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PRICE FORECASTING MODEL FOR PERISHABLE COMMODITIES: A CASE OF TOMATOES IN PUNJAB

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ABSTRACT

This study focused on developing forecasting model for perishable commodities and tomato is taken as a case to study. The model is developed on in-depth analysis of market dynamics and structure. An estimable theoretically founded model is the major output of this study which is based on true structure of the market. Complete model is comprised of inverted demand equation, Plantation and yield equations and the role of price expectations. The study reveals the fact that the farmers' production decisions are affected by the expected profitability which is based on the expected output prices. However, due to the involvement of certain intermediaries the farmers couldn't get the proper prices of its output whereas the domestic production meets 31.5% to its total demand only and the deficit is imported from other provinces of the country and from India. Low per acre yield and inefficient management practices, non-availability of hybrid seed, weather conditions and less profit margins and declining area of production causes the production to fall short of its potential maximum. Moreover, the increased reliance on imports and the increased demand due to increase in population causes the domestic prices to becomes more volatile. The majority of the small farmers sell their product through commission agents and wholesaler that cause imperfections in the market. Tomatoes value chain have certain problems like there exists a disparity between the small and large farmers in cost of production, yield and profitability. The model may forecast the prices on monthly or weekly basis depending upon the data availability.

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1. INTRODUCTION

Prices of tomato show unwanted increases some times during the year which is primarily due to demand pressures during specific days like Ramadan and Eid-ul-Azha and during restricted supply from India during Dewali. Considering the fact that Punjab meets around 31% of its total demand through domestic production that create demand and supply gap at domestic level and results in heavy reliance on imports from other provinces of the country and from India[2]. This study aims to develop a comprehensive theoretical model for tomato prices in dynamic framework keeping in view the structure of the market. It naturally diverts us to first develop an in-depth understanding of the structure of the market through survey of literature and demand supply gap analysis.

Forecasting is used to determine how to allocate resources and to plan for anticipated expenses for the upcoming period of time. Forecast is based on the projected demand for the goods and services and supply of the goods and services offered in the markets. Various studies [Box & Jenkins, (1970), Engle, (1982), Ayyub R.M. et al (2011)] forecasted the prices using the univariate models like ARMA, ARIMA, ARCH, GARCH etc. The study by Anwar, et. al (2016) forecasted the prices by using the time series moving averages on the historical data for potato prices. The studies that presented the hedonic model to forecast the house prices includes [Limsombunchao, V. (2004), Griliches, Z. (1961)]. However, the alternative models like Structural Vector Autoregressive models should be preferred over the others due to structural underpinning and theoretical adequacy (Yeh, C. Y. et al, 2011).

Forecasting acts as an early warning signal and helps the policy makers to get insights of future prices and to manage the resources needed. Various policy interventions like keeping the buffer stock etc, tries to stabilize the prices, because stable prices avoid the economy from negative impacts. Price stability helps in avoiding prolonged inflation and deflation and contributes to achieving high levels of economic activity and employment. Price stability allows making well informed consumption decision thus making resource allocation more efficiently. The unproductive activities avoided and hedge against negative impact of price volatility, and contributing to financial stability.

[2] Authors calculation are based on the data access from Agricultural Marketing Information System website, www.amis.pk

Various factors are responsible of changing prices includes demand and supply situations, the cyclical and structural factors also cause the prices to fluctuate, however, the prices are affected by the domestic and international market dynamics. Fluctuation in consumer demand and changing supply causes the price to fluctuate. A smooth supply and demand ensure the stable prices. This study focused on forecasting the prices for tomato crop. Because the tomato crop is perishable in nature. It faced the short supply in the months of July and August every year, and it's increasing reliance on imports to meet the domestic requirement.

Structure of the remaining sections is as: section 1 presents the brief introduction of the study. Section 2 consists of review of literature. Demand-supply gap analysis and international comparisons presented in section 3. Tomatoes market outlook is given in section 4. Details of theoretical forecasting model is elaborated in section 5. Section 6 comprised of conclusion and policy recommendations are presented in section 7.

2. REVIEW OF LITERATURE

The earlier research on the tomatoes indicates that the tomato yield varies from the size of farms. The household with larger farm size are less technically inefficient than the farmers with small size. Hence, the productivity of the large farmers is higher than the small farmers. The tomatoes yield also varies from early season and late season. The late seasonal farmers have less productivity as compared with the main growing season farmers. This difference is due to different weather conditions. The tomatoes yield also affected by the application of fertilizers and pesticides. The research emphasized the need to adopt the sustainable pest and weeds management approach. The farmers faced the losses due to the higher cost of production and limited access to credit. The tomatoes yield and efficiency is also affected by the variety of tomatoes grown. The post-harvest losses accounts for 40% share in main season and 14% share in late season (Asante, B. O., et al, 2013, and Aidoo et al., 2014). According to the study done by Murthy et al., (2009) the non-adoption of hybrid seed, pests and diseases management plays important role in tomatoes yield per acre. The crop yield is affected by the farm size holding, input use pattern such as labor, fertilizers, seed cost tractor cost and the farmers' profitability.

The study by Eltoum (2015) find that the higher harvesting cost, lack of inputs availability and the seasonality affects the tomatoes productivity. The main components of cost of production for

tomatoes were irrigation cost and the harvesting cost. The study determines that the cost of land preparation, clearing cost of weeds, pesticides cost, fertilizer quantity, the labor used for crop and the expected profits are the main factors that affects the tomatoes production. Moreover, the months of July and August were found to have the highest prices of tomatoes while the months of March and April reported the lowest prices. Moreover, tomato crop is perishable therefore in summer starting from April-September a relative shortage exists in these months. However, during winter season tomatoes abundantly available. The seasonality and perishability causes the lower prices in winter and higher prices in summer. Furthermore, tomato prices are affected by the market integrations. The lack of transportation and storage facilities compels the farmers to sell the crop in hands of middleman.

While in the marketing of tomatoes, the profit margins for the farmers are lesser than the margins received by the retailers and wholesalers. The retailers receive the 75.4% profit margins while wholesalers receive 99.5%. The study justified that the storage of commodity makes the wholesalers to get higher profit margins (Nwaru et al., 2011 and Hernandez, 2007).

The study by Luciar (2000) shows that the tomatoes consumption is higher in the regions that have higher population. The study also indicated that the level of income affects the tomatoes consumption. The household that have higher income consumes greater amount of tomatoes. However, the processed tomatoes products increased the tomatoes demand in the study area.

The studies by Shownkwiler, (1982) found that the farmers make the expectations of the prices based on the several factors. These factor includes the production mechanism such as weather conditions, input use pattern and expected profitability.

