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Supply Chain Analysis of Onion and Cauliflower in Punjab

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Abstract

The present study was conducted in Rajpura block of Patiala district in Punjab with a sample of 50 vegetables growers. The total cost of cultivation was estimated at Rs 49563/ha for onion and Rs 34840/ha for cauliflower. The net returns were found higher for onion (Rs 74597/ha) as compared to that from cauliflower (Rs 38072/ha). Majority of these vegetables were being disposed off through commission agent/wholesaler (more than 90 per cent) followed by retailer and directly to the consumer. The efficiency of the these market channels can be enhanced through competition by organized retail chains and modernizing the vegetable market system in the state. The wholesale markets of Pune, Ludhiana and Patiala for onion and that of Shimla, Ludhiana and Patiala for cauliflower have been found integrated with price of onion and cauliflower transmitting quickly from the independent to the dependent markets. The highest elasticity of price transmission in onion has been observed between Ludhiana and Patiala markets with almost 90 per cent of the price change in Ludhiana getting transmitted to the Patiala market. Such transmission has been 100 per cent for cauliflower between Shimla and Patiala markets. The price transmission has been observed faster in cauliflower than onion. Though a long-term equilibrium relationship exists between all the studied markets in terms of weekly price of the two vegetables crops, there also exists a short-run disequilibrium between some of the market pairs with almost 15 to 25 per cent of the fluctuations usually getting corrected within a week. Greater integration in these markets may help the farmers as well as consumers of the vegetables through better price signals.

Introduction

Growing demand for fruits and vegetables induced by rising incomes and changing consumption patterns coupled with declining farm incomes due to rising costs and stagnating foodgrain productivity has necessitated diversification towards high-value crops in recent times. Apart from income enhancement, these high-value crops have potential to generate additional employment opportunities in farming due to their labour- intensive character (Weinberger and Lumpkin, 2006). The monoculture of rice-wheat in the state of Punjab has resulted into the emergence of various problems like over-exploitation of the groundwater resources, depletion of soil fertility and higher susceptibility of crops to the attack of various insect-pests and diseases (Sidhu, 2002). The Punjab state showcases the classic example of fast agricultural development based on few grain crops culminating to agrarian crisis of stagnating productivity, falling income and growing indebtedness and farmers' suicides. Thus, to improve income, provide gainful employment and save natural resources from further degradation, diversification from grain crops to high-value crops like vegetables has emerged as an important strategy for agricultural growth (Sekhon and Kaur, 2004).

There was a clear economic advantage in producing vegetables as compared to the traditional crops, but lack of marketing facilities has been the major impediment. Transportation costs and marketing margins of both retailers and wholesalers were identified as the major reasons for high marketing costs of vegetables, adversely affecting the profitability of such crops (Kumar *et al.*, 2004; Kumar and Arora, 1999). Navadkar *et al.* (2005) have raised the issues of high cost of packing, high commission, high

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transportation costs, delayed payments to the farmers and existence of malpractices in the marketing of vegetable crops. There are reservations on the potential of agro-processing to boost vegetable production due to lack of sufficient demand for processed vegetable products and very high capital requirements for such initiatives (Sidhu, 2005). There has been a significant negative relationship between the market arrivals and vegetable prices (Khunt *et al.,* 2006). There are large variations in the share of vegetable producers in consumer's rupee as well as marketing margins across different marketing channels. As a result, market intermediaries tend to apportion greater margins on the pretext of sharing larger proportion of producer's risk (Radha and Prasad, 2001).

Market plays an important role in determining the pattern as well as pace of diversification in favour of high-value crops. The adoption of these crops not only depends on socio-economic characteristics of the farmers, but also on production and market characteristics of these crops/enterprises such as amount of capital investments required, cost of production, prices realized, marketing margins and marketing efficiency. While large capital requirements and high cost of production may sometime play deterrent to the adoption, higher margins and efficient markets may allure farmers to go for such crops.

