

Economic Analysis of Price Shocks of Production Inputs and Their Impact on Cotton Price in Iran: The Application of Panel Data Vector Auto-Regression (PVAR) Model

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Abstract

Cotton is a strategic crop with a critical role in the economy and agriculture. The increasing price of crop inputs is the main challenge for the developing countries, including Iran, so that it is crucial for the economy of the states to recognize the underpinning factors. Accordingly, the present study aimed to identify the relationship between price shocks of cotton production inputs and cotton price in 12 provinces of Iran over the 2000-2016 time period using panel-data vector auto regression (PVAR) model. The results to estimate the model and to check the interrelationships of the research variables in the context of the impulse response functions and analysis of variance showed that the variables of seed price, labor price, and pesticide price have a significant positive relationship with cotton price with the numerical values of 0.296, 0.002 and 0.017, respectively. The relationship of the variables of land and fertilizer prices was found to be negative but non-significant with the numerical values of 8.23 and 0.118, respectively. According to the results, to avoid the price volatility and shocks in input and output markets, it is recommended to organize and regulate the demand and supply system of the inputs and output.

Keywords: Economic Analysis, Price Shock, Agricultural Input, Cotton, Panel Vector Autoregression

Introduction

Cotton, the white gold, is one of the most valuable industrial crops and is a key product of the agricultural sector with an essential role in this sector and the industrial sector (Ghasemian et al., 2014). Statistics show that cotton accounts for 75 percent of the total natural fiber production in the world. Cottonseed is the second most important oilseed in the world (Haeri & Asayesh, 2009; Fathi et al., 2011). Also, this crop plays a vital role in the supply of raw material for textile industry, oil production, and employment in the agricultural, industrial and commercial sectors (Rostami et al., 2017). According to the crop statistics of 2015-2016, Iran annually produces 161,164 t cotton. The total harvesting area of this crop in Iran is estimated at about

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14.4 million ha. Irrigated farms produce 159,075 t cotton and rain-fed farms produce 2,088 t. The yield of the irrigated farms is 2,302 kg ha⁻¹, while rain-fed farms report a yield of 1,371 kg ha⁻¹. Also, the acreage of irrigated cotton is 69,102 ha and that of rain-fed cotton is 1,523 ha (Crop Statistic Book, 2016).

One of the most basic foundations of neoclassical economics is the theory of price. Prices are among the main determinants of the income level of farmers, importers and exporters of the agricultural products as well as the economic welfare of consumers (Hosseini & Nikoukar, 2006; Frigon et al., 1999; Campenhout et al., 2018; Charley & Rohan, 2018). The analysis of crop prices is important from the economic and political perspectives. So, most agricultural economists have focused on the structure of the relevant markets (from farm to retail) and the process of price transmission (Hosseini & Dourandish 2006; Broson et al., 1985; Wharton, 2017; Hussein, 2018). A major issue faced by people and policymakers at the macro level is the price volatility of the agricultural commodities because these volatilities are a barrier against the improvement of the productivity of the agricultural sector. These volatilities are blamed for the increase in inflation pressures. Inflation by itself makes agricultural production a risky activity, and this affects investment decisions, thereby having dramatic consequences for farmers, growth, income, productivity, and profitability (Kargbo, 2005; Wang et al., 2017; Joets et al., 2017; Alan Ker et al., 2017; Seth & Sidhu, 2018; Url et al., 2018). In this regard, crop price is mainly influenced by the price of the inputs and their relationship with the crop price in the agricultural sector, and this has been considered by many researchers. Therefore, to analyze agricultural crop markets, it is imperative to understand the relationship between input and crop and their pricing effect on one another in order to use it for the sake of sound policymaking (Marab & Moghadasi, 2007; Bailey Norwood & Lusk, 2018; Alizadeh & Handifield, 2018).

Given the significance of the research, an essential feature of the agricultural crops is the volatility of their prices at different market levels. Since most studies in Iran have focused on the transmission of price from producers to retailers on the one hand and cotton is a key crop with high economic value due to its extensive applications on the other hand, it is imperative to assess the effects of price shocks of cotton inputs (labor, seed, land, pesticide, fertilizer, and water) on the price of cotton in Iran. So, the present study aims to use vector auto-regression model with panel data (PVAR) to answer the question as to how price shocks of cotton production inputs affect its production and price.

Literature Review

A distinguishing characteristic of the agricultural crops is their constant price fluctuations. There are several factors that can cause price volatility in the agricultural sector. The most important factors can be listed as the seasonal and cyclic changes in supply, volatility transmission from the global markets to the domestic markets of the agricultural crops, and the fluctuations induced by the general trend of the prices (Kajvari Ghashniani, 2014). Research shows that in Iran, cotton is the second widely used agricultural oilseed in the oil industry. Despite the importance of this crop, the market of this strategic crop has always been prone to price volatility. So, the present study focuses on the factors underpinning cotton price fluctuations. Various models have been presented to explore the effect of the changes in input

prices on the prices of the agricultural crops.