The study by Arshad, F. M., & Hameed, A. A. A. (2009) revealed that gasoline and diesel are heavily used in ploughing, planting, cultivating, harvesting and other farm operations, an increase in domestic oil prices leads towards the expensive farm operations, expensive tractor, expensive transportation and other farm operations, as a result cost of production increases, consequently increases the prices. The study Binuomote, S. O., & Odeniyi, K. A. (2013) shows that oil prices negatively affect the productivity of the crops.

The study Roeger, E., & Leibtag, E. (2011) shows that increase in commodity price due to increase in oil prices primarily depends upon the geographical location. A place away from market has higher impact on commodity prices due to higher transportation cost while place near to market have smaller impact on prices due to lesser transportation cost

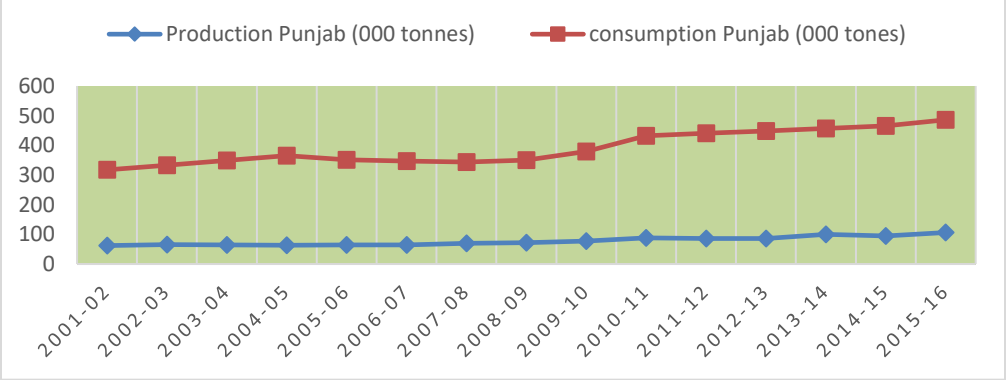
The study by Eckstein, (1984) shows that the farmers decision on production and land allocation based on the expected output prices. Farmers optimal allocation decisions are derived from the linear function of the past land allocations, expectations of future product prices and other exogenous factors. The farmer make the optimal allocations of resources based on the expectations.

Changes in the production can leads towards the changes in the prices. However, domestic agriculture is also sensitive to the changes in the world market conditions (Askari et al, 1977) Yield is attributed to the management practices, area planted, and hybrid cultivars. The element that affects the yield most is the behavior of output prices (Schultz, 1942).

3. Demand Supply Gap Analysis and International Comparison

Domestic production of Punjab province is less than the total consumption of the province. It produced 106.23 thousand tons of tomatoes in 2015-16. While its total consumption was 317.2 thousand tons. The domestic production contributed 31.5 % share of total consumption in year 2015-16 which was 29.2% in year 2014-15. Punjab faced the deficit of tomatoes 217.1 thousand tons, 228.5 thousand tons and 231 thousand tons in years 2013-14, 2014-15 and 2015-16 respectively (Estimates are based on data accessed from agricultural marketing information system). The consumption is increasing with the passage of time and the domestic production is unable to meet the requirement. It indicates that the province is not self-sufficient in tomatoes production and rely on imports to fulfill the domestic requirement from other provinces and countries.

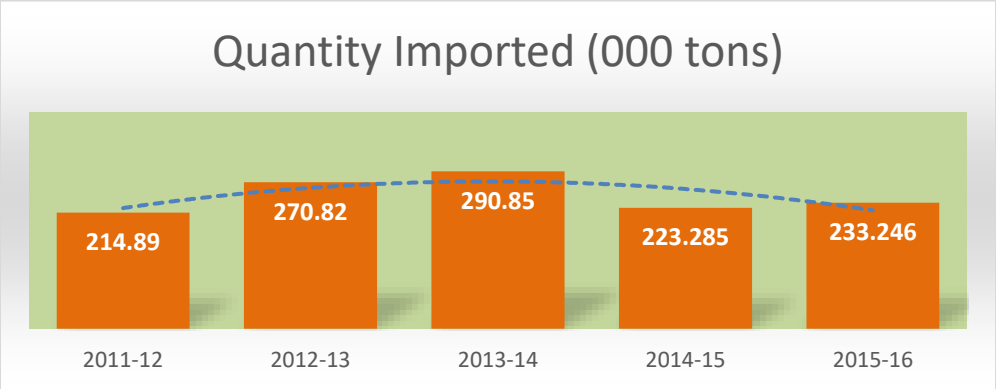
Figure-1: Punjab tomatoes domestic production and consumption from 2001-02 to 2015-16



Source: Author's calculations are based on data accessed from www.amis.pk

The Punjab's deficit is met through imports and Pakistan is 6th largest tomatoes importer country in the world. Pakistan has imported 233.24 thousand tones tomatoes in 2015-16 which was 223.28 thousand tones in last year 2014-15. It accounts 4.46% increase than the previous year. Pakistan spent large amount of foreign exchange on tomatoes imports. It has imported worth Rs. 7.916 billion tomatoes in year 2015-16[3].

Figure-2: Total tomatoes imports from 2011-12 to 2015-16



Source: Author's calculations are based on data accessed from www.amis.pk

The reliance on imports and a large amount of foreign exchange can be saved by attaining the self-sufficiency in production. The production can be raised by raising the per acre yield[4]. Moreover, the average yield of Punjab is around 112 mounds/acre.

Figure-3: Tomato yield in Pakistan from 2001-02 to 2015-16

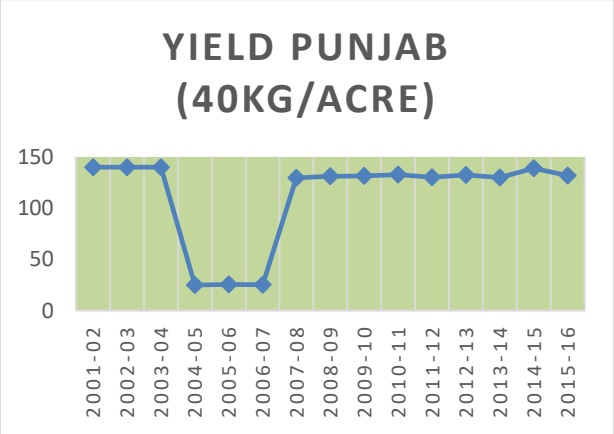
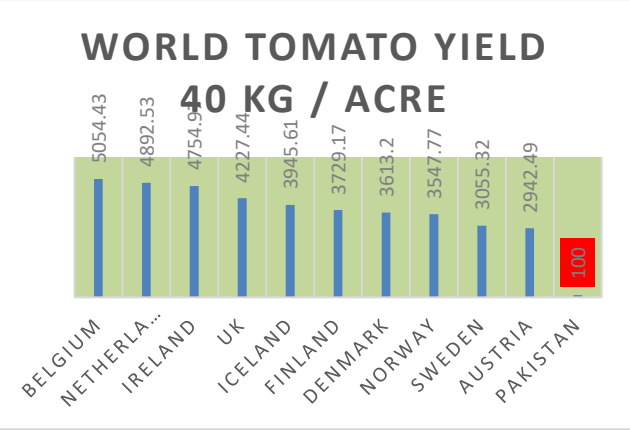


Figure-4: Yield comparison of Pakistan with world



Source: Author's calculations are based on data accessed from www.amis.pk

[3] Pakistan, tomato imports worth Rs.9.53 billion, Rs.14.975 billion and Rs.11.625 and Rs.9.22 billion in year 2014-15, 2013-14, 2012-13 and 2011-12 respectively (amis.pk).