This paper has carried out an in-depth supply-chain analysis of two important vegetable crops, namely onion and cauliflower grown in the Punjab state. These two vegetables were purposively selected for analysis due to their importance in the production and consumption patterns. The paper has estimated the costs and returns from cultivation, has identified different supply-chain systems and associated margins and finally has looked into the price integration among different markets for these crops.

Database and Methodology

The study has used both primary and secondary data collected from the farmers and different market functionaries associated with marketing of the selected vegetables for the year 2006-07. The study was conducted in the Rajpura development block of the Patiala district of Punjab, having the largest production of onion and cauliflower amongst all the blocks in the state. The total number of farmers growing onion and cauliflower in this block ranged between 100 and 125. These vegetable farmers are spread over a large number of villages as the number of these farmers in one village seldom exceeds 4-5. The study intended to select 20 to 25 per cent of these farmers, and hence, a sample of 25 growers each of onion and cauliflower, was randomly selected from the list of all the onion and cauliflower growers in the block, making a total sample of 50 vegetable growers. The data were collected by a well-structured pre-tested questionnaire. The marketing data were collected from a random selection of 10 traders and 20 retailers in Rajpura market. Costs, returns, vegetable disposal systems and marketing margins were calculated by using simple tabular analysis. Time-series analysis was carried out for studying the price-integration between different markets for both the crops by using weekly wholesale price data from July 2002 to June 2006. The markets covered were the wholesale markets of Ludhiana, Patiala and Pune for onion and Ludhiana, Patiala and Shimla for cauliflower. These markets represented a blend of producing and consuming centres in order to study the price transmission process from production to consumption areas.

Two wholesale markets are considered to be integrated when a long-term equilibrium exists between them. However, two price-series need to be stationary to establish any such relationship. In the absence of stationarity, the estimated relationship may be spurious without any significant meaning. The relationship is also expected to hold good when two price-series are found stationary at the same level of differencing. The price-series in different wholesale markets were first checked for stationarity by using Augmented Dicky-Fuller (ADF) unit-root test. The test was applied after running the regression of the following form:

$$Y_t = \alpha_0 + \delta Y_{t-1} + \alpha_i \Sigma \Delta Y_{t-i} + \varepsilon_t$$

where,

Y_t = Price of a commodity in a given market at time 't',
$\Delta Y_{t-i} = Y_{t-1} - Y_{t-2}$, and
ε_t = Pure white noise error-term.

Once it was confirmed that either of the two price-series were stationary or of the same order of integration, the co-integration of two markets was tested by using Augmented Engle-Granger test. This test was undertaken by running the ordinary regression of the following form:

$$Y_t = \beta_0 + \beta_0 X_t + e_t$$

where,

Y_t = Price of a commodity in the dependent market at time't',
X_t = Price of a commodity in the independent market at time't',
β_0 = Constant term,
β_1 = Long-run elasticity of price transmission, and
e_t = Error-term.

After estimation of the above regression equation, the error-terms were subjected to the test of stationarity. The critical values used for the test were taken from Davidson and MacKinnon (1993). The stationarity of error-term confirmed the existence of co-integration of the markets and hence, the existence of a long-term equilibrium between the prices of two markets. Even after the existence of a long-term equilibrium between the prices of two markets, there is a possibility of short-term disequilibrium, due to which, the price change in one market is not transmitted immediately to the other market but takes some time for such transmission. The speed of such transmission was estimated by using the Error Correction Model (ECM) which is given below.

$$\Delta Y_t = \alpha_0 + \alpha_1 \Delta X_t + \alpha_2 e_{t-1} + \varepsilon_t$$

where,

ΔY_{t-i} = $Y_{t-1} - Y_{t-2}$,
α_0 = Constant term,
α_2 = Speed of price transmission (expected to be negative in sign),
ΔX_{t-i} = $X_{t-1} - X_{t-2,}$
e_{t-1} = Lagged error-term of the co-integration model, and
ε_t = Pure white noise error-term.

