JOURNAL OF RELATIONSHIP MARKETING
https://doi.org/10.1080/15332667.2020.1858738

Selection of Agricultural Contract Sales Models to Wholesalers to Maximize Supply Chain Profit (an Experimental Study)

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ABSTRACT

In the new approach to the supply chain, the emphasis is on securing the benefits of all the categories in the chain and providing ways to improve the performance of the chain in order to achieve the desired goal. Due to the production of people's daily commodities and the low durability of some products, supply is important because supply and demand must be proportionate. This case study was conducted on tomato crop and selecting the model of contract of sale of agricultural products to wholesalers in order to maximize the whole supply chain profit. By reviewing the literature on supply chain contracts, 5 coordinated contract models were identified and tested through an empirical experiment on the supply chain wholesalers. The results of the experiment compared to the optimum value determined by the newsvendor model show that the order value received in each of the contracts did not reach the optimum value (280).

KEYWORDS

Profit maximization; pre-sale product; supply chain; coordinated contract; Newsvendor model

Introduction

Today's approach to supply chain management is to bring the benefits of the whole supply chain together (Jüttner et al. 2010). Each of the chain categories is based on the chain's profit-sharing policy, so it is necessary to manage the different category activities in order to gain benefits for the whole chain (Chopra & Sodhi, 2004; Lei et al. 2012).

One of the key issues in supply chain management is order quantity discussion (Liu et al. 2020). Manufacturing companies contract with suppliers to provide raw materials and components and order their required materials during the contract period (Guo et al. 2017; Routroy & Behera, 2017). The order quantity should be satisfactory for both buyer and seller (Katok & Pavlov, 2013). This optimal amount of ordering or inventory storage for distributors and sellers in the supply chain can be determined by the

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Newsvendor Mathematical Model (Arrow et al., 1951). The Newsvendor model is a proven mathematical model that allows the development of chain profit maximization by coordinating in the supply chain to find the best pricing and ordering policies to maximize supply chain profit. Mechanisms such as contracts should be provided that, in addition to guaranteeing these conditions, distribute the appropriate profits among the members of the chain in order to motivate the members of the chain to continue their activities (Cachon, 2003).

The agricultural industry is one of the most important sectors of the economy in most developing and developed countries (Kamble et al., 2020; Somashekhar et al., 2014), referred to as the engine of economic growth (Borah et al., 2020). Today, the prominent role of agriculture in development, especially in food security and the accession of countries to the World Trade Organization, has made policymaking and planning important in this area (Castañeda et al., 2019; Tefera, 2012). Also, most agricultural planners and policy makers have focused on the agricultural economy, its principles for managing production, maximizing farmers' income and their welfare (Choi & Guo, 2020; Parwez, 2014).

There are various categories, including farmers, wholesalers, retailers and end consumers in the agricultural production and consumption chain, each of which strives to increase its profits by making the right decisions. The performance of each category has a direct impact on the other (Schipmann & Qaim, 2011). The amount of crop production in each crop season depends on the farmers' decision on the level of crop cultivation except where natural events such as flood or drought affect production. In the supply chain of crops, the low production of a crop by farmers in a given period reduces the income of distributors due to the lack of sufficient crop for sale. Due to the relatively constant demand for agricultural products, the lack of it makes the crop expensive and the consumer dissatisfied. On the other hand, over-production leads to surplus stocks, which will result in price declines and product corruption, and consequently, loss to farmers. Due to limited resources in crop production, the opportunity to produce another crop is lost by cultivating one crop (Hu & Feng, 2017). Farmers and buyers at the community level are numerous and dispersed, which makes it impossible to establish a proper link between these two levels of the supply chain, and farmers are unable to obtain complete information about consumer demand (Zhou et al., 2019).

In order to solve this problem, the role of the government in the chain can be seen as an intermediary between farmers and wholesalers. The government can use coordinated supply chain contracts (Kerdsriseam & Suwanmaneepong, 2015). In this model of contracts, the profit and the risk of non-selling are divided between the manufacturer and the buyer in the agreed ratio (El Ouardighi & Shniderman, 2019; Katok & Wu, 2009). Therefore, major distributors and buyers of agricultural products are required to forecast market demand based on their own knowledge and determine their orders on a contract basis before each production season begins. Since supply chain coordinated contracts can be preordered before the season begins (Chen & Özer, 2019), therefore, in order to balance agricultural production, this kind of contracts can be used to transfer demand information to farmers and pre-sell crops. For this purpose, it is necessary that the contractual model be presented to the wholesaler for pre-sale of the products to order the optimal quantity.

Various studies have been carried out to find the optimal contracts and orders (Asian & Nie, 2014; Govindan et al., 2013). Lim and Ho (2007) have used pricing contracts in their research. Katok and Wu (2009) three Types of Contracts including Wholesale Price, Buyback and Revenue Sharing and Elahi et al. (2013) have compared five types of contracts including Mixed contracts, risk-averse contracts, free offers, demand pattern display, and collective feedback provision. Cachon and Lariviere (2005) have compared the revenue-sharing contract with other contracts such as buyback, price-discount, and quantity-flexibility. In another study conducted by Becker-Peth et al. (2013), the performance of buyback contracts was examined through empirical research. Also, Shampanier et al. (2007) in a study of zero as a special price, have made the real value of free items. Other researches have investigated the tensile behavior toward the center (Bostian et al., 2008; Schweitzer & Cachon, 2000). According to the literature review, no research has been conducted to determine which contracts are effective and which leads to optimal order quantity. The purpose of this research is to prioritize coordinated contracts to determine which contract model is most effective.