[4] The farmers in Punjab facing different problems due to inadequate input system like costly imported seed, non-availability of pesticides and packing material and transportation (Sharif et al., 2010).

The less production of Punjab province is due to the less yield per acre as compared with other countries of the world. The tomato yield of Indian farmers' is 190 mounds/acre[5]. While, an average farmer in Punjab has an average yield of 112 mounds/acre. However, the yield per acre in Belgium, Netherland and Ireland is 5054 mounds/acre, 4892 mounds/acre and 4754 mounds/acre respectively. Several factors are responsible for less per acre yield of tomato farmers in Punjab. The non-availability of certified hybrid seed is one of the major factor. The commonly sown cultivars in Pakistan are Money Maker, Yaqui, Avinash, Lyreka, Roma and Riogrande. Yaqui and Avinash that has maximum yield which varies from 11.22 tons per hectare to 9.52 tons per hectare. Yaqui and Avainash are the most suited varieties in Pakistan (Naz, Falak, et al (2011) While, high yielding countries like Belgium, Netherlands and Ireland, the 'hybrid Giant Belgium' tomato varieties are commonly used. These varieties have maximum number of plants in the field and bears the highest number of fruits per plant.

Weather conditions also have larger impact on the per acre yield of tomatoes. The yield of varieties depends upon the temperature and rainfalls. Tomato plant requires normally 15°C to 35°C range of temperature.[6] The most difficult period of tomato production in Punjab is mid-May to June when the temperature is very high. Tomato crop also suffers during July-August (monsoon season) because in monsoon season high rainfall causes the pests, weeds and diseases to spread rapidly. The tomato crop has certain diseases caused by fungi, bacteria and viruses like leaf, fruit, stem and root diseases. The damage caused by these diseases results in considerable loss to crop yield.

Punjab has average yield of 138.6 mounds/acre in year 2014-15 which was 142.7 mounds/acre in 2012-13. The tomato yield in Punjab has decreased up to -2.65% since the previous year (estimates based on data accessed from Agriculture Marketing Information System) Per acre yield of tomatoes is associated with the expected profit margins. An average profit margins for farmers is around 33%. However, this 33% percent profit margins don't exist if the post-harvest losses of the farmers are considered. Post-harvest losses accounts for 28% at farm level while it is 40% at

[5] This yield is observed for "Arka Rakshak" hybrid variety. It is accessed from http://www.thehindu.com/sci-tech/agriculture/new-tomato-variety-that-yields-19-kg-a-plant/article5113247.ece#! on 13-february, 2017.

[6] Seed germination cannot occur below 10°C and above 35°C.The normal range for seed germination is 15.5°C to 29°C. Flowering is very sensitive to cold and cannot develop below 15°C and above 35°C. The optimum range for flowering is between 21°C to 24°C.

national level (Sharif et al., 2010). Moreover, the farmers expected profit reduced to zero and even farmers face losses at farm level if post-harvest losses may be considered. Furthermore, the farmers in Punjab are facing loss in tomatoes production. Therefore, Punjab remained unable to attain the self-sufficiency in production. The losses can be minimized by adopting the proper technology, training and handling techniques. Post- harvest losses can also be reduced if farmers expecting the higher output prices in future however, if farmers expecting the lower prices in future than the farmer's behavior would negatively impact the tomatoes per acre yield.

The major part of country's tomatoes productions is grown in Balochistan. It is major stakeholder in tomatoes production. Balochistan accounts for 34% share in total tomatoes production of the country.[7] However, in 2012-13 and 2013-14 the tomatoes production in Balochistan has declined. Several factors are responsible of declining production of Balochistan province. Area of tomatoes plantation has decreased in Balochistan from 35% to 29% in year 2015-16 as against of 2010-11. Reduction in area of production is the main factor that causes the Balochistan production to decline. While, Punjab province has least share in area of production for tomatoes that accounts for an average of 12%[8]. Moreover, Punjab can attain self-sufficiency in tomatoes production by increasing its area of plantation.

Figure-5: Province-wise area of plantation for tomatoes

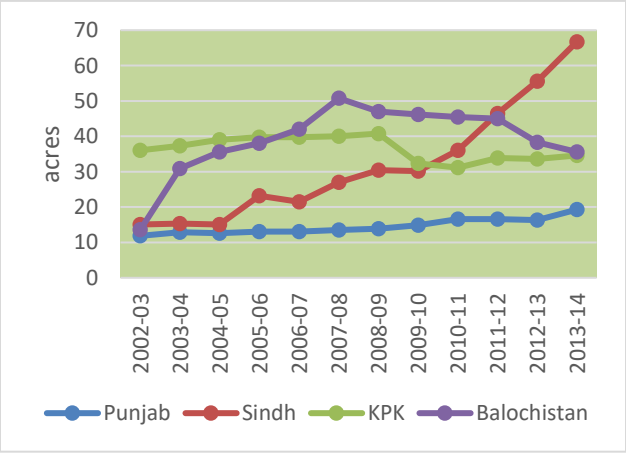
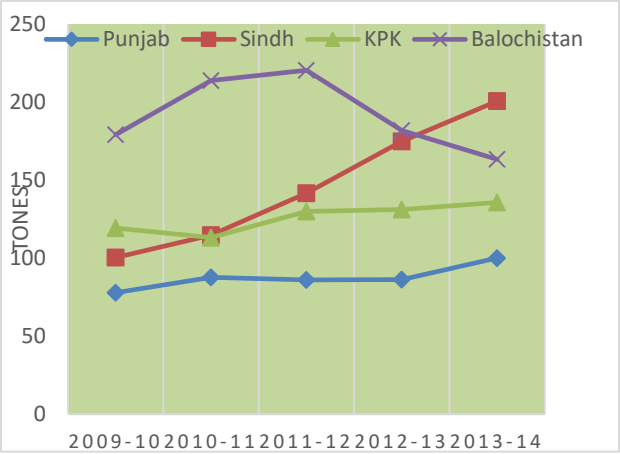