Land Resources and Cropping Pattern

The average size of operational holding for onion and cauliflower growers was 4.9 ha and 3.7 ha, respectively. The vegetable growers were observed to be leasing-in large chunk of land to increase their operational area in order to improve their economies of scale. The proportion of leased-in area was about 35 per cent for onion and 27 per cent for cauliflower cultivators. Onion covered 3 per cent and 5 per cent of the gross cropped area (GCA), while cauliflower was grown on 8 per cent and 19 per cent of the GCA on these farm situations.

Cost of Cultivation and Returns

The total cost of cultivation was estimated at Rs 49,563/ha for onion and Rs 34,840/ha for cauliflower (Table 1). Within the variable costs of cultivation, the share of human labour exceeded 35 per cent in both the crops, indicating the labour-intensive character of the vegetable crops. The seed and nursery-raising were

Table 1. Cost of cultivation of onion and cauliflower crops in Punjab

(Rs/ha)

Particulars	Onion	Cauliflower
A. Variable costs		
Seed and nursery raising	9400	4012
	(25.75)	(16.36)
Manures	1037	953
	(2.84)	(3.89)
Fertilizers	3231	4009
	(8.85)	(16.35)
Plant protection	4219	3754
	(11.56)	(15.31)
Micronutrients	190	93
	(0.52)	(0.38)
Hired labour	14695	7305
	(40.26)	(29.80)
Family labour	639	1371
	(1.75)	(5.59)
Machine labour	2030	2658
	(5.56)	(10.84)
Interest on working capital	1063	362
	(2.91)	(1.48)
Sub-total	36504	24517
	(73.65)	(70.37)
B. Fixed costs		
Rental value of owned land	6758	5461
	(51.75)	(52.90)
Rental value of leased-in land	3639	2020
	(27.87)	(19.57)
Depreciation of farm implements and machinery	1159	1223
	(8.88)	(11.85)
Interest on fixed capital	1503	1619
	(11.51)	(15.68)
Sub-total	13059	10323
	(26.35)	(29.63)
Total costs	49563	34840

Note: Figures within the parentheses for different components of operational cost and fixed cost are the percentages to their respective totals, while the percentages to the total operational cost and fixed cost are to the total cost. Interest on working capital has been calculated @ 12 per cent per annum for half the production period, while interest on fixed capital has been calculated @ 12 per cent per annum for the entire production period.

Table 2. Cost-return structure of onion and cauliflower crops in Punjab

Particulars	Onion	Cauliflower
Yield (q/ha)	256	196
Price (Rs/q)	485	372
Gross returns (Rs/ha)	124160	72912
Total variable costs (Rs/ha)	36504	24517
Total costs (Rs/ha)	49563	34840
Returns over variable costs (Rs/ha)	87656	48395
Net returns (Rs/ha)	74597	38072
Benefit-cost ratio	2.51	2.09

Source: Primary Survey

other important cost components accounting for 25 per cent and 16 per cent of the variable costs of onion and cauliflower crops, respectively. Expenditure on fertilizers and pesticides was also a significant cost item for these vegetables. The share of fixed cost in total cost for onion and cauliflower ranged between 25 per cent and 29 per cent; the rental value of land was the major constituent accounting for almost three-fourths of the total fixed cost.

The gross returns from onion were Rs 1.24 lakh/ha, while gross returns from cauliflower were Rs 72,912/ha (Table 2). Both yield and price differentials accounted for large differences in the gross returns from these two crops. While the returns over variable costs were Rs 87,656/ha for onion and Rs 48,395/ha for cauliflower, the respective net returns amounted to be Rs 74,597/ha for onion and Rs 38,072/ha for cauliflower cultivation.

Disposal Pattern and Marketing Channels

The onion and cauliflower crops were marketed through three different modes, namely commission agent/wholesaler, retailer and directly to the ultimate consumer. The proportion of vegetable farmers disposing off their produce through these channels along with the proportion of their produce is shown in Figure 1.

