen value)

Maximum Eigen value	Trace Matrix	Test type
6.6396	6.6396	Test statistic value
9.1645	9.1645	Critical values in level of 95%
0.1467	0.1468	Probability value in level of 95%
1	2	The number of reported cointegration vector

Ref: Research Finding

Considering that we seek to study wheat production response to the applied shocks, a function including the effect of changes in economic variables on low production of wheat (LPOW) has been estimated. The results of estimation obtained from VAR model is described as follows:

Table 5- The results of model estimation

LPOW =	-0.1777	LS +	0.9294	LV –	0.0560	LPW –	2.0994	C
(S.E)	(0.5568)		(0.0538)		(0.3769)		(3.2052)	

Ref: Research Finding

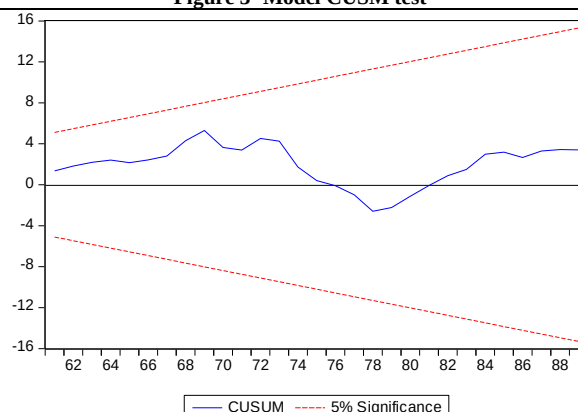
Considering that we have used logarithm of variables in the model, the obtained coefficients also indicate elasticity and in this case, elasticity of the cultivation area relative to production of wheat is negative and equal to 0.1777. In other words, increased cultivation area leads to reduction of 0.1777 units in production of wheat. A unit of increase in value added of agricultural division leads to increase of 0.9294 units in production of wheat. A unit of increase in guaranteed price of wheat leads to reduction of production by 0.0560 units.

B. Parameters stability test

In parameters stability test for the dependent variable, we study if parameters of the model along with structural break of the dependent variable are unstable or not?

Figure 3 indicates the results of CUSUM test at confidence level of 5% for the model and the results indicate structural stability of this equation. This test is performed based on cumulative sum of residual sentences. In Figure of this test, cumulative sum of residual sentences is shown in time. You also notice critical lines in it. If cumulative sum of residual sentences is excluded from the zone between two critical lines, it will indicate structural instability of the equation.

Figure 3- Model CUSM test



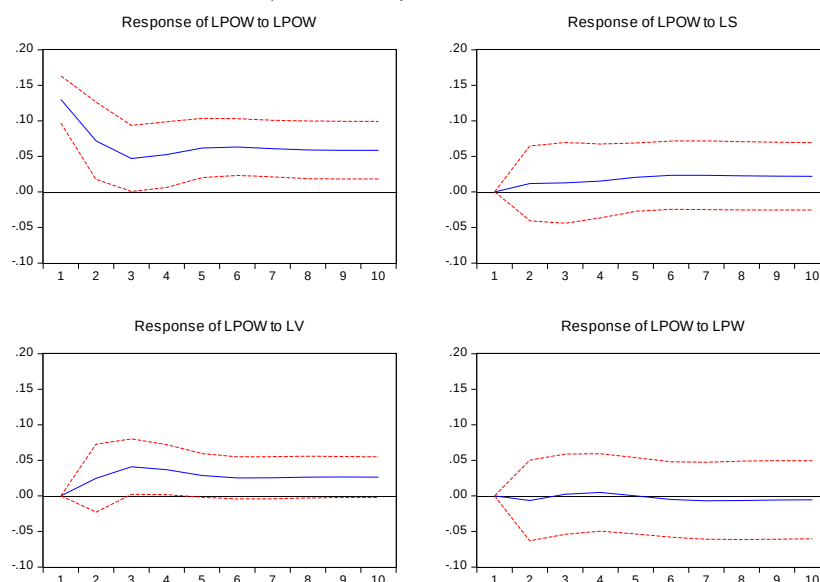
Ref: Research Finding

C. Results Of Impulse Function

The results of impulse function obtained from VAR model after estimation of model examined response of variables within the next 10 years. Figure 4 shows response of variable of wheat production to impulse of variables of wheat cultivation area, value added of agricultural division and price of wheat. Response of variable of wheat production to impulse of variables of wheat cultivation area is positive and shows an unchanged trend. Response of wheat production to changes in value added of agricultural division is positive until the end of the period which shows increasing trend in the first three periods and unchanged trend until the end of the period. Response of wheat production to shock caused by variable of wheat price is almost zero and negligible and has passed uniform trend and is in long term equilibrium.