Figure-6: Province-wise production of tomatoes

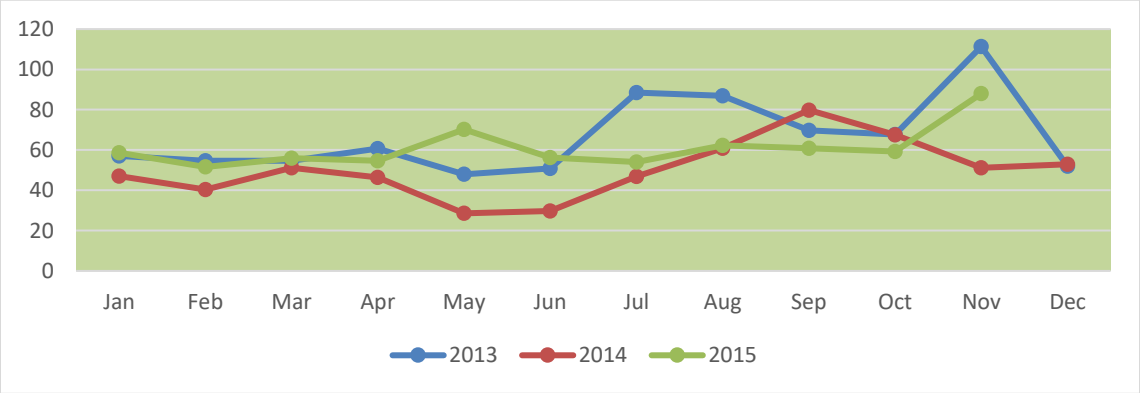


Source: Author's calculations are based on data accessed from www.amis.pk

[7] Moreover, Punjab, KPK and Sindh has16%, 22% and 27% shares respectively.
[8] Author's calculations are based on the data accessed from website www.amis.pk

Punjab has very volatile tomato prices. The heavy reliance on imports and less domestic production causes the prices to fluctuate. However, the tomato rising demand contributes in increasing the prices[9]. The increased tomato demand creates the imports substitution. The prices can be stabilized by increasing domestic production through improving the technology and promoting the tunnel farming culture. The imports may be planed carefully in such a way that the domestic tunnel farming can be protected and their profit margin may not be compromised. Moreover, the prices can be stabilized by reducing the demand and supply gaps of tomatoes.

Figure-7: Month-wise prices of tomatoes from 2013 to 2015



Source: Punjab Bureau of Statistics, 2017

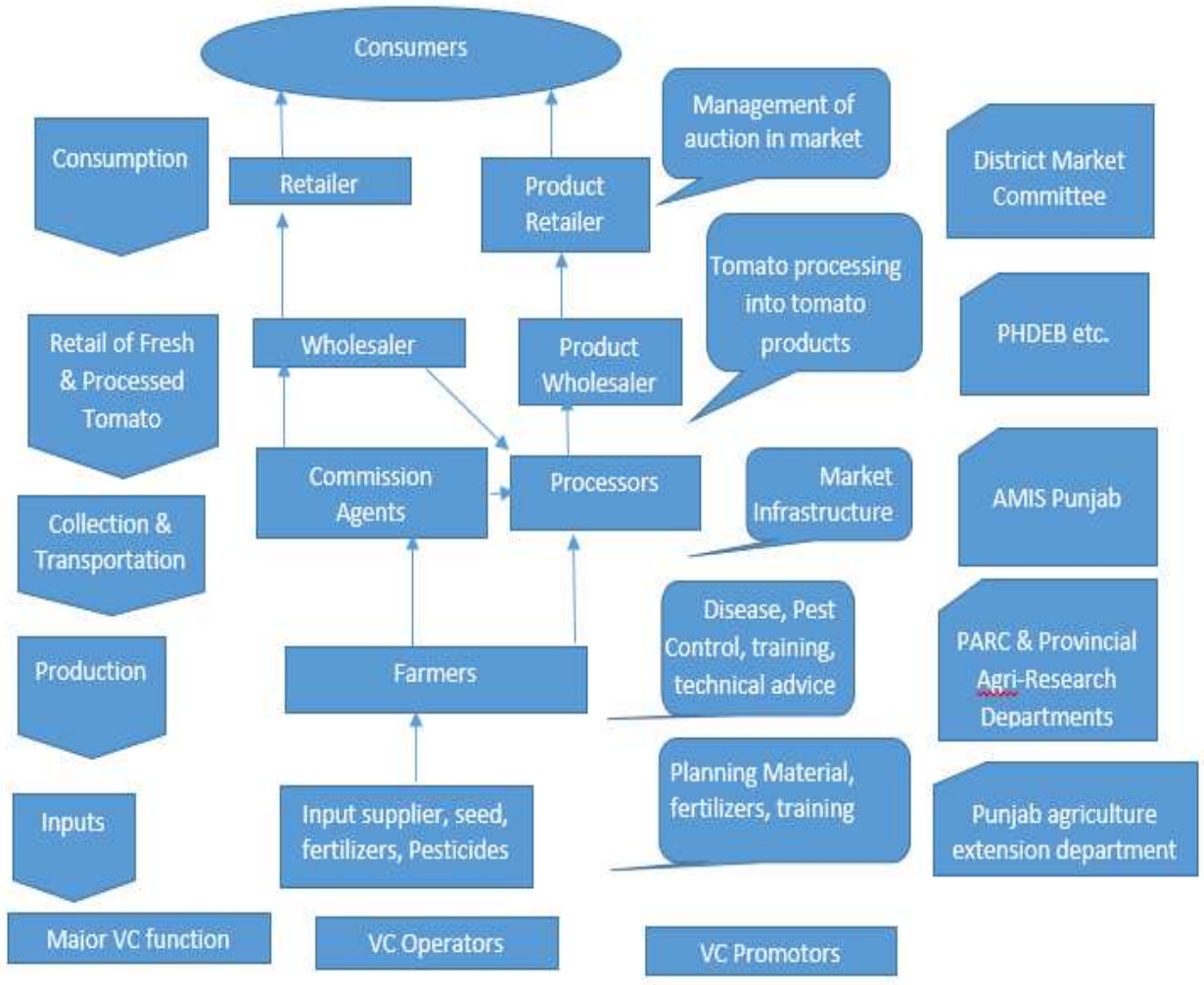
[9] The tomatoes demand rises during certain events such as Ramadan, Eid-ul-Azha and in Diwali and Holi.

4. TOMATO MARKET STRUCTURE: AN OUTLOOK

Tomatoes production primarily depends upon the expected profitability. In order to explore, why farmers' profitability is low and why farmers' are not receiving full prices of produce due to involvement of certain intermediaries? The supply chain analysis helps in understanding the functions of different stakeholders involved in tomatoes marketing.

There are two commonly known market channels in which the tomato farmers sell their produce in the market. One is from farmers to retailers in way through commission agents to wholesalers. This market channel is widely adopted by the small farmers. Small farmers sell there produce in the hands of commission agents that earn the abnormal profit via processing, storing etc. However, the second channel is through farmers to retailers through processors and product wholesaler. The larger farmer mostly adopts this market channel to sell their product into the markets.