More than 90 per cent of the produce was disposed of through commission agents/wholesalers and a small proportion was sold through retailers and directly to consumers. It needs to be mentioned that a sizable proportion of the onion growers were selling directly to the ultimate consumers and that of cauliflower to the retailers but the quantity being disposed of was relatively insignificant. Though the vegetable growers tend to diversify their market portfolio by selling to retailers and consumers to realize better prices for their produce, relatively small capacity of these channels to handle large volumes of the produce creates hindrance to these sales. Hence, their increased dependence on the commission agents/wholesalers for selling their produce and relatively greater vulnerability to sharp fall in prices in times of excessive production.

The three supply channels being followed for marketing of the selected vegetables were:

Channel-I: Producer-Commission agent/Wholesaler-Retailer-Consumer

Channel-II: Producer-Retailer-Consumer

Channel-III: Producer-Consumer

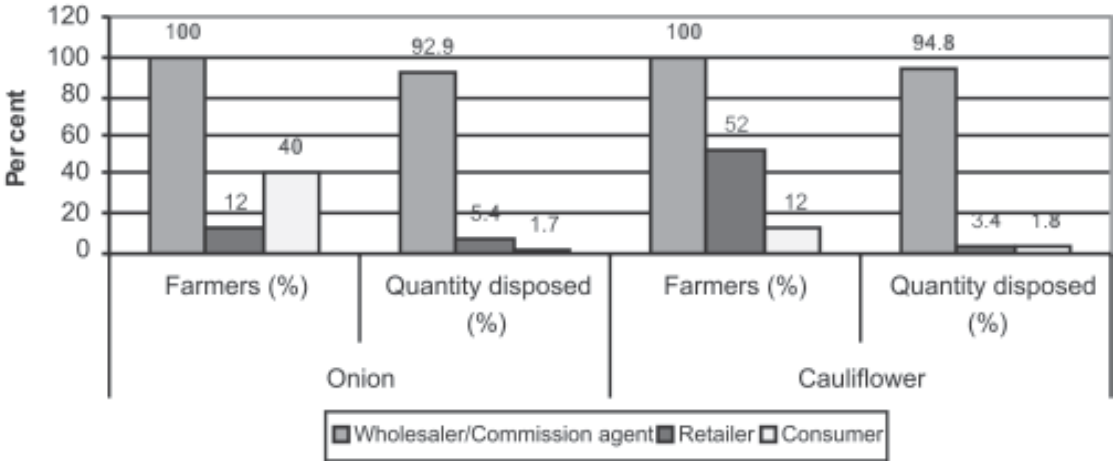

Figure 1. Disposal pattern of onion and cauliflower

Source: Primary Survey

Channel-III (direct sales to consumers) though was the smallest channel handling very small volumes of production, but was found to be the most efficient as it ensured not only the maximum price of the produce to the farmers but also the largest share in the consumer's rupee. The prices of vegetables and producer's share in consumer's rupee varied inversely with the length of the channel. Inclusion of more number of market intermediaries in the supply chain appropriated significant margins of the producers. This seems to be happening for facilitating easy and quick marketing of large volumes of the produce. However, intermediaries, especially wholesalers did not appear to be helping farmers in getting better prices. Producers were selling their produce to the secondary wholesalers through commission agents.

The marketing costs, margins and price spread for onion and cauliflower have been presented in Tables 3 and 4. Under producer-wholesaler-retailer-consumer supply channel in the case of onion, the marketing costs incurred by sample farmers, secondary wholesaler and retailer were: Rs 35.23/q, Rs 49.38/q and Rs 12.46/q, respectively. The marketing margins of secondary wholesaler and retailer were Rs 26/q and Rs 195/q, respectively. In producer-retailer-consumer supply-chain, the marketing cost incurred by retailer was Rs 37.36/q and his marketing margin was Rs 197/q. The share of wholesalers in consumer rupee was 3.28 per cent and that of retailers was 24.57 per cent under channel I. In channel II, the marketing costs of retailers were 4.42 per cent and their margins constituted 23.31 per cent of what consumer was paying.