In this study, the Newsvendor model has been used as a framework to determine the most effective contract model. The Newsvendor model is a proven mathematical model that is used in operations management and applied economics to determine the optimal inventory level and is known for its perishable price characteristics and random demand for a perishable product. Edgeworth (1888) first raised the issue of Newsvendor in the issue of newspaper publication and the optimal number of copies per day. The optimal order quantity or inventory reserve for distributors and sellers in the supply chain can be deduced through the Newsvendor mathematical model (Wu et al., 2009). There are also contracts for the pre-sale of goods to sellers, known as coordination contracts, and it is theoretically possible to obtain the best order quantity through them (Rekik et al., 2007). In other words, the number specified by the Newsvendor model is the most desirable for both the buyer and the seller, and if the contract number is closer to the Newsvendor model number, it is considered as the most effective model (Weng, 2004).

Literature review

Katok and Wu (2009) study empirical research on supply chain contract , which is an empirical study, examining the performance of three common mechanisms in two-tier supply chain contracts, including one supplier and one retailer. Their three types of contracts are: wholesale price, buyback, and revenue-sharing, and their results are compared in a laboratory study. They assumed a two-tiered chain in which the retailer faced a newsvendor problem and the supplier had no capacity constraints to order and delivery was speedy. The results showed that despite the increase in supply chain efficiency in buyback and revenue-sharing contracts compared to wholesale price contract, this increase was less than theoretical predictions. They also find that although buyback and revenue sharing contracts are mathematically equivalent, they are not equal in supply chain performance.

Elahi et al (2013) in a study "How can we improve the performance of supply chain contracts?" They researched supply chain coordinated contracts, including wholesale prices, revenue-sharing and buyback. They also provide 5 approaches that help improve retailer decisions (in response to the contract provided by the supplier). These five approaches are: 1) hybrid contracts 2) risk-averse contracts 3) free offerings 4) demand pattern presentation 5) collective feedback. This study showed that among the approaches presented, offering free items to the retailer leads to an effective order quantity close to the optimal value.

Cachon and Lariviere (2005) have conducted a study titled "Investigating the Strengths and Weaknesses of the Contract of Income Distribution and Supply Chain Coordination". They examine the revenue-sharing contract in a public supply chain model with revenues from the quantity and price of the retailer's purchase. By comparing the revenue sharing contract with other contracts such as buyback, price discounting, and quantity flexibility, they concluded that revenue sharing was equivalent to redemption in the newsvendor model and equivalent to the discount in the newsvendor price adjustment. The results also suggest that despite the many strengths, there are some limitations to the income-sharing contract, which explains why it is not common in all industries.

In a study conducted by Becker-Peth et al. (2013), the performance of buyback contracts was examined through empirical research. They set different retailer responses to different parameters. They developed a behavioral model based on average customer demand. The authors first estimated the model parameters through individuals' responses to a wide range of contract parameters, and then found a contract that could lead to the optimal chain solution. They also showed that contracts can be customized individually. Since their method cannot control the supplier's profit share of the whole chain's profit, so the supplier cannot target for a specific profit with a contractor.

Shampanier et al. (2007) did a study of zero as a special price: the real value of free items. They show that people tend to see the benefits associated with free products more than classical economics predicts. They attributed this behavior to the complexity of people's perception of benefit. So they are very inclined to get a free product because they see it as a no-harm option.

Schweitzer and Cachon (2000) observed in an empirical study that people's order quantity is always between the average demand and the optimal quantity. For a high profit margin product where the optimal order quantity is above the average demand, the average order quantity is also above the average demand and lower than the optimal value. But for a low profit margin product where the optimal order quantity is below the average demand; the average order quantity is also lower than the average demand but higher than the optimal value. This behavior is known as pulling toward the center. The authors attributed this behavior to past inventory errors and inadequate settings. They ruled out the influence of other factors such as risk aversion, loss aversion, long-term theory priorities, loss aversion, and stock aversion.

Bostian et al. (2008) in a study proposed a adaptive training algorithm to justify stretching behavior toward the center. They found that the average order value per person was very close to the average demand in the early decision periods.Their adaptive training model explains the pull-down behavior of the center and shows that individuals respond to the gains and losses of later courses.

Lurie and Swaminathan (2009) conducted a study, "Is Information Always Better in the Moment?" have done. They believe that the overwhelming amount of feedback can sometimes lead to a decline in performance. They conducted an experimental study that tested more than 200 people and found that repeating and updating information was not necessarily good. Their findings suggest that in high profit margin conditions, people will perform better in low demand variance when compared to those who find more feedback. People who find more feedback will do better if demand is high variance. If the profit margin is low, people with more feedback will have better performance. But if you consider a significant cost to change the order quantity, getting less feedback is more appropriate.

Research on supply chain contracts has begun with research results that show that there is a discrepancy between the optimal order quantity and the order quantity occurring, and thus does not maximize seller profit and supply chain profit. Some of the people in their research explained the reasons for this discrepancy and described the behavioral reasons for the sub-optimal order. Research was also conducted on coordinated contracts, and contracts that could maximize the profit chain theory were presented. Some have also taken note of the structural dimensions, and eventually research has been done to improve the performance of coordinated contracts through the use of appropriate vocabulary to result in contracts that can, in practice, bring the order quantity closer to the optimum value. It has not been determined which of these contracts is best suited for use in a particular supply chain. Given the importance of managing the supply of crops and the use of coordinated contracts in the agricultural supply chain, an in vitro study of prioritizing coordinated contracts will be conducted to determine which contract model can best generate the optimal order quantity.