From the perspective of statistical methodology, the study of the relationship between variables has evolved through four phases. The first phase was based on vector auto-regression method (VAR) in that the property of the stationarity of the variables was neglected. In the second phase, given the non-stationarity of the variables, the two-stage process of Engle-Granger was used to test the cointegration relations of two variables. In the third phase, multivariate predictors like Johansen were applied in which more than two variables were applicable in cointegration relations and causality analysis. In the fourth phase, the research was based on unit root test, cointegration test and causality test of Granger or others (Shahateet, 2014; Tarfirenyika, 2017; Amin & Alam, 2018; Molele & Ncanywa, 2018). Given the many advantages of panel data methods, panel data-based vector auto-regression model (PVAR) can be used to cope with the statistical limitations and uncertainty about the exogeneity of the variables in time-series model in short periods. PVAR encompasses the conventional VAR method, and the only difference is that it uses panel data (Jafari Samimi et al., 2009; Amoli Diva & Jafari Samimi, 2010; Jouda, 2018; Thach & Oanh, 2018). The PVAR approach is a non-structural approach that is employed to model the relations among multiple variables (Love and Ziccino, 2006). PVAR works with the same rationale of VAR. What is important in VAR models is to apply the shocks and to trace their results. In PVAR models, shocks can be recognized with standard methods (Mohammadzadeh Asl, 2017). In this regard, the following research can be noted.

Farajzadeh and Ismaili (2010) studied price transmission in pistachio markets in two parts – time series (1972-2005) and panel data (1989-2005). They found a long-run reciprocal relationship between domestic price and global price of pistachio. The results of time series analysis revealed a long-run symmetric pattern of transmission in both the domestic and global markets of pistachio. Also, the results of hybrid data showed that the multiplicity of the countries importing Iran's pistachio had a decreasing trend and that the increase in their share in purchase market and the decrease in Iran's share of the global market has resulted in symmetric price transmission between the domestic and global markets. Mohammadi et al. (2015) used the sensitivity analysis in artificial neural network model to conduct an empirical study on the trend of exchange rate pass-through and the effect of its volatility on pistachio export price in Iran in 1961-2011. The results showed a direct relationship between exchange rate fluctuations and pistachio export price. So, in case of the decline of exchange rate volatility, exporting pistachio can be supplied at lower prices to the global markets, and given the elasticity of the global demand, the incomes of exporting this crop are enhanced.

Kohansal and Hezareh (2017) evaluated the impact of oil price shocks and exchange rate on food price in urban areas of Iran in 2002-2014 using PVAR, generalized method of moment (GMM) and exponential generalized autoregressive conditional heteroskedastic (EGARCH). They found that oil price shocks in the studied time period did not have a significant impact on food prices in the short run. Another example of studies on similar subject matters is Moradi and Afsharmanesh (2017). They addressed the price shock of grain maize production inputs and its impact on crop price using PVAR in 16 provinces of Iran over 2000-2012. Their results revealed that maize price fluctuation influenced the prices of the production factors greatly. Given the relationship between the prices of the inputs and output of maize, organizing the demand market of the inputs, and the timely supply and distribution of the inputs to control

price fluctuations and shocks in input market can contribute to stabilizing maize crop price. Also, Parsley (2012) worked on the extent of exchange rate pass-through in South Africa using panel data over the 1998-2009 period. They found that the pass-through of exchange rate variations to import price was 60 percent. Zare Mehrjerdi and Tohidi (2014) applied dynamic panel data model and GMM to study exchange rate and tariff pass-through to saffron export price in 2000-2011. They found that the exchange rate pass-through to saffron export price was incomplete. Da Silveira and Mattos (2015) focused on the transmission of price and volatility between feed and livestock markets in the US and Brazil during 1996-2014 using vector error correction method. According to their findings, price volatilities has changed between feed markets in the US in the short and long run, but the volatilities in Brazil just existed in the short run. Mekbib et al. (2016) examined the effect of price volatility of the products and inputs on wheat, rice, maize, and soybean using the panel data approach. The results showed that supply price elasticity varied in the range of 0.04-0.05. On the other hand, price volatility was negatively related to supply. Ojewumi and Akinlo (2017) considered foreign direct investment, economic growth and environmental quality in sub-Saharan Africa using a dynamic model. They reported dynamic interactions among foreign direct investment, economic growth and environmental quality whereas their effect on one another varied in the range of 13.1-32.8 percent. As well, the member states of Southern Africa should make a balance between investment policies and environmental conservation policies so that foreign direct investment is increased in the region, resulting in the improvement of the environmental quality of the local countries. A review of the empirical studies shows that they have mostly focused on price transmission and no study has assessed the price shock transmission from inputs market to commodity market. On the other hand, most models have used time series data, while models have not utilized hybrid data, which are of high analytical power. The application of simultaneous equations system and the examination of the long-term relationship between market variables via PVAR, the assessment of the impacts of instantaneous shocks of each individual market variable on cotton price in the context of impulse response function (IRF) and the determination of the long-term relations of these variables (the price of the production factors and output) are issues that should be assessed due to the significance of agriculture and its products in new studies in agriculture economics. Therefore, the present study aims to use panel vector autoregression (PVAR) model to analyze the price in input and output market and their price shocks.

