Impact of revenue-sharing contracts on improving profits for manufacturers and suppliers in the supply chain of organic textile products

Hasan Halife*

Department of Mechanical Engineering of Textile Industries and Their Technologies,
Faculty of Mechanical and Electrical Engineering,
Damascus University,
Damascus, Syria
and
Business Administration Department,
Akdeniz University,
Antalya, Turkey
Email: hkh1982@gmail.com
*Corresponding author

Malek Alshukur

Department of Mechanical Engineering of Textile Industries and Their Technologies,
Faculty of Mechanical and Electrical Engineering,
Damascus University,
Damascus, Syria
Email: malekshukur@yahoo.com

Abstract: This article is concerned with designing a supply chain for organic textile products to improve, to increase and to ensure a fair distribution of profits for all participants in such a supply chain. To make such a supply chain as an integrated system, it was first important to ensure that the cotton products are produced organically, and then to suggest a supply chain in a 'win-win' strategy. The various contracts possible between the various members of the supply chain were presented and analysed mathematically using game theory. It was found that there were six possible contracts based on the scenarios of the game between the suppliers and the vendors. Further, it was possible to define the conditions which improve the profits in comparison with the case in which these contracts were not employed. This study is important because it promotes sustainability through encouraging the trade in organic cottons. Additionally, it helps in ensuring a fair distribution of the benefits and in improving profit shares for most members of the supply chain of organic cotton, in particular suppliers and manufacturers.

Keywords: supply chain; organic textiles; green products; revenue-sharing contracts; game theory.

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Biographical notes: Hasan Halife obtained his Engineering degree in 2005, Masters degree in 2007 and in 2013, PhD in Business Administration from Damascus University (Syria). He worked for over eight years as a lecturer, and researcher in Damascus University. In Turkey, he worked as a lecturer at Alzhraa University. He also has worked since 2019 till now with NGOs in livelihood and economic empowerment projects. He has nine peer-reviewed articles in textile engineering and management, and reviewer for three articles in supply chain and risk management, in addition to two university books in management and textile engineering.

Malek Alshukur obtained his Engineering degree in 2006 from Damascus University (Syria). He worked in a spinning mill and after that he worked for two years as technician and lab tutor for the same department where he did his engineering degree. He obtained his Master's in 2012 and PhD in 2017 from Heriot-Watt University (UK). He worked a Senior Scientist in Composites and Nanomaterials for CPI (Catapult/UK), where he was helping SMEs and also developing the next generation of graphene-enhanced composites for the UK aerospace industry. He worked as a Materials Research Engineer for Jaguar Land Rover (UK), where he was helping to developing their capabilities in composites. He is currently working for NIRI (UK), where he is developing non-wovens, advanced fibres technologies, materials and products for various industries such as medical industry. So far, he has 20 peer-reviewed articles in various topics including materials, textiles, engineering and management.

1 Introduction

Typically, the relationships between members of any supply chain, including an organic supply chain, can take many forms, e.g., formal and informal, but often vendors and suppliers agree on supply contracts. In one study, supply contracts between the members of any supply chain were classified based on types of transfer payments using mathematical modelling and equations (Cachon, 2003). Such a classification divided those contracts into wholesale price contract, quantity discount contract, sales rebate contract, quantity flexibility contract, revenue-sharing contract and buyback contract (Cachon, 2003). Revenue-sharing contracts between the members of a supply chain are those contracts where the wholesalers provide the suppliers with a wholesale price for each unit purchased, in addition to a percentage of revenue (Cachon and Lariviere, 2005). A comparison between several types of supply chain contracts was made with particular emphasis on revenue-sharing contracts (Cachon and Lariviere, 2005). It has been found that revenue-sharing contracts are equivalent to both buyback and price discount contracts. It has also been concluded that, despite the many benefits of revenue-sharing contracts, they should be used within limitations. This is because they may lead to a slight improvement in profits, and they may not satisfy retailers who encounter significant cost as a result of retail sale, which is the reason that those contracts are not found in many industries (Cachon and Lariviere, 2005).

Supply chain coordination was also studied when revenue-sharing contracts were governing the relationships between the members of a supply chain (Giannoccaro and Pontrandolfo, 2004). It was found that supply chain coordination can be accomplished through either a centralised or a decentralised approach to decision-making. It was also found that working according to revenue-sharing contracts may improve profit for all members of the supply chain (Giannoccaro and Pontrandolfo, 2004). To emphasise the importance of supply chain coordination, two researchers examined revenue-sharing contracts in supply chains for recycled computers where computers would be sent back to the relevant retailer, and after that to the relevant factory for remanufacturing and re-utilisation (Govindan and Popiuc, 2014). The results of such a study showed that supply chain profits may improve significantly by coordinating revenue-sharing contracts.