Newsvendor model and supply chain

Reducing the life cycle of products and a sudden drop in their prices has led manufacturers and buyers to be more consistent in their decisions. One of the expected goals of buyers and producers is to maximize the expected profit (Weng, 2004). Researches by Fisher and Raman (1996) Corbett and Fransoo (2007) show that wholesalers and retailers make mistakes in delivering the optimal order quantity and order less than the optimal quantity, which means that the profit of the whole chain is not maximized. One of the proven mathematical models in the field of supply chain profit maximization - between producer and buyer - is the Newsvendor model (Rekik et al., 2007). The Newsvendor model is used in inventory management, pricing and revenue management, and planning and capacity (Kalkanci & Perakis, 2017). The standard Newsvendor profit function is as follows:

$$\pi = E\left[p \ \min(q.D)\right] - cq$$

D is a random variable with a probabilistic distribution and represents demand. P is the selling price of each unit of goods, c is the purchase price of each unit of goods and q is the amount of the order or stock. E is also the expected performance. The solution to the optimal storage amount that maximizes Newsvendor profit is as follows:

$$q = F^{-1}\left(\frac{\mathrm{p-c}}{\mathrm{p}}\right)$$

In this formula, F^{-1} is the inverse of the cumulative distribution function D and the fraction $(\frac{p-c}{p})$ is called the critical fraction. This rate is obtained (cu + co) by dividing the cost of inventory shortage ($c_u = p-c$) by the sum of cost of inventory shortage and cost of excess inventory ($co = c$). When there is market demand for a commodity and the seller's stock is exhausted, profit is lost by the difference between the selling price and the purchase price ($p-c$) per unit of commodity, which is called the cost of inventory shortages. If the amount of reserve is more than market demand, then the seller will suffer a loss equal to the purchase price (c) per unit of surplus inventory, which is called the cost of surplus inventory.

Types of contracts

Simple buyback contract

In a buyback agreement, the supplier offers the retailer a wholesale price higher than the cost of production but guarantees to repurchase it at a lower price than the wholesale price if the product is not sold. As the retailer contract is less risk-averse in this model, it is expected to find the incentive to order at the optimum value, but because it must invest high capital in the initial purchase, the order quantity may be less than the optimum value.

Simple revenue sharing contract

In a revenue sharing contract, the supplier first offers the retailer a wholesale price lower than the cost of producing the product. But at the end of the sales season, the retailer must pay him a percentage of his sales as a supplier share. In this contract, in order to motivate the retailer to order an optimal quantity, the supplier offers him a price lower than the cost of production.

Buyback and mixed revenue-sharing contract

In this contract, the supplier sells the goods to the retailer at a higher rate than is provided in the revenue sharing contract and below what is provided in the buyback agreement. But at the end of the period it receives a percentage of its share of the goods sold and also redeems the unsold goods at the specified price. This contract model is a combination of a simple buyback agreement and a simple revenue sharing contract, henceforth called a mixed contract. This contract model was created with the aim of simultaneously reaping the benefits of two revenue sharing and buyback contracts.

Free item revenue sharing contract

In this contract model, by considering the parameters of the simple revenue sharing contract, one can create conditions that bring the order value created by the simple revenue sharing contract closer to the optimal value specified by the newsvendor model. Offering free items can have two effects in the supply chain: firstly, increasing effective ordering, secondly, the desire to get free items can encourage the seller to order more. The effective order quantity in the revenue-sharing contract with free items includes the sum of actual orders made and free items offered. In this contract, the retailer receives one unit of free merchandise for each n unit purchased. And its value is determined as: (actual order quantity) divided by (difference between optimum order quantity and actual order quantity).

Free item buyback contract

In this model of contract, taking into account the parameters of simple buyback contract, conditions are created by which the order quantity created from the simple buyback contract is closer to the optimum value determined by the newsvendor model. Offering free items can have two effects in the supply chain. First, increasing effective ordering, secondly, the desire to get free items can encourage the seller to order more. The effective order amount in the buyback contract with the free delivery includes the actual order amount and free shipping. In this contract, the retailer receives one unit of free merchandise for each n unit purchased. And its value is determined as: (actual order quantity) divided by (difference between optimum order quantity and actual order quantity). The financial flow of harmonized contracts is set out in the Appendix 1.

Methodology

For this study, 5 coordinated contract models were identified. Then, a series of assumptions were identified to focus on the main research topic. Data collection was obtained through the expression of a problem and the simulation of the conditions governing the chain for participants and their placement in decision making. In order to make the terms more tangible for decision makers, tomato products were selected for pre-sale through contract to wholesalers. Because tomatoes are a perishable commodity and have seasonal production and wholesalers have to make a decision on the future order quantity according to the circumstances (the parameters set in the previous step). Then, by conducting an empirical experiment, the model of supply chain coordinated contracts in the category of wholesalers was investigated. By presenting a problem and providing complete