Materials and methods

PVAR is a combination of the traditional VAR approach, which treats all variables as to be endogenous, and the panel data approach, which includes invisible factors in the model (Galariotis et al., 2018). The main source of vector autoregressive models is an alternative to the simultaneous multi-variable equation model (Sims, 1980). In a vector self-regression model, all variables are considered as intrinsic. Although the identification of constraints based on a theoretical model or statistical methods to investigate the effect of exogenous shocks on the simultaneous system of equations of the vector regression model can also be expressed (Holtz-Eakin *et al.*, 1988). PVAR has some advantages to the already used methods. First, VAR model is very practical and useful when theoretical data are few about the relationship between the

variables. Second, it has been designed to show the problem of endogeneity (Lin and Zhu, 2017). As such, VAR models alleviate the problem of endogeneity without applying unnecessary constraints. Third, VAR-based IRFs can consider the lagging impacts on variables and the effect of shocks whilst these dynamic impacts are not shown by PVAR models. Fourth, PVAR models allow considering the fixed cross-provincial (cross-sectional) and cross-time impacts. Finally, PVAR can also be used in relatively short time-series using cross-sectional dimension (Grossmann et al., 2014; Galariotis et al., 2018). PVAR is structurally expressed as:

$$\begin{aligned}
 y_{1it} + b_{12}y_{2it} &= \gamma_{10} + \gamma_{11}y_{1i,t-1} + \gamma_{12}y_{2i,t-1} + \varepsilon_{1it} \\
 b_{21}y_{1it} + y_{2it} &= \gamma_{20} + \gamma_{21}y_{1i,t-1} + \gamma_{22}y_{2i,t-1} + \varepsilon_{2it}
 \end{aligned}
 \tag{1}$$

$$\begin{pmatrix} \varepsilon_{1it} \\ \varepsilon_{2it} \end{pmatrix} \approx N(0, \Omega) \text{ where } \Omega = \begin{pmatrix} \omega_1^2 & 0 \\ 0 & \omega_2^2 \end{pmatrix}$$

So that the sequences y_{1it} and y_{2it} are stationary. ε_{1it} and ε_{2it} are error terms with the variances ω_1 and ω_2 , respectively. They are independent of one another. The maximum number of lags included in these equations is one lag. So, these equations form the structural form of the first-order PVAR. The structure of the system is so that it allows either variable to influence the other. However, if $b_{12} \neq 0$, ε_{1it} will have an indirect impact on y_{2it} , and if $b_{22} \neq 0$, ε_{2it} will have an indirect impact on y_{1it} . The simultaneous effectiveness of y_{1it} and y_{2it} , as well as y_{2it} and y_{1it} , reflects the fact that these equations do not have a reduced form. If the above structural form is rewritten in the matrix form, the equations will be changed to (Hayakawa, 2016):

$$\begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix} \begin{bmatrix} y_{1it} \\ y_{2it} \end{bmatrix} = \begin{bmatrix} \gamma_{10} \\ \gamma_{20} \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix} \begin{bmatrix} y_{1i,t-1} \\ y_{2i,t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1it} \\ \varepsilon_{2it} \end{bmatrix}$$

$$\Rightarrow By_{it} = \Gamma_0 + \Gamma_1 y_{i,t-1} + \varepsilon_{it}, \varepsilon_{it} \approx N(0, \Omega)$$

Equation (2) is for the bivariate state. The structural form of PVAR for the n-variate state is as below:

$$\begin{bmatrix} Y_{1it} \\ Y_{2it} \\ Y_{3it} \\ \vdots \\ Y_{nit} \end{bmatrix} = \begin{bmatrix} Y_{10} \\ Y_{20} \\ Y_{30} \\ \vdots \\ Y_{n0} \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} & \dots & \gamma_{1n} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} & \dots & \gamma_{2n} \\ & & & & \\ & & & & \\ \gamma_{n1} & \gamma_{n2} & \gamma_{n3} & \dots & \gamma_{nn} \end{bmatrix} \begin{bmatrix} Y_{1i,t-1} \\ Y_{2i,t-1} \\ Y_{3i,t-1} \\ \vdots \\ Y_{ni,t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1it} \\ \varepsilon_{2it} \\ \varepsilon_{3it} \\ \vdots \\ \varepsilon_{nit} \end{bmatrix}$$