It has been argued that revenue-sharing contracts can play a major role in improving benefits amongst the members of green supply chains, in comparison with supply chain contracts that are based on decentralised models. It has also been concluded that revenue-sharing contracts can enhance the profits for both manufacturers and retailers; thus, such contracts may lead to effective improvement of green supply chains compared to decentralised contracts (Song and Gao, 2018). Before that, revenue-sharing contracts were studied for a supply chain consisting of one manufacturer and two competing retailers using both the classic Newsvendor Problem model and numerical methods. It was found that revenue-sharing contracts may lead to better results than traditional sales contracts between the members of any supply chain, and the benefits gained in revenue-sharing contracts may vary between them according to demand volatility and price sensitivity factors (Yao et al., 2008).

Other studies were also concerned with multi-stage supply chain models. In a simple two-stage supply chain model, it has been sought to improve supply chain coordination through revenue-sharing contracts, in order to improve the ultimate performance of members of a supply chain. In each stage of the supply chain, two members or parties were considered, i.e., one supplier and one retailer, and coordination between these two parties was made using revenue-sharing contracts. The results of such a study show that the profits generated by both members of such a supply chain would be better than those resulting from decentralised coordination (Hou et al., 2009). In a more complicated N-stage model of supply chain, the researchers wanted to deal with the reliability amongst supply chain members, so they studied reliable revenue-sharing contracts in a supply chain that would consist of N-stage. In such a study, a two-stage scenario was examined: the first stage was based on allocating the initial profits, while the second one was based on adjusting the profits through the reliability of all members. The conclusions of such a study indicate that the profits resulting from reliable revenue-sharing contracts would be higher than the case of traditional profit-sharing contracts (Feng et al., 2014).

The problem that is tackled in this study is the unfair distribution of profits to all members of the supply chain of organic cotton products/textiles, where it is believed that re-sharing of revenues according to a certain methodology can benefit all members/stages of the supply chain. This problem of can be formulated through the following question:

- Does the implementation of revenue sharing contracts in the supply chain of organic cotton products/textiles improve the benefits for the members of the supply chain?

- What is the revenue-sharing ratio for each of the chain members that makes the outcome of this contract as a win-win situation?

Therefore, this article aims to suggest an integrated supply chain which may benefit textile firms if such an integrated supply chain were to be adapted by them and to suggest a form of revenue-sharing contract which may maximise profit and ensure a fair distribution of benefit for all members of the supply chain. These two aims were achieved through designing a supply chain for organic cotton products and building a revenue-sharing contract between the various members of such a supply chain, showing the sequences of such a contract and the benefits that may accrue for each member of the supply chain.

2 Supply chain contracts suggested for organic cotton textiles

An organic supply chain is a network of organisations that co-operate to produce organic products, and to improve the flow of material and information between suppliers and customers at the lowest cost and the highest speed possible (Simchi-Levi et al., 2009). The supply chain of organic cotton products was chosen as an example of the supply chains of organic textile products. This is because cotton products are important in the textile market, especially as cotton products are demanded in the European/Western markets and other developed countries for health and comfort reasons (Halife, 2013). Further, there are a large number of textile products available in the market, with every product having its own supply chain, which makes it difficult to suggest a single supply chain that is universal for all of them. Furthermore, the use of organic cotton, whether for clothing or any other use, is important as it comes from a 100% renewable source. Therefore, organic cotton can be used to make textile commodities in a way that promotes sustainability in our planet.