Figure-8: Value chain mapping of Punjab for tomatoes



Source: Sharif et al., (2010)

Tomatoes supply chain consists of the various operators and promotors. Those peoples who performs the basic supply chain functions and holds the raw material, semi processed or finished are the operators/actors. However, the facilitating agencies or departments acts as the promotors of supply chain. Tomatoes supply chain flows as follow;

Production: It includes the peoples that are directly involved in the agricultural production i.e. cultivation, harvesting and self-marketing.

Post-harvest handling and processing: The supply chain operators who are directly related to the post-harvest management including cleaning, storing, packaging and delivering etc.

Trading: In tomatoes supply chain, the commission agents, wholesalers, retailers and processors are the trading agents that involved in the function of buying and selling of product.

Supply Chain Promoters/Supporters: These agents remain outside the regular business while facilitate the supply chain by upgrading strategies. It includes associations, networks or organizations that provide support services and represent the common interest. The services provided by promoters/supporters includes awareness, strategy building and coordination of activities through providing tangible and intangible assistance i.e. machinery, storage, training etc. Many farmers perform two or more function of the supply chain such as cultivation and post-harvest handling and transporting the product to the wholesaler.

Punjab farmers follows two basic routes to market the product. In 1st channel through the commission agents, wholesalers to retailer, the farmers perform transactional functions that involve growing, harvesting, sorting, grading, packing and transport to market. The research by Sharif et al., (2010) shows that almost 99.5% farmers adopt this channel to sell product in the market. Moreover, the 2nd channel in which farmer sell produce after harvesting with loose packing and delivered to tomato processing factory. Almost 1% farmers adopt this channel to sell into the markets.

The majority of the small farmers are trapped in the hands of commission agents due to lack of market information and lack of finances under such situations small farmers operate at a sub-optimal subsistence level and prefer to sell their produce in the hand of commission agents. High level of market margins exists as compared to the farm level. High margins at retailers followed by wholesalers, commission agents and farmer level.

Commission agents controls the commodity and information more than any other participant. Commission agents are the second major source of market information for many of the small and

large farmers. Commission agents usually operate from wholesale markets where tomato is auctioned to wholesalers and retailers etc.

It is also revealed from value chain analysis that there exists a disparity between the small and large farmers in form of cost of production, yield and profitability. The share of small farmers in pesticides, seed and irrigation costs accounts for 13.6%, 5.7% and 9.4% while this share for large farmers is 13.1%, 4.7% and 8.3%. The marketing cost is 47% of the total cost due to high rates of commission, higher transportation and packing cost. The marketing cost components includes the cost in crates 49.4%, transportation cost 19.8% and commission charges 12.1% (Sharif et al., 2010).

The profit rates earned by small and large farmers are different depending on the marketing channels adopted. The profit rate under horizontal coordination is lower than vertical coordination. According to Sharif et al. (2010), if the small farmer sales its product in the wholesale markets (horizontal co-ordination) than the profit margin obtained is 33.3% without considering the post-harvest losses while the profit margin is 48.8% if farmer sales its product to the processing factory (vertical co-ordination). Moreover, the large farmers can obtain the profit margins 37% under wholesale markets (Horizontal coordination) and 49% if sell to the processing factory (Vertical coordination). Hence, it is shown that there is a potential for high profits which is underutilized due to adoption of inefficient coordination channel, that is horizontal channel.

5. THEORETICAL FORECASTING MODEL

Based on review of literature and tomato market dynamics, we develop a purpose built theoretical model in this section. This model will help policy makers to not only understand how elastic is price to different factors but will also help in forecasting the price, conditional upon the availability of data at an appropriate frequency. The model has the feature to capture all the underlying forces affecting demand and supply of tomato. Role of price expectations has also been incorporated.

The price response model specified three different equations of farmer's behavior to capture the responses of area planted, yield and demand. These behavioral equations also include an identity that represent the market equilibrium. Furthermore, a composite of expectations of prices will be introduced depicting the hybrid form of expectations.

5.1 Supply Side

The decision by farmers about the production of tomatoes is based on two factors, one is the area planted and second is yield of the crop. Accordingly, the response of supply is represented by two equations. Rationale of these equations is that the decision regarding acreage and yield are based on different timing and information.

5.1.1 Area Planted

At the time of plantation, the uncertainty about prices remains an issue until and unless farmers engage into forward contract agreements with the food processors or the middleman. However, according to Sharif et al., (2010) large scale does have contracts with food processors but small scale farmers mostly rely on future prices. Therefore, role of price expectations by the farmers is critically important in decision about acreage plantation. Moreover, number of acreage planted also depends upon the expected price of the substitute crops. If the expected substitutes price increases, then the area of production for tomato decreases. The cost of production and the area planted during previous period strongly influence the planting decision of tomatoes (Shonkwiler, et al (1982)[10]. The farmers may continue to produce considering cost of production factors as fixed and due to psychological incentives to carryon tomatoes production. While, the urban pressure acts as a shifter, an increase in urbanization reduces the area of production and ultimately reduces the production so urbanization negatively affects the production. Urbanization is a critical factor affecting the crops production, increase in urbanization increases the opportunity cost of land, increased urbanization negatively influences the total agriculture land and accordingly the production, more specifically the area planted (weliwita,1997). The total production of tomatoes is the multiplication of area planted and the yield. Having said that only negligible percentage area remains unharvested, the total area planted is assumed as the total area harvested.

Following above theoretical underpinning, we can write the following equation for area planted.

$$A_t = \beta_0 + \beta_1 \left(\frac{P_t^*}{CP_t}\right) + \beta_2 A_{t-1} - \beta_3 \left(\frac{SP_t^*}{CP_t}\right) - \beta_4 UP_t + U_t$$

Taking log on both sides

[10] Shonkwiler, J. Scott, and Robert D. Emerson. "Imports and the supply of winter tomatoes: An application of rational expectations." *American Journal of Agricultural Economics* 64.4 (1982): 634-641.

$$lnA_t = \beta_0 + \beta_1 ln\left(\frac{P_t^*}{CP_t}\right) + \beta_2 lnA_{t-1} - \beta_3 ln\left(\frac{SP_t^*}{CP_t}\right) - \beta_4 lnUP_t + U_t$$

Hence;

$$a_t = \beta_{10} + \beta_{11}(p_t^* - cp_t) + \beta_{12}a_{t-1} - \beta_{13}(sp_t^* - cp_t) - \beta_4 up_t + U_{1t} \text{---------- (1)}$$

Where

a_t= Natural Logarithm ln of total area sown for tomato crop

p_t^*= Natural Logarithm of expected tomatoes price

cp_t= Natural Logarithm of cost of production

a_{t-1}= Natural Logarithm of area sown for tomatoes in last year

sp_t^*= Natural Logarithm of expected prices of tomatoes substitutes

up_t= Natural Logarithm of urbanization pressure

U_{1t}= stochastic component

5.1.2 Yield

Weather conditions and price-wage differential are primary determinants of tomato production. Tomato yield is affected by the weather conditions many times throughout the production period from sowing to harvesting (ranging normally 15^0C-35^0C). Moreover, the harvest frequency decisions also affect the yield of the crop, since tomatoes may be harvested based upon the purpose of use and the plantation technique. If planted through field stalks, then it may be picked two times and if planted in grounds then it may be picked five times. Wage rate is important factor influence the tomatoes yield as the increase (decrease) in wage rate (increase) decrease harvest frequency. Wage rate is negatively associated with the production (Weliwita, 1997). Moreover, the higher current output prices make farmers inclined towards more production due to incentive in harvesting.