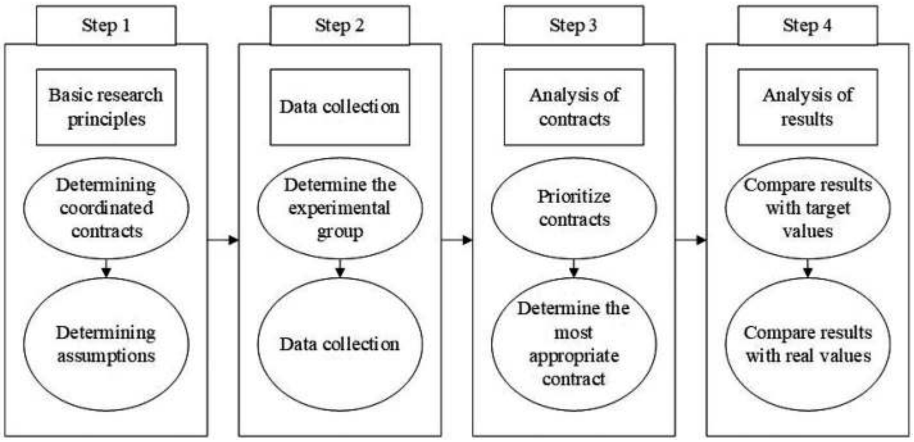

Figure 1. Research process

information for decision making, participants are required to act as a decision maker who must complete their order quantity before the production season begins. Then, with each ordering, feedback was given to people about the amount of order they made. Experiments were performed on 50 participants in 5 groups in 15 periods.

The participants in the study were wholesalers of agricultural products in Mashhad, with whom the type of communication was face-to-face. Information was also provided to the participants about the research topic, its importance and the importance of the results. The participants were among the wholesalers of the fruit and vegetable market in Mashhad, which is the second largest city in Iran and there were more than 250 wholesalers in this fruit market. For research, individuals were selected who not only had experience in this field but also were familiar with software for information exchange. At the beginning of the study, 80 people participated, but then they were forced to cancel due to various reasons, including busy schedule and unavailability of the information exchange system. But this study was done with so many different people that finally for each of the contract groups, complete information was obtained from 10 participants for 15 courses. Because the results of the competition between the wholesalers were publicly announced to them in the form of a competitive league, there was sufficient incentive for the wholesalers to participate in this research. The following chart (Figure 1) shows the steps to do the research:

Step 1: research planning

Determining coordinated contracts

Initially reviewing the literature, (Becker-Peth et al., 2013; Cachon & Lariviere, 2005; Elahi et al., 2013; Katok & Wu, 2009) Identified contractual model characteristics and features. And the characteristics of each were determined. These contracts are special modes of a revenue sharing or buy-back contracts and have been proven theoretically and mathematically optimal through them. These 5 contract models include simple buyback, simple revenue sharing, Buyback and Mixed Revenue-Sharing, Free Revenue Sharing, and free item buyback agreement. These contracts yield similar results under similar conditions, but there are differences in terms, terminology and flow of financial transfers.

Assumptions

In determining assumptions for testing, production costs and sales prices were assumed to be constant. The value of zero and demand losses for each period was also considered to be random, with a minimum and a maximum specified, which follows a uniform distribution. The extent of the wholesaler and supplier's participation in the profit and loss is a fixed percentage. These assumptions are also taken into account in empirical experiments previously conducted by researchers in the field of coordinated contracts. And the reason is that in conducting experiments with these conditions one can focus on the behavior and error of decision makers and examine their behavior more closely.

According to the assumptions, the values of the parameters for the test were determined as follows: Production cost 400 Tomans, Sales price 1000 Tomans, waste price 0 Tomans, Wholesale participation in 40% profit and loss, Minimum demand 100 Tons and Maximum demand 400 Tons. Given these values for the parameters, the average demand will be 250 tons and the optimal order quantity determined by the newsvendor model is 280 tons. The shortage cost for the wholesaler is 240 Tomans per unit. The surplus inventory cost per unit of surplus goods at the end of the period is 160 Tomans. On the other hand, since the cost of producing the commodity for the farmer is 400 Tomans, its selling price was set by the wholesaler for 1000 Tomans to provide a critical fraction of more than 0.5 to reach the optimum value above the average demand.

Step 2: collect the data

Determining the experimental group

To determine the participants of the experiment, there was a discussion among the wholesalers of agricultural products and activists in Mashhad about the experiment. After providing sufficient explanations and answers to the initial questions and expressing the importance of the research and the significance of the results, the individuals who were prepared to take

Table 1. Parameter values.

Sign	Symbol	Value	Sign	Symbol	Value
C	Cost of production	400	λ	Percentage of participation	0.4
P	sales price	1000	**Co**	Excess inventory cost	160
A	Minimum demand	100	**Cu**	Cost of inventory shortage	240
B	Maximum demand	400			

the test were identified. In this study, all participants in the empirical experiment were selected from wholesalers and activists in the field and are homogeneous in terms of data obtained. These homogeneous subjects were then randomly assigned into 5 groups to increase the validity of the results, and then each of the contracts was randomly assigned to each group.

No individuals in the two groups were included in the experiment, and each participant was used to obtain data regarding a contract model. The reason for this was that in each iteration of the experiment the feedback from the previous period was given to individuals, which made it clear that no real difference between the coordinated contracts was made and the same orders were given. The sign, symbol and values of the parameters are given in Table 1.

Data collection

After determining the experimental group, subjects were placed in the decision condition. They were given a written and schematic view of how the chain functioned. Individuals were then given verbal explanations of their hypothetical position in the chain, earning profits, and ordering. In this experiment, each individual was given information and during the experiment it was tried not to be related to each other in order not to influence each other's decisions.

After providing all the information required and according to the set conditions, participants were asked to determine their order quantity for tomato production in the coming season. Information on the order quantity of individuals during each ordering period was obtained via SMS and telegram virtual network. Withdrawals were at the test stage for various reasons, such as overwork and, most importantly, the inaccessibility of the information exchange system. The experiment was conducted with so many people that at the end of each group, 10 participants received complete information for 15 courses. The data collection took 6 months.