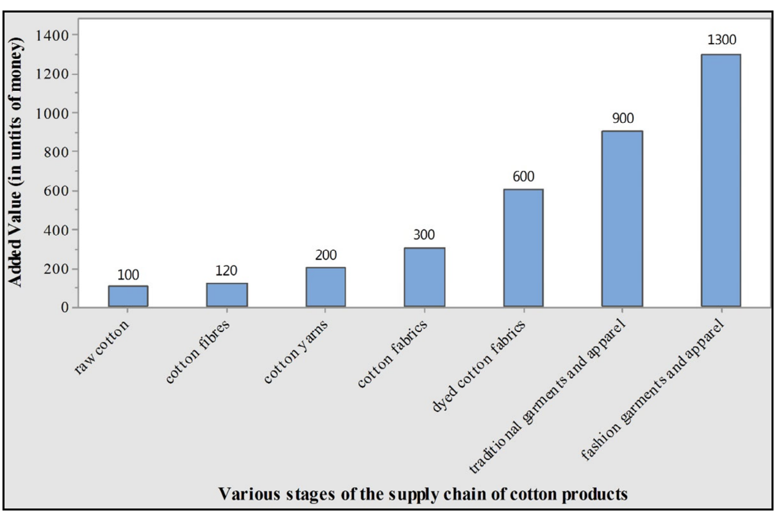
Since the nineties of the last century, competition in the global textile sector has increased. The main reason for that trend was the increase in cheap production in many countries such as China, India, Pakistan, Egypt, Turkey, etc. These countries also continuously seek access to the European/Western markets to sell their textile products. However, due to competition and the large difference between supply and demand, the conditions of access to European/Western and other developed countries as required by these countries have greatly increased. Not only in terms of quality and price, but also many other conditions were put in place. Some of these conditions were manifested as environmental requirements, social responsibility requirements or requirements to ensure the products were organic, i.e., green, or sustainable. Recently, many companies which produce textile products have started working in the field of organic textiles by focusing on every stage of the production lines. However, this effort is still being conducted individually instead of through co-operation with other interested parties as an integrated system, e.g., an integrated supply chain. The co-operation between the members of an integrated supply chain is important for the following reasons:

- It makes it easier to meet the standards of organic products. This is simply because any material not accepted to be found in products that are classified as being organic may pass on through to the other stages of production and the supply chain; thus it can not be removed if it was allowed in the first instance, whether intentionally or by a mistake. For example, any chemical used in the fields to treat cotton crops will be found to have traces in the final products. Another example is that chemicals that are used for dyeing or finishing a fabric may pass on to the final clothes or garments. Subsequently, such products will not meet the standards for organic products.

- Further, there is a huge gap in the added value gained by the various producers along the traditional supply chain of textiles. For example, Figure 1 (Anon, 2008) shows the distribution of added value for cotton products; clearly, the retailer of fashion clothes claim the highest share of the profit. Therefore, unless the supply chain is made as an integrated system which divides the ultimate profit fairly between the various members of the supply chain, the motivation for participating in the traditional supply chain may be different.
- Furthermore, the gross revenue from organic textile products may be small if compared to its costs. Therefore, many companies may not think of producing organic textile products unless they are convinced that they may get a fair share of the ultimate revenue.

The main members or stages of the suggested supply chain are suppliers of organic cotton, spinners, weavers or knitters, dyers and printers, sewers, distributors, and finally vendors or retailers. In an organic supply chain contract, the vendor and supplier should agree on the specifications that must be available in the products, the prices of the product, the percentage of discount, the minimum and maximum quantities purchased, the lead delivery time, the quality of the products and the return policy. Since it is desirable in European/Western markets, the OEKO-TEX 100 standard was chosen as a reference for the technical contract between members of the supply chain. The OEKO-TEX 100 standard is an independent testing and certification system for textile raw materials, intermediate and end products at all stages of production (OEKO-TEX®, 2017).

Figure 1 Distribution of the added value of cotton products (see online version for colours)



3 Theoretical analysis of the suggested supply chain and the stages required to sign a contract

It is assumed that there are two main stages in the suggested supply chain, i.e., a supplier (containing all manufacturing stages and organic cotton suppliers) and a vendor/retailer as shown in Figure 2 (Halife, 2015). The vendor faces the newsvendor's problem, so the vendor must decide an order quantity before the start of a selling season that has random demand. In this analysis, the contract stages were decided using the game theory. The following sequence of events occurs in this game between the supplier and the vendor.

1 Contract is introduced to vendors by suppliers.

2 Vendors accept the suggested contracts.

3 Vendors submit orders of quantity (q) to suppliers.

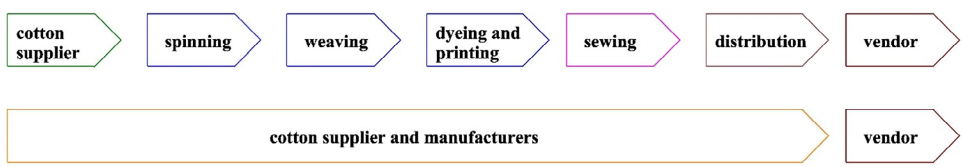
4 Suppliers produce and deliver quantity (q) to vendors.

5 Demand is observed and products are sold.

6 Remaining payments are made.

These events are detailed in Figure 2.