Mathematically, it can be written as follows;

$$Y_t = \beta_0 + \beta_1\left(\frac{P_t}{W_t}\right) + \beta_2(TmPr_t) + U_t$$

Taking log on both sides

$$lnY_t = \beta_0 + \beta_1 ln\left(\frac{P_t}{W_t}\right) + \beta_2 ln(TmPr_t) + U_t$$

Hence:

$$y_t = \beta_{20} + \beta_{21}(p_t - w_t) + \beta_{22}(TmPr_t) + U_{2t}\text{------- (2)}$$

Where

y_t = ln of tomatoes yield per acre

p_t = ln of on-ground tomatoes prices

w_t = ln of wage rate

$TmPr_t$ = ln of temperature and precipitation

U_{2t} = disturbances

5.1.3 Production

The total quantity produce is the function of the total acreage planted and the per acre yield of tomatoes. Hence;

$$q_t = a_t + y_t\text{----- (4)}$$

Where

q_t = ln of tomatoes production

a_t = ln of area planted

y_t = ln of yield per acre

5.2 Demand

After harvesting, the tomatoes supply is fixed. Hence, the price of tomatoes at farm level is determined by the tomatoes production, imports from other provinces or countries and the variables such as population, general price level impact the consumer consumption. Because of the perishable nature of the tomatoes or other vegetables, the price of tomatoes is also affected by the domestic production and imports at that period. The total demand of tomatoes is comprised of two main components, per capita consumption and the total population whereas per capita consumption is derived from per capita income. Therefore, instead of including the total consumption in the equation, the derived demand components (per capita income and population) ca be included in the price equation. Hence the demand side equation in inverted demand function format can be written as follows;

$$P_t = \beta_0 - \beta_1 Q_t - \beta_2 IMP_t + \beta_3 PI_t + \beta_4 CPI_t + U_t$$

The study by Baumeister, C., & Kilian, L., (2014) shows that oil price increase causes the cost push inflation as a result the domestic prices of commodities increases. Moreover, oil prices affect the transportation cost, an increase in oil prices increase the transportation cost while a reduction in oil prices reduces the transportation cost (Dillon, B., & Barrett, C. B., 2013). Higher oil prices lead towards expensive transportation and increases the domestic prices [Arshad, F. M., & Hameed, A. A. A., 2009 and Roeger, E., & Leibtag, E., 2011]. Hence, we can write price equation as follow;

$$P_t = \beta_0 - \beta_1 Q_t - \beta_2 IMP_t + \beta_3 PI_t + \beta_4 CPI_t + \beta_5 OilP_t + U_t$$

Taking log on both sides

$$lnP_t = \beta_0 - \beta_1 lnQ_t - \beta_2 lnIMP_t + \beta_3 lnPI_t + \beta_4 lnCPI_t + \beta_5 lnOilP_t + U_t$$

Hence;

$$p_t = \beta_{30} - \beta_{31} q_t - \beta_{32} imp_t + \beta_{33} pi_t + \beta_{34} cpi_t + \beta_{35} oilp_t + U_{3t} \text{------ (3)}$$

Where

p_t = ln of actual prices

cpi_t = ln of consumer price index

q_t = ln of total tomato production

imp_t = ln of imports of tomatoes from other countries

pi_t = ln of consumer per capita income

$oilp_t$ = ln of domestic oil prices

U_{3t} = disturbances or unseen factors

5.3 Price Expectations

The acreage response is based on the expectations rather than actual values. Acreage decision is ex-ante decision. As the expected values are not observed so the hypothesis has to be made how expectations are formed. Tomatoes markets form the expectations of the output price by looking the previous year's prices. It can be determined through cobweb phenomena, distributive lag or through the adoptive expectations. Furthermore, some farmers make expectation by looking the

current market information. These expectations are known as the rational expectations. A study done by Lopez (1986)[11] shows that the tomato markets possessed both type of expectations either adoptive and the rational expectations. Therefore, hybrid form of expectations are assumed capturing the proportion of both types of farmers. The price expectation equation is as follows:

$$p_t^* = \lambda E(p_t) + (1 - \lambda)p_{t-1} \text{ -------- (5)}$$

Where

p_t^* = ln of expected prices

$E(p_t)$ = ln of rationally expected price

p_{t-1} = ln of previous year price

λ indicates that the prices may be forecasted using the rational expectations hypothesis or through the adaptive expectations and using cobweb, naïve forecasting methods. If λ=0 shows that the prices expectations are made through the adaptive ways or by looking at the price of previous period. However, if λ=1, it indicates that 100% of the famers use the current market information while making their expectations about prices. Moreover, if 0<λ<1 then some farmers make rational expectations and some may make the price expectations by using the cob-web phenomena. So, all make expectations and forecast the prices using the available previous prices and the current information.

Eq (3) capture the demand side factors while eq. (1), (2), (4) and eq. (5) captures the supply side factors. Shipments (imports) and local production are captured in single variable however, the specific equation can also be used to determine the impact of imports on prices and production of tomatoes. The total quantity produced is determined through equation (4) which is function of total area planted and the yield. The equation (5) is the hybrid price expectations equation that includes the weighted sum of the adoptive expectations and the rational expectations. It can be interpreted as the farmers may use the past information as well as the current available information while making decision the plantation area.

[11] Lopez, Rigoberto A. "The use of composite price expectations in supply response models." *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie* 34.3 (1986): 455-474.

5.4 Transforming Complete Market Model into Price Model

The complete market model developed in the previous section can be transformed into optimal price equation that have the feature to understand the dynamics of price in response to changes in different structural shocks in addition to determining the magnitude of coefficients. Complete model is rewritten to start transformation.

$$a_t = \beta_{10} + \beta_{11}(p_t^* - cp_t) + \beta_{12}a_{t-1} - \beta_{13}(sp_t^* - cp_t) - \beta_{14}up_t + U_{1t} \text{---------- (1)}$$

$$y_t = \beta_{20} + \beta_{21}(p_t - w_t) + \beta_{22}TmPr_t + U_{2t} \text{------- (2)}$$

$$p_t = \beta_{30} - \beta_{31}q_t - \beta_{32}imp_t + \beta_{33}pi_t + \beta_{34}cpi_t + \beta_{35}oilp_t + U_{3t} \text{------ (3)}$$

$$q_t = a_t + y_t \text{----- (4)}$$

$$p_t^* = \lambda E(p_t) + (1-\lambda)p_{t-1} \text{-------- (5)}$$

Keeping the external factors or the mean value of disturbance terms as zero, solving the above system of equations leads to price model.