The number of replicate courses in this experiment was set to 15. For this purpose, 15 random numbers ranging from 100 to 400 were obtained from the computer and were considered as the actual demand amount for the first to fifteenth period respectively. These values were the same for all 5 groups in each period. The random numbers are obtained and their order of application for the 15 periods of testing is as follows (Table 2).

Table 2. Occurred Demand.

Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Demand rate	201	213	143	345	233	284	289	255	196	187	212	378	169	251	124

Table 3. Average order quantity over 15 periods.

Decision makers	Simple Buyback	Simple Revenue Sharing	Mixed	Free Item Revenue Sharing	Free Item Buyback
1	257.4	275.2	246	278.2	273.9
2	218.6	252.5	254.1	256.3	285
3	253	265	255.3	260.4	264.2
4	250.8	269.6	251.8	270.1	258.4
5	257.8	248.2	247.6	269.2	255.9
6	263.1	277.1	255.3	283.2	245.3
7	260	249.4	258.8	285.3	267
8	249.3	228	252.4	267.8	244.2
9	251	251.3	270.6	284.6	246.8
10	247	262.3	259.3	242.4	256

After each order was determined by the decision maker, the order information and demand information were provided. Following the test process, each participant was only allowed to decide on the amount of order for the next course after receiving feedback from each course. This process lasted up to 15 sessions and participants were informed about the order quantity feedback via telegram and in some cases in written form. Participant order information was also obtained in this way. Table 3 shows the average order quantity.

Step 3: analyze contracts

Prioritizing contracts

ANOVA was used to compare the mean order value of 5 contract models. The following hypothesis was examined to verify whether or not the claim was true:

$$\begin{cases} H_0 : \mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5 \\ H_1 : \ \textit{At least two averages are not the same.} \end{cases}$$

Table 4 shows the results of comparison tests of mean contracts, which include the sum of second power, degree of freedom, mean power, F statistic and sig. Since sig is less than 5%, so the assumption of H. is rejected. In other words, there is a significant difference between the mean of societies.

Table 5 shows the mean deviations, standard error, sig and 95% confidence intervals, respectively. In the mean differences column, significant differences are indicated by the * sign. According to the results of the test, it can be seen that the mean value of the simple buyback order has a

Table 4. Mean comparison test results.

	Sum of the second power	Degrees of freedom	Average Second Power	F statistics	Sig.
Between groups	1989.574	4	497.393	3.144	0.023
Within groups	7118.746	45	158.194		
Total	9108.320	49			

Table 5. Average contract order difference.

(I) Contract Model	(J) Contract Model	Average difference (I-J)	standard error	Sig.	95% confidence level	
					Lower limit	Upper limit
bb	rs	−7.06	5.6248	0.719	−23.043	8.923
	mixed	−4.32	5.6248	0.938	−20.303	11.663
	frs	−18.95*	5.6248	0.013	−34.933	−2.967
	fbb	−8.87	5.6248	0.520	−24.853	7.113
rs	bb	7.06	5.6248	0.719	−8.923	23.043
	mixed	2.74	5.6248	0.988	−13.243	18.723
	frs	−11.89	5.6248	0.232	−27.873	4.093
	fbb	−1.81	5.6248	0.998	−17.793	14.173
mixed	bb	4.32	5.6248	0.938	−11.663	20.303
	rs	−2.74	5.6248	0.988	−18.723	13.243
	frs	−14.63	5.6248	0.087	−30.613	1.353
	fbb	−4.55	5.6248	0.927	−20.533	11.433
frs	bb	18.95*	5.6248	0.013	2.967	34.933
	rs	11.89	5.6248	0.232	−4.093	27.873
	mixed	14.63	5.6248	0.087	−1.353	30.613
	fbb	10.08	5.6248	0.391	−5.903	26.063
fbb	bb	8.87	5.6248	0.520	−7.113	24.853
	rs	1.81	5.6248	0.998	−14.173	17.793
	mixed	4.55	5.6248	0.927	−11.433	20.533
	frs	−10.08	5.6248	0.391	−26.063	5.903

Table 6. Classification of contracts into homogeneous groups.

Reference for alpha 0.05			
1	2	Number	Classification of contracts
250.8		10	bb
255.12	255.12	10	mixed
257.86	257.86	10	rs
259.67	259.67	10	fbb
	269.75	10	frs
0.52	0.87		Sig.

significant difference with the free revenue sharing contract. But there is no significant difference between the other contracts.

The results presented in Table 6 show which contracts are not significantly different from each other and fall into one category. The first category is simple Buyback, Mixed, simple Revenue sharing and free Item Buyback contracts. In the second category are Mixed, simple revenue sharing, Free Item Buyback, and Free Item Revenue sharing. The reason for the three Mixed, simple revenue sharing and Free Item Buyback in both categories is that the average order value of these three contract models is not significantly different from the other two contract models.

