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### Abstract

Forecasting values of prices and production are important for value chain actors because they can plan their activities while considering these values in mind for improving profitability. The present study is designed to determine forecasting values of production and prices of mung bean, lentil and chickpeas using arrival quantity of pulses in the big market of pulses in Punjab, i.e. Faisalabad. Similarly price data is used to forecast future prices of pulses. ARIMA model is employed to determine forecasting arrival quantities and prices of pulses using monthly data from January, 2018 to June, 2023. Results show that there is no smooth price increases in mung beans during different months of a year. A declining value of lentil and chickpeas is an alarming indications for all value chain actors. Estimated values based on ARIMA models for price and arrival quantities of pulses have important implications for the producers and wholesalers dealing in pulses particularly chickpeas, mung beans and lentil. A declining forecasting value of lentil and chickpeas leaves a serious thought on the sustainability of value chain of these pulses in the province. A declining supply in the market with an increase in the price of lentil in future will affect stakeholders of supply chain of lentil.

**Keywords:** Forecasting values, Production, Prices, Pulses

### 1. Introduction

Although the demand for pulses in Pakistan has increased significantly since 1960, change in dietary habits, rapid population growth and awareness of nutritional benefits for human health are major contributors for a significant increase in pulses demand in the last few decades (Wu and Findlay 1997). As a result of a change in dietary habits, consumers are consuming more pulses than ever before. The nutritional strength and other health benefits of pulses have caused an increase in demand and prices of pulses (Raza et al. 2022). On an average yearly pulses consumption is 7 kg/per person in Pakistan (FAO 2023) whereas per capita consumption of chickpeas is 3-4 kg and lentils consumption per person is 0.5-1 kg (Special One Grain 2018). Pakistan produced 382000 tons of pulses, imported 920000 ton and consumed 1290000 tons in 2022-23 (USDA 2023), implying that the country is not self-sufficient<sup>4</sup> in pulses production and has to import a significant volume of pulses to meet the need of the rising population (Ullah et al. 2020). Dramatic increase in pulses consumption and stagnant production of pulses has significantly increased the import of pulses in Pakistan (USDA 2023). That is why the government of Pakistan has banned pulses export in 2007 by imposing 35 percent export tax with the intention of meeting domestic pulses demand. There are many factors causing a decline in production of pulses. They include old and vulnerable varieties (Ullah and Farooq 2022), lack of improved seed, price fluctuation, labor intensive practices (Kavesh et al. 2023), diseases, environmental variables (Rasool et al., 2024) and allocating pulses cultivated area to cash crops namely sugarcane, rice, etc. Supply of pulses can be improved by diversifying import sources, enhancing open market participation, investing in research and development and providing social protection programs and safety net to farmers growing pulses (Vanzetti et al. 2017; Ullah and Farooq 2022).

Improved marketing practices and strategies can increase the interest of farmers in increasing land area under production of pulses as a result of increasing profitability and competitiveness of production of pulses with other crops. Presently there exists a weak supply chain of pulses in Pakistan and is mainly controlled by private sector and farmers commonly sell their produce to the local dealers or collectors without cleaning or grading (Raza et al. 2022). Big wholesale markets are located at a far distance from pulses growing districts. Those big wholesale markets in Punjab include Faisalabad, Sargodha, Lahore, Multan and Rawalpindi. Since small farmers dominate in Pakistan's agriculture economy, they are not able to sell their produce in these big wholesale markets. However, big wholesale markets are integrated through price signaling where bidirectional relationships exist between them. Transmission channels of prices follow from the Sargodha market and followed by other markets in the region (Mushtaq et al. 2020). However, farmers gain very little benefits of integration of wholesale markets because of very little access to market information, lack of transport facilities, financial constraints, etc.

Raza et al. (2022) argue that farmers growing pulses gain less profitability. Little profitability leads to little interest in pulses production and allocation of few acres of land to pulses (Ullah et al. 2020; Ullah and Farooq 2022). Further, average yield of pulses in Pakistan is stagnant over the years mainly due to lack of availability of good quality seed, absences of improved value chain (Kavesh et al. 2023), poor marketing channel and lack of government policy support for pulses. Self-sufficiency in pulses can be attained if farmers have access to high quality seed with climate and pest resilience (Ullah and Farooq 2022; Raza et al. 2022), in addition to developing a competitive value chain of pulses in Pakistan.