Despite the feedback mechanism[†], Equations (1) and (2) cannot be estimated in the structural form. To solve this problem, one needs the solved form of PVAR. The structure form is transformed into the solved form by the following equation (Hayakawa, 2017):

$$\begin{bmatrix} y_{1it} \\ y_{2it} \end{bmatrix} = \begin{bmatrix} \frac{\gamma_{10} - b_{12}\gamma_{20}}{1 - b_{21}b_{12}} \\ \frac{-b_{21}\gamma_{10} + \gamma_{20}}{1 - b_{21}b_{12}} \end{bmatrix} + \begin{bmatrix} \frac{\gamma_{11} - b_{12}\gamma_{21}}{1 - b_{21}b_{12}} & \frac{\gamma_{12} - b_{12}\gamma_{22}}{1 - b_{21}b_{12}} \\ \frac{-b_{21}\gamma_{11} + \gamma_{21}}{1 - b_{21}b_{12}} & \frac{-b_{21}\gamma_{12} + \gamma_{22}}{1 - b_{21}b_{12}} \end{bmatrix} \begin{bmatrix} y_{1i,t-1} \\ y_{2i,t-1} \end{bmatrix} + \begin{bmatrix} \frac{\varepsilon_{1it} - b_{12}\varepsilon_{2it}}{1 - b_{21}b_{12}} \\ \frac{-b_{21}\varepsilon_{1it} + \varepsilon_{2it}}{1 - b_{21}b_{12}} \end{bmatrix}$$

The solved form can be written in more complete form as below:

[†] The correlation of y_{2it} with error term ε_{1it} and the correlation of y_{1it} with ε_{2it} create the feedback mechanism.

$$\begin{bmatrix} y_{1it} \\ y_{2it} \end{bmatrix} = \begin{bmatrix} \alpha_{10} \\ \alpha_{20} \end{bmatrix} + \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix} \begin{bmatrix} y_{1i,t-1} \\ y_{2i,t-1} \end{bmatrix} + \begin{bmatrix} e_{1it} \\ e_{2it} \end{bmatrix} \quad (5)$$

$$\begin{pmatrix} e_{1it} \\ e_{2it} \end{pmatrix} \approx N(0, \Sigma) \quad \text{where } \Sigma = \begin{bmatrix} \sigma_1^2 & \sigma_{12} \\ \sigma_{12} & \sigma_2^2 \end{bmatrix}$$

$$\Rightarrow y_{it} = A_0 + A_1 A_{i,t-1} + e_{it} \quad e_{it} \approx N(0, \Sigma) \quad (6)$$

where $A_0 = B^{-1}\Gamma_0$, $A_1 = B^{-1}\Gamma_1$ and $e_{it} = B^{-1}\varepsilon_{it}$

Model (6) is a standard PVAR model. Equation (5) is estimated by ordinary least squares (OLS) method. But, we can derive data for the structural form from the results of estimating the summarized form. This is due to the fact that by estimating the second system, it is possible to estimate the variables α_{22} , α_{21} , α_{12} , α_{11} , α_{20} , α_{10} , σ_{12} , σ_2^2 , and σ_1^2 if the initial equations system have 10 parameters including γ_{20} , γ_{10} , γ_{22} , γ_{21} , γ_{12} , γ_{11} , b_{21} , and b_{12} and two standard deviations of ω_1^2 and ω_2^2 . In other words, the structural form has 10 parameters, and in the solved form of the PVAR model, 9 parameters are estimated. Therefore, it is not possible to identify the initial equations system without considering constraint on one of the parameters (Sharifi Renani et al., 2013). On the other hand, if in the PVAR structural form, it is assumed that the coefficient b_{12} or b_{21} is zero, the structure form will be as below (in which it is assumed that $b_{21} = 0$)[‡]:

$$y_{1it} + b_{12}y_{2it} = \gamma_{10} + \gamma_{11}y_{1i,t-1} + \gamma_{12}y_{2i,t-1} + \varepsilon_{1it}$$

$$y_{2it} = \gamma_{20} + \gamma_{21}y_{1i,t-1} + \gamma_{22}y_{2i,t-1} + \varepsilon_{2it}$$

In this state, y_{2it} has a simultaneous effect on y_{1it} , but y_{1it} affects y_{2i} with one lag. The application of the constraint that one of the coefficients b_{12} or b_{21} be zero enables us to base the model on the theory of economy. Also, this condition tackles the problem of identifying and restoring the coefficients of the structural form from the results of the solved form estimation (Asid et al., 2012; Juodis, 2017).