In the case of cauliflower, the marketing costs incurred by sample farmers, secondary wholesaler and retailer were 1.81 per cent, 9.48 per cent and 3.26 per cent of consumer price, while their margins were 52.24 per cent, 5.78 per cent and 27.43 per cent, respectively in producer-wholesaler-retailer-consumer supply chain. In supply chain II, the marketing cost incurred by retailer constituted 5.97 per cent of the consumer price and his profit was 27.71 per cent.

The producer's share in consumer's rupee was found to be higher in onion than in cauliflower under producer-wholesaler-retailer-consumer and producer-retailer-consumer supply chains due to relatively lower degree of perishability. Further, as the links of supply chain got reduced, the share of producer in consumer price increased, indicating higher market efficiency under integrated supply chain systems. Though the shortest marketing channel for both onion and cauliflower (Producer-Consumer, Channel-III) seems to be most efficient, very small volume of produce was marketed through it due to its limitations to handle a large quantity of produce. It highlights the need to enhance the efficiency of the other two market channels. This is feasible only by reducing the retailer's margins, which are approximately one-fourth of the consumer's price, through competition by organized retail chains, which are emerging fast in the urban and semi-urban areas. The organized retail chains integrate the supply chain through backward linkages with the farmers and supply fresh vegetables through their outlets. These outlets are supported by pre-cooling facilities, refrigerated transportation and air-conditioned shelf space.

The other option to improve market efficiency and reduce retailer's margins is through modernizing the market system in the state. The market infrastructure for vegetables is traditional and lacks modern facilities such as pre-cooling, efficient transportation of produce and grading & standardization facilities. It increases crop wastages and induces risks for the retailers. Modernization of markets can reduce the risk of retailers and other market functionaries, thereby increasing the share of producer in consumer's price. Such modern markets for vegetables are being developed in Punjab on priority. One such market is already operational in Ludhiana and three more are likely to become operational in Amritsar, Jalandhar and Muktsar districts.

Market Integration

The results of ADF unit-root test for onion prices are given in Table 5. All the onion price-series corresponding to the wholesale markets of Pune, Ludhiana and Patiala were found stationary at the first difference levels, while for cauliflower, the price-series were found stationary at the level.

It was then worthwhile to study the price-integration between these markets for both the vegetable crops. All the market pairs were found to be integrated with certain degree of price transmission from one market to the other. The elasticity of price transmission of onion was 0.63, 0.66 and 0.90 between Pune-Ludhiana, Pune-Patiala and Patiala-Ludhiana markets and that of cauliflower was 0.76, 1.00 and

Table 3. Marketing costs, margins and price spread for onion crop

(Rs/q)

Sl No.	Particulars	Channel-I	Channel-II	Channel-III
1.	Net price received by the producer	475.62 (59.93)	610.63 (72.26)	627.09 (100.00)
2.	Marketing costs of producer			
i.	Packaging/grading	5.07 (0.64)	-	-
ii.	Material used	23.23 (2.93)	-	-
iii.	Loading/unloading	1.99 (0.25)	-	-
iv.	Transportation	4.94 (0.62)	-	-
	Sub-total	35.23 (4.44)	-	-
3.	Purchase price of secondary wholesaler	510.85 (64.36)	-	-
4.	Costs of secondary wholesaler			
i.	Loading/unloading	2.10 (0.26)	-	-
ii.	Market fee	10.22 (1.29)	-	-
iii.	Rural development fund	10.22 (1.29)	-	-
iv.	Commission charges	25.54 (3.22)	-	-
v.	Miscellaneous	1.30 (0.16)	-	-
	Sub-total	49.38 (6.22)	-	-
	Net margin of secondary wholesaler	26.00 (3.28)	-	-
5.	Purchase price of retailer	586.23 (73.86)	610.63 (72.26)	-
6.	Costs of retailer			
i.	Packing/grading	-	5.10 (0.60)	-
ii.	Material used	-	16.67 (1.97)	-
iii.	Loading/unloading	2.10 (0.26)	2.00 (0.24)	-
iv.	Transportation	4.50 (0.57)	8.00 (0.95)	-
v.	Losses @ 1%	5.86 (0.74)	5.59 (0.66)	-
	Sub-total	12.46 (1.57)	37.36 (4.42)	-
	Net margins of the retailer	195.00 (24.57)	197.00 (23.31)	-
7.	Consumer's price	793.69 (100.00)	845.00 (100.00)	627.09 (100.00)