Price fluctuation of pulses is another important determinant of supply in domestic market. Own price fluctuation of pulses and cross price flexibility have significant impact on supply of pulses in the country. Rani et al. (2012) find a positive growth rate in pulses whereas lentils and mung beans have relatively more price flexibility as compared to grams. So prices are important in making decision relating to production of pulses in the country. Fluctuation in prices and production uncertainly can lead to lowering the interests of the producers. Real domestic prices of pulses showed only marginal price increases until 2005, but since then prices increased almost four-folds (Ullah et al. 2020). Further, a decreasing tendency in cultivated area and production of pulses mainly

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<sup>4</sup> Self-sufficient in pulses implies that production of pulses fulfills domestic consumption of the country. Pakistan is not producing enough volume of pulses to meet domestic needs

mung bean and lentil over the last five decades is found, leading to increases in imported pulses to meet domestic demand (Ullah et al. 2020; FAO 2023).

The province of Punjab is a major consumer and producer of pulses in Pakistan, while Faisalabad is one of the big wholesale markets in Punjab and Pakistan (Mushtaq et al. 2020). Increasing consumption of pulses over the time highlights the importance of a suitable policy framework regarding production and prices of pulses, so farmers and other stakeholders in value chain of pulses can attain benefits. Forecasting production and prices of pulses is thus important for designing policies framework and pulses planning at national level to resolve the increasing concerns of demand supply gap (Amir et al. 2022). Thus it is imperative to study major pulse markets in Punjab to investigate supply-price relationship. Government and the stakeholders of pulses value chains can take informed decision based on the forecasting values of price and supply information. The present study intends to understand supply and price variation of major pulses in the wholesale market of Faisalabad. Effective forecasting values of future price and arrival quantities of pulses are important for producers and wholesalers. Thus findings of the study provide useful insights for producers and value chain actors to plan their business activities while considering future prices and supply of pulses in the market.

## 2. Methodology

Faisalabad market is famous for wholesale market of pulses in Pakistan as the produce of pulses arrives in this market from different districts and regions of Pakistan. Commonly known districts of Punjab include Bhakkar, Layyah, Minawali, Khushab, etc. in addition to adjoining districts of KP province. Faisalabad is also famous for processing industry of pulses. Therefore, this district is considered a very significant marketing place of pulses.

Data on arrival of three pulses (lentil, mung bean and chickpeas) and prices were obtained from Faisalabad Market. Data contained information on prices and arrival of pulses in the market on daily basis. Data don't have any information relating to quality parameters. Agriculture Marketing Information System, Directorate of Agriculture (Economics and Marketing) Punjab, Pakistan maintains daily record of prices and arrival of commodities in different markets of Punjab province (GoP 2023) through website (for details, see <http://www.amis.pk>). Minimum and maximum prices along with frequently quoted prices and quantity of agriculture commodities including pulses are reported. There is a little variation in the information on daily prices and quantity, monthly data is considered for the present study. This data aggregation is considered useful for saving time, reducing complexity by simplifying large data set, allowing for better decision-making and developing strategic insights.

Data on prices and arrival quantity of chickpeas, lentil and mung beans range from January, 2018 to June, 2023. Data on price of pulses is measured in Rs/100kg and arrival quantity of pulses is given as 100 kg per month. Prices and arrival quantities of pulses have trends, patterns and seasonality. Producers and wholesalers have to consider these information during making business plans. There are different methods to forecast values of prices and supply of agriculture commodities. Autoregressive integrated moving average (ARIMA) model is commonly used for time series data. This model provides unique results when the unit series of data have pattern, trends and seasonality (Gibson et al. 2019). Prices and supply of mung beans, chickpeas and lentil are characterized with seasonality, trends and patterns, so ARIMA is employed in analyzing and forecasting future values of the above mentioned pulses. ARIMA model has the ability to accurately predict future values of production and prices using historical data. Further it does not require additional assumptions and is useful both for linear and non-linear pattern in the data. Since our data contains patterns and seasonality, ARIMA model is the better available model to predict future values of prices and production of pulses.

There are three components of ARIMA model namely auto-regression (AR), differencing and moving average (MA). AR considers relationship between current observation and certain lag value of that observation. Differencing involves making data series stationary. MA considers dependency between current observation and a residual error from a moving average applied to the lagged observations. ARIMA method is a powerful tool for short-term and medium-term forecasting and it has been widely applied to forecast values of agricultural commodities (Adil, et al. 2012; Iqbal et al. 2005; Chattha et al. 2013).