According to the explanations, the present study used the following VAR model:

$$py_{it} = b_{10} - b_{11}py_{it-1} + b_{12}pb_{it-1} + b_{13}pl_{it-1} + b_{14}pla_{it-1} + b_{15}ps_{it-1} + b_{16}psh_{it-1} + b_{17}pw_{it-1} + \varepsilon_{1it}$$

$$pb_{it} = b_{20} - b_{21}py_{it-1} + b_{22}pb_{it-1} + b_{23}pl_{it-1} + b_{24}pla_{it-1} + b_{25}ps_{it-1} + b_{26}psh_{it-1} + b_{27}pw_{it-1} + \varepsilon_{2it}$$

$$pl_{it} = b_{30} - b_{31}py_{it-1} + b_{32}pb_{it-1} + b_{33}pl_{it-1} + b_{34}pla_{it-1} + b_{35}ps_{it-1} + b_{36}psh_{it-1} + b_{37}pw_{it-1} + \varepsilon_{3it}$$

$$pla_{it} = b_{40} - b_{41}py_{it-1} + b_{42}pb_{it-1} + b_{43}pl_{it-1} + b_{44}pla_{it-1} + b_{45}ps_{it-1} + b_{46}psh_{it-1} + b_{47}pw_{it-1} + \varepsilon_{4it}$$

$$ps_{it} = b_{50} - b_{51}py_{it-1} + b_{52}pb_{it-1} + b_{53}pl_{it-1} + b_{54}pla_{it-1} + b_{55}ps_{it-1} + b_{56}psh_{it-1} + b_{57}pw_{it-1} + \varepsilon_{5it}$$

$$psh_{it} = b_{60} - b_{61}py_{it-1} + b_{62}pb_{it-1} + b_{63}pl_{it-1} + b_{64}pla_{it-1} + b_{65}ps_{it-1} + b_{66}psh_{it-1} + b_{67}pw_{it-1} + \varepsilon_{6it}$$

$$pw_{it} = b_{70} - b_{71}py_{it-1} + b_{72}pb_{it-1} + b_{73}pl_{it-1} + b_{74}pla_{it-1} + b_{75}ps_{it-1} + b_{76}psh_{it-1} + b_{77}pw_{it-1} + \varepsilon_{7it}$$

The model was estimated by data for the cotton crop of 12 provinces in Iran for the time period of 2000-2016 using the Eviews 10 software package. The variables included cotton crop

[‡] This is extracted from recursive method presented by Simens (1980) for identifying VAR equations, which can be generalized to the PVAR model.

price (PY), labor price (PL), seed price (PB), land lease price (PLA), pesticide price (PS), fertilizer price (PSH), and water price (PW) derived from the statistic book of Jihad-e Agriculture Ministry. All data are yearly in logarithmic form.

Empirical Results

Unit root tests of panel data

Before model estimation, we need to test the stationarity of all variables used in model estimation because the stationarity of the variables is a source of spurious regression for both time series and panel data types. Unit root expresses that unit root test based on panel data is more robust and correct than the test based on time series data (Salimi Far and Dehnavi, 2009; Jouida, 2018; Thach and Oanh, 2018). We employed the tests of Levin, Lin, and Chu (LLC), Im, Pesaran and Shin (IPS), augmented Dickey-Fuller (ADF), and Phillips and Perron (PPE) for unit root test of the panel data. The results are summarized in Table 1, according to which all variables were made stationary by first-differencing.

Table 1. Results of panel unit root tests for cotton crop

Variable	Lag length	LLC statistic	IPS statistic	ADF statistic	PPE statistic
Cotton price	1	-7.44 (0.00)	-6.68 (0.00)	89.09 (0.00)	181.75 (0.00)
Labor price	1	5.44 (0.00)	-1.89 (0.02)	84.84 (0.00)	35.78 (0.05)
Land price	1	-2.15 (0.01)	-6.63 (0.00)	88.21 (0.00)	157.31 (0.00)
Water price	1	-7.89 (0.00)	-7.17 (0.00)	94.89 (0.00)	228.56 (0.00)
Pesticide price	1	-2.15 (0.01)	-6.61 (0.00)	88.00 (0.00)	172.29 (0.00)
Fertilizer price	1	-5.77 (0.00)	-4.92 (0.00)	67.12 (0.00)	138.90 (0.00)
Seed price	1	-6.08 (0.00)	-5.32 (0.00)	72.22 (0.00)	159.01 (0.00)

Since the variables were made stationary by first-differencing, panel cointegration test was applied to ensure the feasibility of including the variables in the model because in panel data, if there exists a cointegration among the variables, it is not necessary to make the data stationary, and if stationarity test is refuted for the variables, it is necessary to perform cointegration test. Thus, in case the variables are cointegrated, the results will be reliable (Nasir and Du, 2018). There are some tests including the Kao, Pedroni, and Fisher tests to examine cointegration. We employed the Kao test to prove that regression was not spurious. The Pedroni test could not be used due to the high number of model variables, and the Fisher test could not be applied due to the inadequacy of data (Gamtessa and Olani, 2018).

The results of the Kao test support the presence of cointegration and implies that the studied independent variables were cointegrated with the dependent variable and there were long-run equilibrium relationships between cotton crop price and the independent variables of the model.