Table 7. Average total order quantity received per contract model.

contract type	BB	RS	MIXED	FRS	FBB
Average order	250/8	257/9	255/1	269/7	259/7

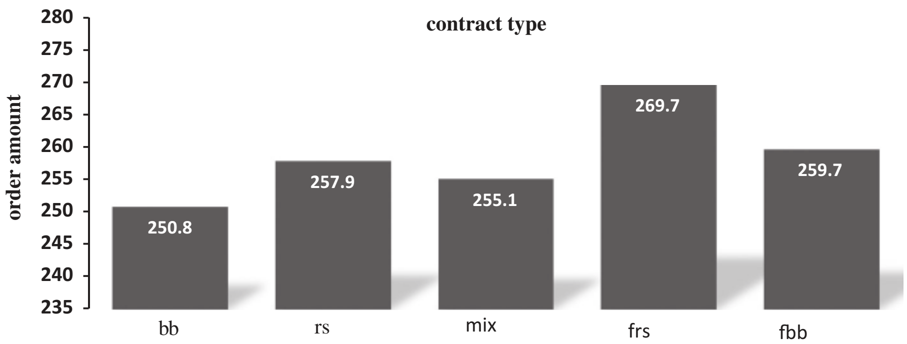

Figure 2. Average total order value per contract model.

Determining the most appropriate contract

By comparing the average total orders received for each contract model, they can be prioritized by the amount of orders received. As such, the Free Item Revenue sharing contract with an average of 267.7 received the highest order value and is identified as the most appropriate contract model for use in the agricultural supply chain. Free Item Buyback contract with average order value of 259.7, simple revenue sharing contract with 257.9, Mixed Contract 255.1 and simple Buyback agreement with 250.28 are next.

Step 4: analyze the results

Compare results with target values

Check the difference of the average total quantity of orders with the optimum quantity

The results of this study show that the average order quantity received through each contract model is lower than the optimal order quantity 280 (Table 7).

As it is known, the value of the order received from any of the contract models did not reach the optimal value of 280. But there is a significant difference between the amount of order received through different contract models . This difference in values is shown in Figure 2.

Compare average order quantity with average random demand

A comparison of the average amount of orders executed with the average random demand in each period shows that the ordering of individuals in each of the 5 contract models was in some cases far below the average

Table 8. Average order amount per contract per period.

	Pe1	Pe2	Pe3	Pe4	Pe5	Pe6	Pe7	Pe8	Pe9	Pe10	Pe11	Pe12	Pe13	Pe14	Pe15
BB	274/5	235/8	232	162/8	326	250/3	286/4	296/7	270	216/1	197/1	222/5	340/2	218/7	233/4
RS	269/3	226	221/6	197/8	329/3	276	302/5	303/4	270/5	235/8	204/1	217/7	334/5	229	251
MIX	274	223	225/3	187/5	329	279/9	280/7	289/7	272/7	217/1	206/9	230/5	334	232/7	244/3
FRS	318/5	244/8	226/9	200/4	340/7	279/4	289/5	298/2	282/2	242/6	219/6	239/4	335	271/7	257/6
FBB	273/9	244/8	239/8	188/3	353/7	269/4	292/6	276/4	273/3	245/1	211	235/2	338/9	203/9	249/3

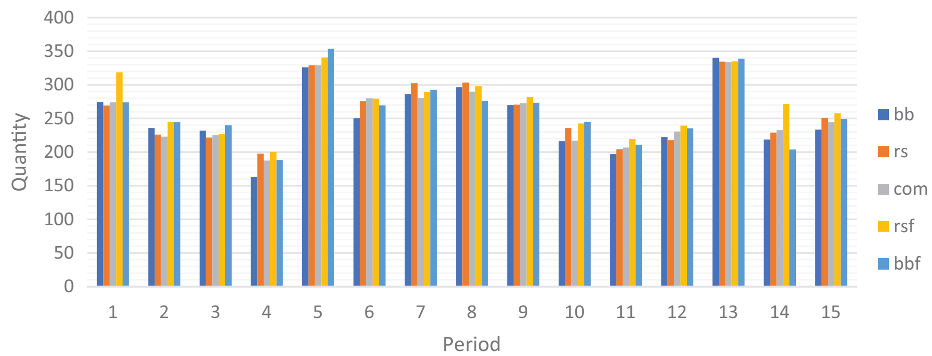

Figure 3. Average order amount per contract per period.

demand forecast. During the 15 testing periods, the lowest order value for the fourth period in the buyback agreement was averaged 162.8. Most of the order placed in the fifth period was in the free item buyback averaging 353.7. However, the average order value of the total of 15 replicate trials in each of the five contract models exceeded the average random demand (250) The average number of orders per contract in each period is clearly shown in Table 8 as well as in Figure 3.

Compare results with real values

Compare the orders of each period with the average demand occurred

Repeating the experiment required feedback on the amount of order for the previous period so that they could decide on the next period. Hence 15 random numbers were received from 100 (minimum demand) and 400 (maximum demand) from the computer. These numbers were considered as the actual demand amount for the first to fifteenth period respectively. Based on these participant numbers and orders, information was provided to participants, including sales volume, number of surplus or defective goods in the period, profit and loss, and proprietary information on each contract model as feedback on each period. The random numbers used in the experiment are as follows (Table 9 and Figure 4).

Comparison of the average order quantity in each period with the average demand up to that period shows that people do not pay much

Table 9. Demand occurring in each period and average demand up to that period.

Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Demand	201	213	143	345	233	284	289	255	196	187	212	378	169	251	124
Average	201	207	186	226	227	237	244	245	240	235	233	244	239	240	232

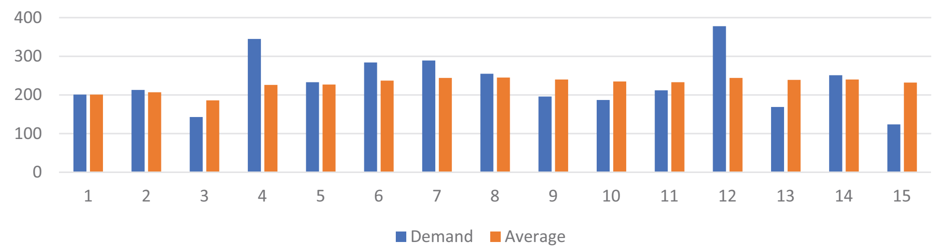

Figure 4. Demand occurring in each period and average demand up to that period.

attention to the overall pattern of demand when making their order. For most periods in all contract models, the amount of orders for each period exceeded the average demand for that period. The mean total orders over the 15 replicate trials in each of the 5 contract models were higher than the mean total demand (232).