## 3. Results

ARIMA model used to forecast prices and supplies of pulses while selecting the best model using important econometric criteria. After deciding the model, forecast is estimated separately.

### 3.1. Selection of the best model for prices of pulses

Akaike information criteria (AIC) is used to select the best model (Snipes and Taylor 2014) for forecasting price of chickpeas, mung beans and lentil in Faisalabad wholesale market. The lower value of AIC indicates the best model among the possible fit models for ARIMA. On the basis of AIC, ARIMA (8,1,11) is the best fit for forecasting price of mung bean in Faisalabad wholesale market. For chickpeas, ARIMA (0,1,2) is selected for the purpose. ARIMA (0,1,1) is the best model selected for forecasting price of lentil.

### 3.2. ARIMA analysis for wholesale prices in Faisalabad market

Table 1 provides information on ARIMA models for prices of lentil, chickpeas and mung beans. In ARIMA (0,1,1) for lentil, intercept is non-significant while MA(1) coefficient is statistically different from zero. For chickpeas ARIMA model, intercept is significant, whereas coefficients of MA(1) and MA(2) are significant thus ARIMA (0,1,2) is considered. For mung bean, ARIMA (8,1,11) is used. Results of moving average with lag 2 are reported only because of the space, otherwise it is MA(11). Other statistics such as Durban Watson statistics show no autocorrelation in the data of prices of all the pulses.

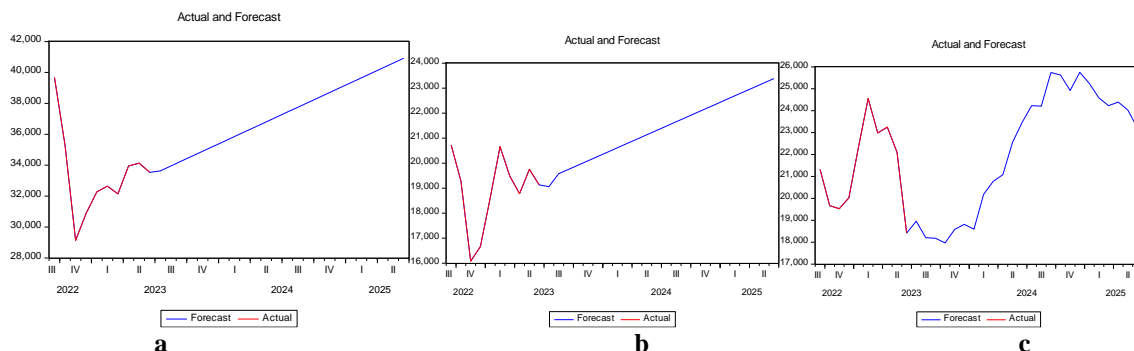
### 3.3. Forecasting wholesale prices of pulses in Faisalabad

Based on the estimates of ARIMA models, prices of pulses are forecasted for Faisalabad wholesale market for a period ranging from July, 2023 to June, 2025. In Fig 1 (a, b and c), actual and forecast values of wholesale prices of pulses are shown. One can see that price increases in lentil and chickpeas is smooth in the forecasting time period. However, forecast values of price of mung bean are not smooth over the forecasting time period (Fig 1, c). These results are consistent with existing literature where, pulses price growth remained consistent over the last five decades and mung prices showed flexible behaviors as compared to other pulses in Pakistan (Rani et al. 2012).

**Table 1: Results of ARIMA for wholesale prices in Faisalabad**

Variables	Lentil	Chickpeas	Mung beans
	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)
Intercept	316.76 (261.96)	173.07 (98.26)*	0.009 (0.005)*
MA(1)	0.29 (0.07)***	0.19 (0.07)***	-0.09 (0.19)
MA(2)		-0.44 (0.07)***	-0.28 (0.20)
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.			
MA (11)			
SIGMASQ	2636354	625131.0 (92836.28)***	0.008 (0.30)
Model	ARIMA (0,1,1)	ARIMA (0,1,2)	ARIMA (8,1,11)
Log likelihood	-572.78	-526.24	58.28
Durban-Watson test	2.01	1.84	1.94
Observations	65	65	65