Figure 2 Suggested supply chain for organic cotton products (see online version for colours)



3.1 Contract introduced to vendor by supplier

To determine the appropriate contract which can be applied in the supply chain for organic cotton products, the following analysis of the members of the supply chain was conducted.

3.1.1 Position of cotton supplier

When a cotton supplier uses organic cotton, the costs will increase unless there is a limited market or organic cotton is compared with cotton grown traditionally using pesticides, fertilisers or other types of chemicals. Further, the value added at this stage is the lowest amongst the other stages of the supply chain.

3.1.2 Position of spinner and yarn maker

Usually, there are no additives or chemical treatments to cotton fibres in spinning mills. Therefore there will be no additional cost in comparison with the cost of spinning of any other type of cotton.

3.1.3 Position of fabric maker: weaver and knitter

When making fabrics from cotton yarns, in particular in weaving mills, weavers usually use sizing materials, softening materials and dyestuff for technological reasons. Using those materials necessarily involves extra costs while the added value at this stage of the supply chain is relatively small. To weave organic cotton, weavers have to use sizing materials of natural source, such as starch, and should they require to use dyed cotton yarns, they have to use natural dyestuff. However, the cost of fixing natural dyestuff is usually high (Bellini et al., 2002). Therefore, the cost of weaving organic cotton yarns is more expensive than non-organic cotton.

3.1.4 Position of dyer and finisher

The dyers have to select natural dyestuff and colouring materials for dyeing, natural pigments for printing and natural finishing materials to give the final fabric an extra property. However, the cost of those materials is high, while applying them is more expensive than chemical dyestuff, pigments and finishing materials. Therefore, the cost of processing organic cotton at this stage may increase profoundly in order to meet the technical conditions of the contract.

3.1.5 Position of sewer, embroider and maker of ready-made garments and clothes

Although those stages have high productivity (Halife, 2015), sewing workshops and firms normally use materials and accessories, such as the expensive sewing threads, buttons, linings, strips, etc. to complete the work. Therefore, there is an increase in the cost of cotton products as they are processed by the aforementioned stages. Further, to process organic cotton clothes, the sewing threads and strips must be coloured using the expensive natural dyestuff and colouring materials. Therefore, in order to meet the technical conditions of the contract, the cost will be higher compared with processing non-organic cotton fabrics.

3.1.6 Position of final textile article distributor

Distribution companies do not bear any additional processing cost on the product, and therefore can be excluded from the contract. However, they can participate in the supply chain using other types of contract.

3.1.7 Position of vendor (seller or retailer)

Members of this stage enjoy the highest share of the added value of the chain. Additionally, they benefit from the efforts of the other member or stages of the supply chain without any processing cost from their side. They also usually have the right to return to the suppliers all defective products or any product that does not meet the technical terms and conditions of the contract. Therefore, generally speaking, they share the revenue with the members of the supply chain while providing small effort or cost to run the retail outlets.

Using the aforementioned analysis, and by resorting to the types of the supply chain contracts as classified by Cachon (2003), the optimum performance for the members of the supply chain may be achieved through using the revenue-sharing contracts. This is because revenue-sharing contracts, by definition, ensure fair distribution of the benefits for all members of the supply chain that actually contribute to making products – including organic products, and they incur additional costs due to processing the products (Giannoccaro and Pontrandolfo, 2004; Cachon and Lariviere, 2005; Chen and Chen, 2006; Koulamas, 2006; Qin and Yang, 2008; Li and He, 2006; Dong and Li, 2009). Therefore, this type of contract may be an incentive for companies to produce organic products. The mechanism of this type of contract is as follows:

The vendor pays the supplier a wholesale price (w_r) per unit purchased. However, when the selling season ends, the vendor/retailer shares the revenue realised with the supplier. The vendor/retailer keeps a proportion Ø from the revenue, while the supplier gets the rest (1 – Ø) (Cachon and Lariviere, 2005). The transfer payment T_r is calculated as follows (Govindan and Popiuc, 2011):

$$T_r = (q, w_r, \varnothing) = w_r q + (1-\varnothing)pS(q) + (1-\varnothing)\nu(q - S(q)) \tag{1}$$

or

$$T_r(q, w_r, \varnothing) = (w_r + (1-\varnothing)\nu)q + (1-\varnothing)(p-\nu)S(q) \tag{2}$$

where W_r is the wholesale price, T_r is the transfer payment, T_r (q, wr, Ø) is the transfer payment in revenue sharing contracts, Ø is the vendor proportion from the revenue, S(q) is the expected sales, ν is the leftover inventory salvage value, p is the vendor price.