Demand assessment

For the purpose of examining the amount of demand by participants in each contract model, the average order value for each contract model is compared with the quantity demanded in the previous period. But for the first period that the decision makers did not receive feedback, the first period orders were compared with the average random demand (250) and the amount of demand occurred in the 15th period was not included.

Comparison of the average order quantity in each period with the amount of demand in the previous period shows that individuals in the decision making of their order quantity are strongly influenced by the amount of demand in the previous period. The results also show that in the period when demand was lowest, the average of orders in each of the five contract models exceeded that value and in the period where demand was highest the average of orders was less than that one. Table 10 and figure 5 show the average amount of orders per period for each model of contract and demand occurred in the previous period (Figure 5).

Discussion

The process of supplying goods or services in a supply chain is greatly affected by the flow of information between the categories of the chain. Because of the impact on the interests of each category, it has led them to more connections with other categories in the chain and efforts to manage

Table 10. Chase Demand Investigation.

	Pe1	Pe2	Pe3	Pe4	Pe5	Pe6	Pe7	Pe8	Pe9	Pe10	Pe11	Pe12	Pe13	Pe14	Pe15
BB	274/5	235/8	232	162/8	326	250/3	286/4	296/7	270	216/1	197/1	222/5	340/2	218/7	233/4
RS	269/3	226	221/6	197/8	329/3	276	302/5	303/4	270/5	235/8	204/1	217/7	334/5	229	251
MIX	274	223	225/3	187/5	329	279/9	280/7	289/7	272/7	217/1	206/9	230/5	334	232/7	244/3
FRS	318/5	244/8	226/9	200/4	340/7	279/4	289/5	298/2	282/2	242/6	219/6	239/4	335	271/7	257/6
FBB	273/9	244/8	239/8	188/3	353/7	269/4	292/6	276/4	273/3	245/1	211	235/2	338/9	203/9	249/3
d	250	201	213	143	345	233	284	289	255	196	187	212	378	169	251

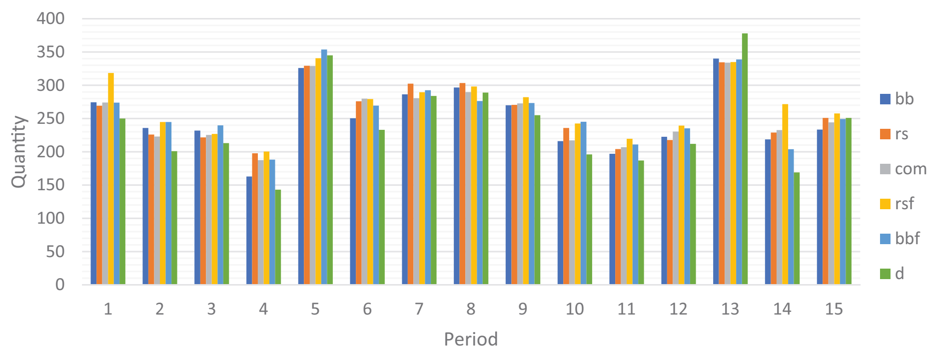

Figure 5. Chase Demand Investigation.

the supply chain in order to gain more benefits. Therefore, due to the high importance of the supply chain of agricultural products, this research is done to provide a solution to manage this chain in order to obtain the most benefits for all members of the chain. The optimal order quantity or inventory for distributors and sellers in the supply chain can be determined through the Newsvendor mathematical model. There are also contracts for the pre-sale of goods to sellers, known as coordinated contracts, and in theory it is possible to achieve the optimal order quantity through them.

The obtained data show that the comparison of the average amount of orders placed in each period with the average random demand obtained is based on the specified values of the problem parameters that individuals in all 5 contract models have ordered far below average predictable demand in some periods. The average random demand is 250. During the 15 testing periods, the lowest orders were placed in the fourth period in the simple buyback contract with an average value of 162.8. The highest amount of orders placed in the fifth period in the free item buyback contract was done with an average amount of 353.7. However, the average order quantity for a total of 15 test repetitions in all 5 contract models was higher than the average random demand.

A comparison between the average order quantity placed in each period and the average demand occurred up to that period shows that individuals do not pay much attention to the overall demand pattern in making their order quantity decision. In most periods, in all contract models, the amount of orders in each period was greater than the average amount of demand that occurred up to that period. The average of total orders in 15 test repetition periods in all 5 contract models is higher than the average of total demand (232). Also, comparing the average amount of order placed in each period with the amount of demand that occurred in the previous period shows that people are strongly influenced by the amount of demand that occurred in the previous period in deciding the amount of their order.

The results show that in the period when the demand occurred was at the lowest amount, the average amount of orders in all 5 contract models was more than that amount and in the period when there was the highest amount of demand, the average amount of orders was less than that amount. By comparing the average of the total orders received for each contract model, they can be prioritized for use in the agricultural supply chain according to the amount of orders they have received. Thus, the free item revenue sharing contract has received the highest order amount with an average of 269.7 and is determined as the most appropriate contract model for use in the supply chain of agricultural products. In the next ranks are the free item buybak contract with an average order amount of 259.7 and simple revenue sharing contract with 257.9, buyback and mixed revenue-sharing contract with 255.1 and simple buyback contract with 250.8.