Figure 4- The results of response of model

Response to Cholesky One S.D. Innovations ± 2 S.E.



Ref: Research Finding

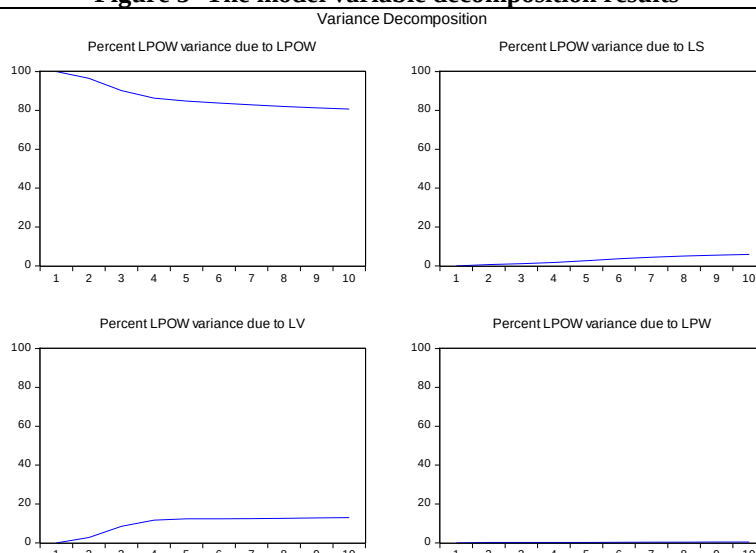
D. Results Of Variance Decomposition

Variance decomposition as a criterion for performance of dynamicity is able to determine instability of each variable against the shock applied on each of the other variables. In variance decomposition, the role of the shocks applied on different variables of model in variance of variable prediction error is specified in short term

and long term. For example, if a variable based on values with lag is optimally predictable, then, prediction error variance is described only based on the shock applied on that variable.

In the following Figure (No.5), variance decomposition of wheat production changes has been mentioned based on variables of wheat cultivation area, value added of agricultural division and price of wheat for 10 periods and it means effectiveness of each of the explanatory variables i.e. shocks applied on changes of wheat production. The results indicate that the standard deviation which has been created in production of wheat in the first period has been completely explained by production of wheat. Gradually, explanatory power of wheat cultivation area and value added of agricultural division has increased while explanatory power of wheat price is almost fixed and insignificant.

Figure 5- The model variable decomposition results



Ref: Research Finding

IV. Conclusion

This paper studies the dynamic relationship between variables of wheat production, value added of agricultural division, wheat cultivation area and wheat price using time series data of Iran during 1971-2011. Since the presence of structural break in the studied time series trend is probable, set of tests introduced in Andrews (1993) has been used to determine endogenous structural break and unit root test has been used considering Perron's endogenous structural break (1988) to study durability of the studied variables, break points obtained from the used tests usually relate to 2000-2004. In this regard, the impulses applied by the model's variables on variable of wheat production were analyzed using impulse response functions. To study long-term equilibrium relationship between variables, Johansen-Juselius co-integration test was used. Considering that structural break has been proved in variables of the model, Cusum test was used to study stability of the studied models and the results indicated stability in the estimated model.

Impulse response function showed that generally impulses of variables of value added of agricultural division and wheat cultivation area had positive and increasing behavior while response of wheat production to changes of wheat price shows a fixed trend and has not led to intensive changes and factor of guaranteed price of wheat is not effective in creation of shock on production of wheat and as a result, application of guaranteed price policies has not changed production rate of wheat.

Results obtained from variable decomposition show that all changes result from changes in the variable of wheat production in the starting periods and role of value added of agricultural division in shocks applied on variable of wheat production has increased in prediction error variance since the fifth period later on. As a result, instability of variable of wheat production against shocks applied on value added in agricultural division and wheat cultivation area and guaranteed price of wheat is based on the reported impulse response function.

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