Note: Figures within the parentheses show percentages of consumer's price
Source: Primary Survey

Table 4. Marketing costs, margins and price spread for cauliflower

(Rs/q)

Sl No.	Particulars	Channel-I	Channel-II	Channel-III
1.	Net price received by the producer	361.82 (52.24)	478.65 (66.32)	671.00 (100.00)
2.	Marketing costs of producer			
i.	Packaging/grading	-	-	-
ii.	Loading/unloading	2.91 (0.42)	-	-
iii.	Transportation	9.62 (1.39)	-	-
	Sub-total	12.53 (1.81)	-	-
3.	Purchase price of secondary wholesaler	374.35 (54.05)	-	-
4.	Costs of secondary wholesaler			
i.	Packing/grading	3.50 (0.51)	-	-
ii.	Material used	25.50 (3.68)	-	-
iii.	Loading/unloading	2.95 (0.43)	-	-
iv.	Transportation	-	-	-
v.	Market fee	7.49 (1.08)	-	-
vi.	Rural development fund	7.49 (1.08)	-	-
vii.	Commission charges	18.72 (2.72)	-	-
	Sub-total	65.65 (9.48)	-	-
	Net margin of secondary wholesaler	40.00 (5.78)	-	-
5.	Purchase price of retailer	480.00 (69.30)	478.65 (66.32)	-
6.	Costs of retailer			
i.	Packing/grading	-	3.50 (0.48)	-
ii.	Material used	-	24.00 (3.33)	-
iii.	Loading/unloading	4.00 (0.58)	1.02 (0.14)	-
iv.	Transportation	7.50 (1.08)	5.02 (0.70)	-
v.	Losses @ 2%	9.60 (1.39)	9.57 (1.33)	-
vi.	Miscellaneous	1.50 (0.22)	-	
	Sub-total	22.60 (3.26)	43.11 (5.97)	-
	Net margins of the retailer	190.00 (27.43)	200.00 (27.71)	-
7.	Consumer's price	692.20 (100.00)	721.76 (100.00)	671.00 (100.00)

Note: Figures within the parentheses show percentages of consumer's price
Source: Primary survey

Table 5. ADF unit-root test for wholesale prices of onion and cauliflower

Wholesale market	Level	First differences
	Onion	
Pune	-2.52	-13.28*
Ludhiana	-2.78	-16.29*
Patiala	-2.86	-15.38*
	Cauliflower	
Shimla	-4.18*	-
Ludhiana	-4.94*	-
Patiala	-3.55*	-

Note: *denotes significance at 5 per cent levels. Other values are non-significant.

Mckinnon critical value is -2.88 for 5 per cent level.

Source: National Horticultural Board

0.85 between Shimla-Ludhiana, Shimal-Patiala and Patiala-Ludhiana markets, respectively (Table 6). The highest price transmission in onion was observed between Ludhiana and Patiala markets with almost 90 per cent of the price change in Ludhiana getting transmitted to the Patiala market due to shorter distance between these markets. Such transmission was 100 per cent for cauliflower between Shimla and Patiala markets. The price transmission was relatively faster in cauliflower as compared to onion due to its fast perishability.