Table 2. Results of panel cointegration test using the Kao test for cotton crop

Kao cointegration	t-statistic	Probability
ADF	-6.27	0.00

PVAR model estimation*Determining optimal lag length*

The selection of an optimal lag length is a very important step in PVAR models so that correct forecasts depend on this selection. Small lags may be unable to reflect the dynamic of the system and cause the problem of the variable elimination from the model. They may also make the residual of the coefficients biased, which is likely to create correlated errors. On the other hand, very large lags may erode degrees of freedom rapidly and lead to over parameterization (Abrigow and Low, 2015). To find out the optimal lag in an econometric model, all variables are estimated in the context of a VAR equation using such statistics as the Akaike information criterion (AIC; Akaike, 1969), the Bayesian information criterion (BIC; Schwartz; Akaike, 1977), and the Hannan-Quinn information criterion (HQIC; Hannan and Quin, 1979) which is calculated by the logarithm of the likelihood function. The lag that has the lowest Akaike, Schwartz, and Hannan-Quinn values constitutes the optimal lag number (Noferesti, 2008). Table 3 presents the results of tests for determining optimal lag of the model.

Table 3. Results of the test to determine optimal lag for VAR

Lag	Log L	LR	FPE	AIC	SC	HQ
0	-7123.167	NA	5.21e+48	132.0401	132.2140	132.1106
1	-6651.474	873.5058*	2.08e+45*	124.2125*	125.6032*	124.7764*
2	-6614.539	63.60972	2.63e+45	124.4359	127.0435	125.4923
3	-6596.255	29.11871	4.78e+45	125.0047	128.8293	126.5554
4	-6575.604	30.21286	8.52e+45	125.5297	130.5711	127.5738
5	-6545.497	40.14282	1.32e+46	125.8796	132.1379	128.4171
6	-6516.362	35.06871	2.20e+46	125.2475	133.7227	129.2784
7	-6498.220	19.48603	4.80e+46	126.8189	135.5110	130.3432
8	-6443.803	51.39392	5.84e+46	126.7186	136.6276	130.7363

According to Table 3, all three criteria of Akaike, Schwartz, and Hannan-Quinn determined the lag number of 1 as the optimal lag for cotton crop in Iran.

Model estimation

Table 4 shows the results of the model estimation to test cotton price relationship with the price of inputs including labor, seed, land (land lease), fertilizer, pesticide, and water.

It is observed that the variables of seed price, labor price, and pesticide price has a significant positive effect and water price has a non-significant positive effect of the cotton price after one lag period. Also, the variables of land price and fertilizer price have a non-significant negative effect on cotton price after one lag period. In other words, assuming that all other conditions are constant, one unit increase in these variables results in 0.296, 0.002, 0.017 and 0.0002 units increase and 8.23 and 0.118 units decrease in cotton price, respectively. The non-significance means that the effect of the variable on cotton price is very slight.

Table 4. Results of model estimation by vector auto-regression method for cotton crop

	PB	PL	PLA	PS	PSH	PW	PY
PW(-1)	0.524 (0.078) [6.714]**	-0.795 (0.520) [-1.528]*	27.878 (30.153) [0.924]	0.211 (0.797) [0.264]	0.001 (0.019) [0.075]	-52.314 (30.010) [-1.743]**	0.296 (0.141) [2.097]**
PL (-1)	0.015 (0.004) [3.375]***	0.986 (0.029) [33.116]***	-0.168 (1.726) [-0.097]	0.072 (0.045) [1.583]*	0.001 (0.001) [1.514]*	3.630 (1.718) [2.112]**	0.002 (0.008) [0.253]**
PLA (-1)	2.51 (0.00) [0.243]	0.0008 (0.0006) [1.256]	0.916 (0.039) [23.049]***	-0.0008 (0.001) [-0.846]	-3.15 (2.6) [-1.22]	-0.087 (0.039) [-2.203]**	-8.23 (0.0001) [-0.440]
PS (-1)	0.011 (0.005) [2.240]***	-0.038 (0.033) [-1.153]	1.169 (1.934) [0.604]	0.793 (0.051) [15.50]***	0.001 (0.001) [0.986]	2.735 (1.925) [1.420]*	0.017 (0.009) [1.893]**
PSH (-1)	0.348 (0.254) [1.367]*	2.444 (1.696) [1.440]*	11.574 (98.359) [0.117]	-1.387 (2.602) [-0.533]	0.783 (0.063) [12.284]***	-4.941 (97.894) [-0.050]	-0.118 (0.461) [-0.256]
PW (-1)	-0.0003 (0.0001) [-2.287]**	-0.0004 (0.001) [-0.467]	-0.087 (0.061) [-1.431]*	0.001 (0.001) [0.976]	2.43 (4.0) [0.612]	0.852 (0.060) [14.011]***	0.0002 (0.0002) [1.030]
PY (-1)	0.148 (0.045) [3.264]***	-0.095 (0.303) [-0.467]	-15.762 (17.571) [-0.897]	0.028 (0.464) [0.062]	0.019 (0.011) [1.703]**	25.799 (17.488) [1.475]*	0.738 (0.082) [8.957]***

After the PVAR model is estimated, the next important step is to check the interrelationships and the dynamic relationships of the model variables. According to the subject matter, this section deals with the impact of the price of labor, seed, pesticide, fertilizer, land, and water on cotton price. Figure 1 depicts the dynamic response of the variable of cotton price to the shocks in the descriptive variables. In these graphs, the x -axis is time and the y -axis is the deviation from the initial value. Also, the lines drawn in the middle represent the impulse responses of the cotton price up to 10 periods. The upper and lower lines are the positive and negative bounds for the standard deviation of the impulse responses at the $p < 0.05$ level, which has been calculated with 1000 repetitions using the Monte Carlo simulation.