Putting equation (1) and equation (2) in (4)

$$q_t = (\beta_{10} + \beta_{20}) + \beta_{11}(p_t^* - cp_t) + \beta_{12}a_{t-1} - \beta_{13}(sp_t^* - cp_t) - \beta_{14}up_t + \beta_{21}(p_t - w_t) + \beta_{22}TmPr_t + (U_{1t} + U_{2t}) - - - - - (6)$$

Put (6) in (3)

$$p_t = \beta_{30} - \beta_{31}[(\beta_{10} + \beta_{20}) + \beta_{11}(p_t^* - cp_t) + \beta_{12}a_{t-1} - \beta_{13}(sp_t^* - cp_t) - \beta_{14}up_t + \beta_{21}(p_t - w_t) + \beta_{22}TmPr_t + (U_{1t} + U_{2t})] - \beta_{32}imp_t + \beta_{33}pi_t + \beta_{34}cpi_t + \beta_{35}oilp_t + U_{3t} - - - - - (7)$$

$$\boldsymbol{p_t = \gamma_1 - \gamma_2(p_t^* - cp_t) - \gamma_3 a_{t-1} + \gamma_4(sp_t^* - cp_t) + \gamma_5 up_t - \gamma_6(p_t - w_t) - \gamma_7 TmPr_t - \beta_{32}imp_t + \beta_{33}pi_t + \beta_{34}cpi_t + \beta_{35}oilp_t + \epsilon_t - - - - - (8)}$$

Where $p_t^* = \lambda E(p_t) + (1-\lambda)p_{t-1}$

Box 1

$$p_t = \gamma_1 - \gamma_2(p_t^* - cp_t) - \gamma_3 a_{t-1} + \gamma_4(sp_t^* - cp_t) + \gamma_5 up_t - \gamma_6(p_t - w_t) - \gamma_7 TmPr_t - \beta_{32} imp_t + \beta_{33} pi_t + \beta_{34} cpi_t + \beta_{35} oilp_t + \epsilon_t - - - - - (8)$$

Where $p_t^* = \lambda E(p_t) + (1-\lambda)p_{t-1}$

- If farmers expect price increases in the future then they increase current area of plantation, as a result the production increases that leads to reducing the prices in future.
- Higher previous years area of cultivation has psychological inducement to grow more in the current year because of fixed factor of production as a result the increase in area cultivation increases the production, Hence, more supply consequently reduces the prices.
- Expected higher substitute prices make the farmer to grow less tomatoes and to grow the substitute crop that have higher profit margin as a result tomatoes area of cultivation reduces and production declines which causes the tomatoes prices to rise.
- Rising urban pressure reduces the area of production which causes the production to decline and prices to rise.
- Higher profitability margins increase per acre yield and total production consequently reduces the prices
- Tomatoes per acre yield increases in favorable temperature and rainfall conditions, as a result total production increases which reduces the prices.
- Increased per capita income increases the demand for tomatoes by increasing the purchasing power and a higher demand causes the prices to rise
- Rise in domestic oil prices increases the transportation cost, as a result price increases
- Imports fulfills the domestic deficiency of supply and causes prices to reduce.
- General increase in the inflation rate increases the tomatoes prices.

If the expected price increases, then the area of production for tomato also increases as a consequence the total production increases. Moreover, during sufficient availability of supply, the prices declined. Furthermore, previous years' area of plantation has the psychological inducement for farmers to plant again the tomatoes crop. If previous years' area is higher then there is a probability that current year area of plantation may also higher. Higher area of production causes higher production that ultimately reduces the price. The substitute expected prices impact the tomatoes area of plantation and production negatively. While the urbanization reduces the area of production and production and increases the tomatoes prices. Wage rate negatively impact the production and positively the prices. If tomato crops observed the good weather conditions, then the increased tomatoes production reduces the prices of tomatoes. During the deficit period, tomatoes import fulfills the domestic deficiency and causes the prices to reduce. Domestic oil price

fluctuations, increase or decrease the transportation cost as a result tomato prices increases or decreases. The income of consumer has positive impact on prices, if consumer income is higher than purchasing power parity of consumer increases that make it to buy more things. Finally, the general increase in the inflation rate increases the tomatoes prices.

Equation (8) captures all the possible determinants of price. Any compatible single equation econometric method or model like Generalized Method of Moment (GMM) or VAR model can be used to forecast the prices whereas the appropriate frequency of data is at least monthly. However, due to lack of availability of data, the forecasting can't be done at this stage.

The model incorporates all the factors that affect the production and marketing of the commodity. The model considers the structure of the farmers, price expectation, supply responses and price determination. Moreover, the impact of urbanization pressure and the substitutes crop prices in included in the equation of area planted equation. Furthermore, the static and dynamic effect can also be measured in the model of different economic factors that affect the production of tomatoes and prices of tomatoes.

Box 2: KEY MESSAGES

- Deficiency on the part of availability of data on appropriate frequency (at least monthly) should be dealt with so that price forecasting on appropriate frequency may be done through employing model developed in the study.
- The government may plan the schedule for imports for the months of Ramdan, Eid-ul-Azha and Dewali by assessing the total demand while keeping the domestic tunnel farming seasonal product into consideration.
- There is need to develop direct linkages of farmers with the retailers and processors so that they can accrue more profits, that is, direct market access. It will help to improve the local production.

6. CONCLUSION

Forecasting acts as an early warning signal and helps the policy makers to get insights of future prices so that measures to stabilize prices may be taken accordingly. Price stabilization helps to achieve high level of economic activity and employment. This study focused on forecasting the tomato prices in Punjab. Earlier researches revealed that the tomato production is affected by various factor such as the input use pattern, weather condition, demand pressure and many more. The farmers' production decisions are affected by the expected profitability that based on the expected output prices. However, due to the involvement of certain intermediaries the farmers couldn't get the proper prices of its output. In Punjab, the domestic production only contributes 31.5% to its requirement. Domestic production of Punjab province is less than the total consumption of the province. Hence, the Punjab is not self-sufficient in tomatoes production. Low per acre yield and non-availability of hybrid seed, weather conditions and less profit margins and declining area of production in Balochistan causes the production to fall short of its potential maximum. The deficiency is fulfilled through imports. Pakistan is 6th world's largest importer of tomatoes. Tomato imports have the considerable burden on the national exchequers. Pakistan has imported Rs.7.916 billion tomatoes in year 2015-16. Moreover, in year 2014-15, 2013-14, 2012-13 and 2011-12 the imports were worth Rs.9.53 billion, Rs.14.975 billion and Rs.11.625 billion and Rs.9.22 billion respectively. Moreover, the increased reliance on imports and the increased demand due to increase in population and in festivals causes the domestic prices to becomes more volatile.