Further, the Error Correction Models for onion and cauliflower between different markets revealed that there existed a short-run disequilibrium between Patiala-Ludhiana market for onion and all the market pairs for cauliflower. The estimated equations for the market pairs, for which the short-run disequilibrium existed, are given below.

Table 6. Elasticity of price transmission of onion and cauliflower between different markets

Wholesale market	Pune	Patiala
	Onion	
Ludhiana	0.63*	0.90*
Patiala	0.66*	-
	Cauliflower	
	Shimla	Ludhiana
Ludhiana	0.76*	-
Patiala	1.00*	0.85

Note: * denote significance at 1 per cent level.

Source: National Horticultural Board

Onion

$\Delta \ln Pat = -0.0002 + 0.26\ \Delta \ln Ldh - 0.21^{**} e_{t-1}$

Cauliflower

$\Delta \ln Lud = -0.0002 + 0.50\ \Delta \ln Shim - 0.19^{**} e_{t-1}$

$\Delta \ln Pat = 0.003 + 0.13\ \Delta \ln Shim - 0.15^{*} e_{t-1}$

$\Delta \ln Pat = 0.003 + 0.37\ \Delta \ln Ldh - 0.25^{**} e_{t-1}$

In Patiala-Ludhiana market, 21 per cent of the short-term fluctuations in onion prices were found to get corrected within a week. In the case of cauliflower, 19 per cent, 15 per cent and 25 per cent of the short-term price fluctuations got corrected within a week in Shimla-Ludhiana, Shimla-Patiala and Ludhiana-Patiala markets, respectively.

In nutshell, the analysis has revealed a high degree of co-integration between the markets for onion and cauliflower. Though a long-term equilibrium relationship existed between all the studied markets in terms of weekly price of the two vegetables crops, there also existed a short-run disequilibrium between some of the market pairs with almost 15 to 25 per cent of the fluctuations usually getting corrected within a week. Greater integration in these markets may help the farmers as well as consumers of the vegetables through better price signals resulting into higher producer and consumer surplus.

Conclusions and Policy Implications

Studying supply chain system for high-value crops like vegetables is important for improving market efficiency and increasing producer as well as consumer surplus. In this paper, the supply-chain for onion and cauliflower in Punjab has been carried out with a focus on estimating costs and returns in their cultivation, marketing costs and share of different links of supply chain in marketing of the produce and the degree of price transmission from important producing/distributing market to other markets. It has been estimated that the cultivation of onion and cauliflower provides handsome profits to the farmers. The net profit has been estimated as Rs 74,597/ha from onion and Rs 38,072/ha from cauliflower. However, the sale pattern of these vegetables is skewed largely in favour of producer-wholesaler-retailer-consumer supply chain

under which more than 90 per cent of the produce is disposed of.

Though the vegetable growers tended to diversify their market portfolio by selling to retailers and consumers to realize better prices, relatively small capacity of these channels failing to handle large volumes of the produce obstruct their efforts. It highlights the need to enhance efficiency of the other two market channels through competition by organized retail chains and modernizing the vegetable market system in the state, which is largely traditional and lacks modern facilities such as pre-cooling, efficient transportation of produce and grading & standardization facilities. The wholesale markets of Pune, Ludhiana and Patiala for onion and those of Shimla, Ludhiana and Patiala for cauliflower have been found integrated with prices of onion and cauliflower transmitting quickly from the independent to the dependent markets. The price transmission has been found faster in cauliflower than in onion due to its higher perishability. Though a long-term equilibrium relationship exists between all the studied markets in terms of weekly price of the two vegetable crops, there also exists a short-run disequilibrium between some of the market pairs with almost 15 to 25 per cent of the fluctuations usually getting corrected within a week. Greater integration in these markets may help the farmers as well as consumers of the vegetables through better price signals to increase their surpluses.

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