Conclusion

This study examines the model of coordinated supply chain contracts for its application in the supply chain of agricultural products with the aim of maximizing the profit of the chain because the supply chain management of agricultural products has a high value due to the supply of consumer goods in all communities.

What was innovatively considered in this study is the suggestion of a way for suppliers to conclude the most appropriate contract model with wholesalers. A suitable model is a model that persuades the wholesaler to order close to the optimal amount. Given that coordinated contracts in the same situation give the same results but in appearance have differences. If a contract model is used in which the wholesaler - who makes a mistake due to a mental error and orders less than the optimal amount - is encouraged to order close to the optimal amount to maximize the wholesale profit and the profit of the whole chain.

In this research, an attempt was made to identify the most optimal possible case by Newsvendor model and based on it, the most effective coordinated contract model was selected. In this model of contracts that can be used to pre-sell seasonal products, the profit and loss of the period is divided between the supplier and the distributor in proportion to the agreed percentage. As a result, the risk of non-sale is reduced for both parties, and if the order is placed in the optimal amount, the profit of the whole chain will be maximized.

The results obtained in this study indicate that the amount of orders received in none of the contracts was 280. But there is a significant difference between the contracts in the number of orders, the highest amount of orders was related to the free item revenue sharing contract with 269.7, and similarly, the free item buyback contract with 259.7, simple revenue sharing with 257.9, buyback and mixed revenue-sharing contract with 255.1 and simple buyback contract was 250.8 . Also, the results obtained from this study can be used in other case studies in the agricultural industry because in this study, there were no special and restrictive conditions and therefore can be generalized to similar agricultural products. The only important point is that the parameters of the new products under review are better suited to the parameters used in this study.

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Appendix 1

. Financial flow in concurrent contracts.

	Manufacturer			Buyer	
	Income	Cost		Income	Cost
Buyback	–	Cq	Production	–	–
	$[\lambda c + (1-\lambda)\,p]\,q$	–	Delivery	–	$[\lambda c + (1-\lambda)\,p]\,q$
	–	–	Sell	Ps	–
	–	$[(1-\lambda)\,p]k$	Clearing	$[(1-\lambda)\,p]k$	–
	$[\lambda c + (1-\lambda)\,p]\,q - cq - [(1-\lambda)\,p]k$		Total Profit	$Ps + [(1-\lambda)\,p]k - [\lambda c + (1-\lambda)\,p]\,q$	
Revenue sharing	–	cq	Production	–	–
	λcq	–	Delivery	–	λcq
	–	–	Sell	Ps	–
	$(1-\lambda)\,ps$	–	Clearing	–	$(1-\lambda)\,ps$
	$[\lambda cq + (1-\lambda)\,ps] - cq$		Total Profit	$Ps - [\lambda cq + (1-\lambda)\,ps]$	
combined	–	Cq	Production	–	–
	$[\lambda c + j(1-\lambda)p]\,q$	–	Delivery	–	$[\lambda c + j(1-\lambda)p]\,q$
	–	–	Sell	Ps	–
	$[(1-\lambda)p - j(1-\lambda)p]s$	$[j\,(1-\lambda)\,p]k$	Clearing	$[j\,(1-\lambda)\,p]k$	$[(1-\lambda)p - j(1-\lambda)p]s$
	$[\lambda c + j(1-\lambda)p]\,q + [(1-\lambda)p - j(1-\lambda)p]s - Cq - [j\,(1-\lambda)\,p]k]$		Total Profit	$Ps + [j\,(1-\lambda)\,p]k$ - $[\lambda c + j(1-\lambda)p]\,q - [(1-\lambda)p - j(1-\lambda)p]s$	
Revenue sharing with free items	–	$\mathbf{Cq(1 + \frac{1}{n})}$	Production	–	–
	$\mathbf{[(1 + \frac{1}{n})\lambda c]\,q}$	–	Delivery	–	$\mathbf{[(1 + \frac{1}{n})\lambda c]\,q}$
	–	–	Sell	Ps	–
	$[(1-\lambda)p]\,s$	–	Clearing	–	$[(1-\lambda)p]\,s$
	$\mathbf{[(1 + \frac{1}{n})\lambda c]\,q + [(1-\lambda)p]\,s - cq(1 + \frac{1}{n})}$		Total Profit	$\mathbf{Ps - [(1 + \frac{1}{n})\lambda c]\,q - [(1-\lambda)p]\,s}$	
Buyback with free items	–	$\mathbf{Cq(1 + \frac{1}{n})}$	Production	–	–
	$\mathbf{(1 + \frac{1}{n})[\lambda c + (1-\lambda)p]\,q}$	–	Delivery	–	$\mathbf{(1 + \frac{1}{n})[\lambda c + (1-\lambda)p]\,q}$
	–	–	Sell	Ps	–
	–	$[(1-\lambda)\,p]k$	Clearing	$[(1-\lambda)\,p]k$	–
	$\mathbf{(1 + \frac{1}{n})[\lambda c + (1-\lambda)p]\,q - Cq(1 + \frac{1}{n}) - [(1-\lambda)\,p]k}$		Total Profit	$\mathbf{Ps + [(1-\lambda)\,p]k - (1 + \frac{1}{n})[\lambda c + (1-\lambda)p]\,q}$	