Farmers mostly adopted two basic routes to market its produce on through the commission agents, wholesalers to retailers and one through the processors to retailers. The majority of the small farmers sell their product through commission agents and wholesaler. Commission agents control the commodity in the market than any other agent. The commission agents charges around 5-6% profit in the market. Tomatoes value chain have certain problems that there exists a disparity between the small and large farmers in form of cost of production, yield and profitability. Furthermore, the small farmers yield and profitability is less than the yield and profitability of larger farmers. Thus, imperfections at marketing and distribution stages are also responsible for markup prices. It reveals the fact that vertical marketing by the farmers can cause stability in prices up to some extent.

The model for price forecasting is developed in dynamic fashion through demand supply model. The model considered the impact of all the factors that can influence the tomatoes production and prices. Finally, the farmers' expectations about prices are taken into account by using the rational and adoptive expectations into the model. The model may forecast the prices on monthly or weekly basis depending upon the data availability.

7. POLICY RECCOMMENDATION

The government should intervene in the tomato market and the self-sufficiency can be attained by adopting the following measure;

- The government may plan the schedule for imports for the months of Ramzan and Eid-ul-Azha etc by assessing the total demand while keeping the domestic tunnel farming seasonal product into consideration.
- The hybrid seed that have higher per acre yield may be provided to the farmers on subsidized rates.
- Training may be provided to the farmers regarding the proper use of inputs such as fertilizers, pests, post-harvest handling and other management practices so that the yield per acre can be improved.
- The concerned departments should collect/develop the data of all these variables on monthly or weekly basis so that price forecasting model that captures all the market dynamics should be estimated and the future prices for tomatoes can be determined.
- Coordination may be established between demand and supply among the actors of the value chain because a lack of coordination causes the shortages, uncertain supply and higher prices.
- Weather conditions are significantly important to make decisions by the farmers about the cultivation of tomatoes. Crop insurance schemes can be proved as a supporting tool to reduce the risk on the part of farmers. Therefore, appropriate initiatives should be taken to introduce insurance schemes for the farmers.
- The government may consider the post-harvest losses while calculating the cost of production and post-harvest care management practices may also be introduced so that yield per acre can be further increased. Post-harvest losses can be reduced by establishing the cold-storages the post-harvest losses can be reduced significantly by proper

management that will lead to more profits for the farmers and will encourage the local production. Further, proper processing and packaging can also reduce the post-harvest losses.

- Government expenditure in research and extension can be made more effective and farmers may be supported by the institutions regarding marketing of product. These institutions can be owned by private sector.

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VARIABLE DESCRIPTIONS

The theoretical justification of each and every variable along with its measurement unit is summarized in box-1.

Sr.#	Variable	Description
1	Area sown	The study Ayinde, O. E., et al., (2014) found that with the increase in area of production, total quantity of production increases as a response the increase in quantity supply reduces the price. So area of production is positively correlated with total supply and negatively related with price. The number of hectares planted in different years is used as a variable in study Ayinde, O. E., et al (2014). In this study, It is used as total area (in acres) planted for tomatoes crop in Punjab.
2	Previous year price	The study Jordan, K. H., & VanSickle, J. J. (1995) found that current tomato prices depends significantly on value of past prices. The study revealed that surplus quantities in the recent past put downward pressure on prices but only first period lagged quantities were statistically significant. Jordan, K. H., & VanSickle, J. J. (1995) used lagged price into the model in order to know the impact of past prices on current prices and price expectations are made looking into the past prices (adaptive expectations).
3	Cost of production	Rising cost of production reduces the area of plantation and total production as a result the countries may fulfill deficiency through imports that causes the prices to increase (Trostle, R., 2008). Cost of production reduces the area of production and reduces the supply as a result prices rise (Ayinde, O. E., et al., 2014). Cost of production also reduces the farmers profitability, which impact area of cultivation and prices negatively.
4	Substitutes prices Index	The close substitutes of tomatoes crop are Chillies, Soyabean and Corn. The substitute crops affect the area planted for tomatoes Chern, W. S., & Just, R. E. (1978).The index of prices of Chillies, Soyabean and Corn can be used as the approximation of substitutes prices.
5	Urban pressure	The study by Lopez, R. A., et al., (1988) shows that urbanization benefits the producer of vegetables due to increased profits by increasing the demand, demand increases due to increase in population. However, urbanization reduces the land area. Moreover, overall impact of urbanization is positive. Urbanization reduces the area of production due to its opportunity cost.
6	Yield per acre	Total production is calculated as the multiplication of per acre yield and the total area planted. The yield of crop affects the total supply of

		crops (Chern, W. S., & Just, R. E., 1978). The reduced supply causes prices to increases and sufficient availability of supply reduces the price (Paltasingh, K. R., & Goyari, P., 2013)
7	Temperature/precipitation	Weather conditions have the dominating factor that influence both yield and the acreage of the crops. The study by Paltasingh, K. R., & Goyari, P. (2013). Found significant impact of rainfall conditions on productivity. The weather impact is complementary to prices (Paltasingh, K. R., & Goyari, P., 2013). The monthly rainfall and temperature represents the weather conditions
8	Production of tomatoes	Total production is used as the approximation of total supply of the commodity in the province. The higher production leads towards adequate availability for consumers and reduces the consumer prices. While the less production increased the demand pressure and ultimately raises the prices (International Labor Organization, 2014).
9	Imports	Punjab only produce 30% of its total consumption. The deficiency is fulfilled through the shipments. Cioffi, A., et al (2009) revealed that tomatoes imports play important role in stabilizing the domestic prices.
10	Per capita income and population	Total consumer demand is the basically the derived function of consumer income and population. Higher per capita income increases the consumer's purchasing power and increase the quantity demanded thus put upward pressure on price of the product. Other way round, increased prices reduce the consumer demand so the per capita income is used as the demand shifter. Increase in population results in increase in total demand that put upward pressure on price of the product. The study by Trostle, R. (2008) in line with this finding.
11	Oil Prices	Higher oil prices lead towards expensive transportation and increases the domestic prices [Arshad, F. M., & Hameed, A. A. A., 2009 and Roeger, E., & Leibtag, E., 2011].
12	CPI	CPI is one of the main determinants of price of any product including tomato. Increase in CPI would result in increase of price of tomato.
13	Tomato Actual Prices	The higher prices lead towards the higher supply and lesser consumer demand. So, an equilibrium in the demand and supply can create an equilibrium price. Tomatoes prices prevailed in markets affects the acreage decisions of the tomatoes (Chern, W. S., & Just, R. E., 1978).The consumer prices in rupees is used as the actual prices.