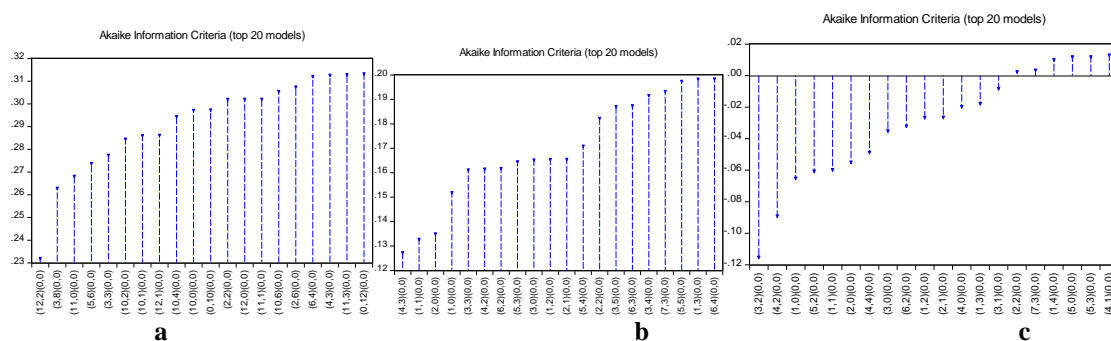
Source: authors own estimation



**Fig 1: Forecasting prices of pulses (a=lentil, b=chickpeas, c=mung beans)**

### 3.4. Selection of the best model for arrival quantity of pulses

A total of 20 different ARIMA models are estimated and based on the AIC, the model with the lower value is taken for each arrival quantities of pulses in wholesale market of Faisalabad. Fig 2 shows AIC information for the top 20 best models. On the basis of lowest value of AIC, ARIMA (12,1,2) is the best model for forecasting arrival quantity of lentil in Faisalabad wholesale market and for chickpeas and mung beans, ARIMA (4,0,3) and ARIMA (3,0,2) are selected respectively.



**Fig 2: Model selection for production of pulses (a=lentil, b=chickpeas, c=mung bean)**

### 3.5. ARIMA analysis for arrival quantities of pulses in Faisalabad market

Arrival quantity of pulses in the wholesale market of Faisalabad is estimated using ARIMA models. Different models are analyzed separately for each pulse arrival quantity. Table 2 shows results of ARIMA models for all three pulses. For ARIMA model (lentil), AR values upto 12 are taken and the first values of AR are significant. Intercept and MA(1 and 2) are not significant. For chickpeas ARIMA model, intercept is found statistically significant, AR (1 and 3) coefficients are also significant whereas MA are non-significant. Considering ARIMA model for mung beans, intercept is significant, coefficients of AR are statistically different from zero while those of MA are not significant.

### 3.6. Forecasting arrival quantities in Faisalabad wholesale market

Fig 3 indicates arrival quantities of mung bean, lentil and chickpeas in the selected wholesale market. Forecast value of lentil records high ups and downs over the period of July, 2023 to June, 2025. The values also imply that arrival quantity of lentil will decline in the forecast time period. It may be due to a decline in area and or productivity of lentil in the province.

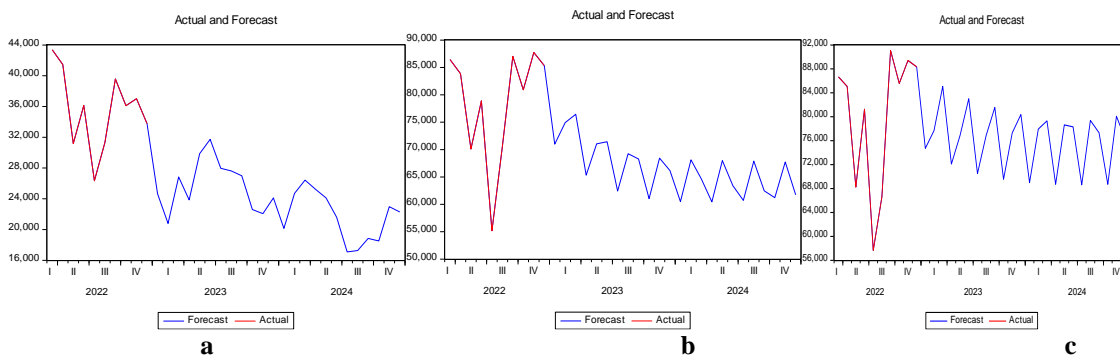
For mung bean and chickpeas, forecast values of both pulses are not smooth but a declining indication is not found as it happens in the case of lentil. Since forecasting values are on monthly basis, arrival quantities during and after harvest season of mung beans (July-August) increase compared to other months, so overall supply is almost smooth. However, values of chickpeas over the

forecasting time period also alert both producers and wholesalers that a decline in arrival quantities of chickpeas in the market would happen.