Crop prices are partially influenced by the price of the production factors (inputs). Figure 1 shows the effect of price shocks of the production factors, including labor, land, seed, pesticide, fertilizer, and water, on cotton price. It is evident that when a price increase shock happens for the inputs, it may lead to the increase in cotton price and its effect is passed to the next periods. IRFs in Figure 1 lead us to the conclusion that the response of cotton price to seed price is first increasing but then it shows a decreasing response. In other words, its effectiveness diminishes after 10 periods. This means that the effect of seed price shock is long run and its offset is time-consuming. The response of cotton price to the prices of labor, pesticide, water, and land is constant. In other words, the prices of labor, pesticides, water, and land are rapidly compensated, and these indicators are convergent with the cotton price. The cotton price reduction shock in one period makes cotton more expensive in the next period. Thus, increasing cotton acreage allows economies of scale, and this contributes to the more optimal use of inputs and the possibility of a discount at its purchase time. Finally, it can be claimed that the impact of all shocks will be offset after a 10-year period.

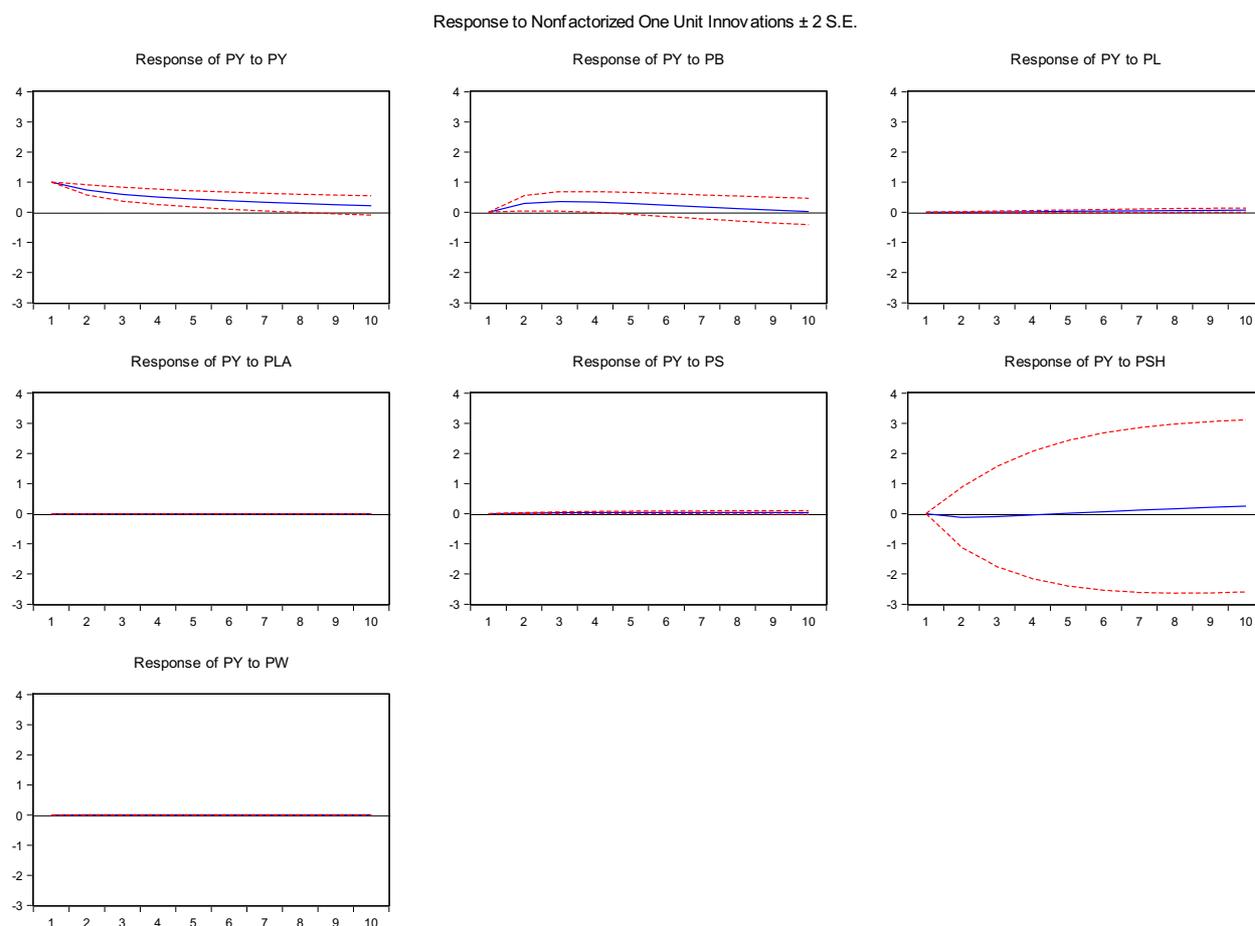


Figure 1. The dynamic response of cotton price to shocks to the descriptive variables of the model

After examining IRFs, we turn to the analysis of variance (ANOVA) for cotton crop. Whilst IRFs reflect the response of an endogenous variable over time to a shock induced by another variable of the system, ANOVA measures the contribution of each shock to the variance of an endogenous variable of the system. The results of ANOVA for the cotton crop are summarized in Table 5.

Table 5. Analysis of variance for cotton price

Period	PB	PL	PLA	PS	PSH	PW	PY
1	22.976	0.505	0.003	1.348	14.705	7.246	53.214
2	30.170	0.389	0.046	0.784	13.563	7.760	47.285
3	34.275	0.290	0.172	1.025	12.910	8.017	43.309
4	36.397	0.308	0.370	1.735	12.547	8.181	40.460
5	37.292	0.866	0.909	3.556	12.278	8.467	36.495
7	37.083	1.422	1.217	4.378	12.276	8.625	34.995
8	36.445	2.151	1.532	5.053	12.329	8.798	33.689
9	35.628	3.033	1.843	5.563	12.420	8.982	32.528
10	34.710	4.047	2.140	5.914	12.538	9.170	31.477

Since the forecast error of each year is estimated on the basis of the previous year error, so the forecast errors have a descending trend over the studied period. The columns in Table 5 show the percentage of the forecast variance due to different shocks in which the sum of each

row is 100 percent.

According to the results, in the 1st period, 53.2 percent of the cotton price variance is accounted for by the variable itself and the remaining is captured by other variables. In the 2nd period, 47.2 percent of the cotton price variance is explained by cotton price, 30.1 percent by seed price, and the remaining by other variables. In the 3rd period, cotton price accounts for 43.3 percent of the cotton price variance, seed price accounts for 34.2 percent, and the remaining is captured by the forecast error of other variables. In the 4th to 10th periods, cotton price accounts for 40.4, 38.2, 36.4, 34.9, 33.6, 32.5, and 31.4 percent of the cotton price variance, respectively; seed price accounts for 36.3, 37.2, 37.4, 37.0, 36.4, 35.6, and 34.7 percent of its variance, respectively; and the remaining is related to the other variables. In other words, it can be observed that over time, the role of cotton price diminishes drastically and seed price gains higher and higher importance so that in the 10th period, 34.7 percent of the variance is captured by the seed price.

Conclusions and Recommendations

With respect to the significance of cotton price in Iran, this study addressed the question as to how much cotton price volatility is influenced by the price shocks of cotton production inputs including labor, land, seed, pesticide, fertilizer, and water. After the optimal lag was specified and the long-run relationship between the variables was determined, the cointegration relationships were employed to find out the variables influencing cotton price volatility in Iran over the time period of 2000-2016 using the PVAR method. The results showed that the price shocks of seed, labor, pesticide, and water have affected cotton price positively, and the variations between seed price increase and the variations of cotton price growth have been of crucial importance. Thus, at purchase time, this should be considered because the increase or decrease in seed price is a decisive factor in cotton pricing in the marketplace. The effect of water price was found to be insignificant because water is supplied to farmers in most regions free of charge or at very low prices. So, it has a very minor role among decisive factors. The variables of land and fertilizer price shocks have influenced cotton price negatively. In case of land, this can be explained by the fact that most farmers are the owners of their lands, so land lease cost does not emerge among implicit costs, leading to its negative impact on cotton price. The negative impact of fertilizer price shock on cotton price is induced by the variations of other factors. The price of pesticide cannot be explained and the results showed that it has not influenced cotton price considerably. This research is consistent with the results of studies by Moradi and Afsharmanesh (2017) and Mekbib et al. (2016).

According to the findings, it is recommended to establish a market in which the prices of the inputs and the crops are specified in order to hinder the price volatility of inputs and cotton price. Also, attention should be paid to market adjustment policies by the relevant organizations and agencies in order to regulate the relationships between demand and supply. Organizations are required to monitor cotton crop imports and its supply to the market to avoid price shocks. Cotton farmers believe that the lack of a trade union is a source of problems in this industry. So, it is recommended to establish unions so that they can create proper markets, strict regulations, and fixed prices for different crops at different qualities so that a relative stability

can be attained in the marketplace and the producers are directed towards a suitable atmosphere to sell their products. Supporting this union can contribute to solving some problems faced by the producers.

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