**Table 2: Results of ARIMA for arrival quantity of pulses in wholesale market of Faisalabad**

Variables	Lentil Coefficient (SE)	Chickpeas Coefficient (SE)	Mung beans Coefficient (SE)
Intercept	-0.02 (0.02)	11.05(0.14)***	11.12(0.12)***
AR (1)		-1.14(0.24)***	-0.25(0.04)***
AR (2)	1.29 (0.16)***	.	.
.	-1.06 (0.18)***	.	.
.	.	0.70(0.16)***	0.82(0.01)***
AR(12)	-0.62 (0.13)***		
MA(1)	-1.41(786.02)	1.87(57.86)	1.07(175.82)
MA(2)	0.99 (1114.88)	.	0.99(327.12)
MA(3)		0.66(62.68)	
SIGMASQ	0.03(19.71)	0.04(2.59)	0.04(6.12)
Model	ARIMA (12,1,2)	ARIMA (4,0,3)	ARIMA (3,0,2)
Log likelihood	9.15	5.18	10.45
Durban-Watson test	1.91	2.00	2.10
Observations	59	60	60

Source: authors own estimation



**Fig 3: Forecast and actual values of arrival of pulses (a=lentil, b=chickpeas, c=mung bean)**

## 4. Discussion

### 4.1. Price variation over the forecasting time period

Forecasting values based on ARIMA models for the selected pulses provide an important insight on the variation in prices of these pulses in the wholesale market in Faisalabad.

Although forecasting values of lentils and chickpeas are smooth over the forecasting time period, price of mung beans is not found smooth. This may be due to the fact that Pakistan imports lentils and chickpeas when shortage of these pulses in the market happens. Moreover, Mung bean shortage can happen as it can be substituted with other major crops (sugarcane, maize, vegetables etc.) where it is relatively more sensitive toward weather (rain, heatwaves, etc) and climatic factors (facing relatively low pest and disease attacks and other socioeconomic constraints, low profitability, marketing, own and cross price elasticities (Rani et al. 2012). The import of mung beans rarely happens and the market has to rely on domestic production (Ahmad & Ali, 2016; Vanzetti et al. 2017). Fluctuation in production of mung beans can result in unsmoothing variation in price in the wholesale market (Mushtaq et al. 2020).

### 4.2. Arrival quantities of pulses in Faisalabad wholesale market

Forecasting values of arrival quantities of lentil is found to decline substantially, although a small decline in the forecast value for chickpeas is also found based on the estimation of ARIMA models. Mung bean supply during the forecast time period doesn't show an alarming situation. Supply fluctuations is expected to happen due to the fact that climate change has devastated effect on pulses in general and chickpeas and mung beans in particular. Chickpeas supply predominantly depends on the weather conditions (rainfall and temperature). Chickpeas is highly concentrated in the barani areas of Bhakkar district and this district is vulnerable to climate change. Same is the case with mung beans. Climatic variations induce spread of pests and diseases in mung beans and chickpeas (Rani et al. 2012). Lentil supply is declining with the passage of time as cash crops are consuming areal allocated to lentil mainly due to the difference in profitability between lentil and cash crops (Vanzetti et al. 2017).

## 5. Conclusion and implications

Forecasting values of prices and arrival quantities of pulses in Faisalabad market show an increase in prices and a decline in arrival quantity during the time period considered. No smooth price increases in mung beans during different months of a year provides useful insights for the producers and wholesalers. They need to plan arrival quantities accordingly. Smooth increase in prices of

chickpeas and lentil is useful for planning production activities by the producers while forecast values of arrival quantities fluctuate in all three pulses. However, a declining value of lentil and chickpeas is an alarming indication for all the concerned stakeholders. Estimated values based on ARIMA models for price and arrival quantities of pulses have important implications for the producers and wholesalers dealing in pulses particularly chickpeas, mung beans and lentil. A declining forecasting value of lentil and chickpeas leaves a serious thought on the sustainability of value chain of these pulses in the province. Further, the producers and wholesalers can make their business plans in order to sustain livelihood.

Supply of lentil leaves a big question mark for the stakeholders involved in this pulse value chain especially sustainability. A declining supply in the market with an increase in price in the coming years will affect stakeholders of this supply chain<sup>5</sup>.

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