3.2 Vendors accept the suggested contract

When the vendor accepts the contract, the game reaches another stage. If the vendor, however, refuses the contract, the game ends.

3.3 Vendors submit orders of quantity (q) to suppliers

In this case, the newsvendor model (newsboy model) may apply and there are two cases when the supplier and the vendor faces stochastic demand. The time frame is only one selling season and the vendor has a single opportunity to replace his inventory. The decision on the order quantity q must be taken before the start of the selling season.

For a vendor to submit an optimum order quantity q, the following calculations apply. The vendor's profits equation is (Govindan and Popiuc, 2011):

$$\pi_r(q) = pS(q) + \nu I(q) - g_r L(q) - c_r q - T \tag{3}$$

or

$$\pi_r(q) = pS(q) + \nu(q - S(q)) - g_r(\mu - S(q)) - c_r q - T \tag{4}$$

So,

$$\pi_r(q) = (p - \nu + g_r)S(q) - (c_r - \nu)q - g_r\mu - T \tag{5}$$

where π_r is the profit equation for the vendor, p is the retailer price in a season, S(q) is the expected sales, T is the expected transfer payment (from the vendor to the supplier), c_r is the retailer cost per unit, I(q) is the expected leftover inventory, g_r is the cost because the retailer is not satisfied, ν is the retailer price for unsold units in the selling season and $\nu < c$.

Further, $I(q) = q - S(q)$. If c_s is the supplier's cost per unit, the $c_s + c_r = c$ and $c < p$. If g_s is the cost when the supplier is not satisfied, then $g_s + g_r = g$.

The supplier's profit equation is:

$$\pi_s(q) = T - c_s q - g_s(\mu - S(q)) \quad (6)$$

So,

$$\pi_s(q) = g_s S(q) - c_s q - g_s \mu + T \quad (7)$$

where π_s is the profit equation for the supplier.

The supply chain's profit equation is (Govindan and Popiuc, 2011):

$$\Pi(q) = \pi_s(q) + \pi_r(q) \quad (8)$$

So,

$$\Pi(q) = (p - \nu + g)S(q) - (c - \nu)q - g\mu \quad (9)$$

where $\Pi(q)$ is the equation of the total profit for supplier and vendor.

Suppose the optimum order quantity for supply chain is q^o, and suppose the profit for this quantity is positive, i.e., $\Pi(q^o) > 0$, where Π is strictly concave and the optimum order quantity is unique. Therefore,

$$\frac{\partial \Pi(q)}{\partial q} = (p - \nu + g)\frac{\partial S(q)}{\partial q} - (c - \nu) \quad (10)$$

However, since $\frac{\partial \Pi(q^o)}{\partial q} = 0$ so,

$$(p - \nu + g)\frac{\partial S(q)}{\partial q} - (c - \nu) = 0 \quad (11)$$

Subsequently,

$$\frac{\partial S(q)}{\partial q} = S`(q) = \frac{(c - \nu)}{(p - \nu + g)} \quad (12)$$

The vendors may decide the optimum order quantity (q) using the last equation.

3.4 Suppliers produce and deliver quantity (q) to vendors

In this stage, the supplier may make the quantities which are decided by vendors using equation (12).

3.5 Demand observed and products are sold

As demand on organic textile products commences, vendors find the opportunities to sell the products which they initially bought from the supplier. They expect to sell out all the quantity q which they ordered so as to maximise their profits.

3.6 Remaining payments are made

The remaining payments are based on the revenue sharing contracts, and assuming that all the revenue is shared between the suppliers and the vendors. For the vendor, the profit is decided using the following equation (Cachon and Lariviere, 2005):

$$\pi_r(q) = \varnothing pS(q) + \varnothing v(q - S(q)) - qw_r - qc_r - g_r(\mu - S(q)) \tag{13}$$

That is,

$$\pi_r(q) = [\varnothing(p - v) + g_r]S(q) - q(w_r + c_r - v\varnothing) - \mu g_r \tag{14}$$

Equation (14) helps us calculate the profit of the vendor generated in the various stages of the supply chain.

Whereas the supplier profit is decided using the following equation:

$$\pi_s(q) = qw_r + (1 - \varnothing)pS(q) + (1 - \varnothing)v(q_1 - S(q)) - qc_s - g_s(\mu - S(q)) \tag{15}$$

That is,

$$\pi_s(q) = S(q)[(1 - \varnothing)p + g_s] + (1 - \varnothing)v(q_1 - S(q)) + q(w_r - c_s) - g_s\mu \tag{16}$$

Equation (16) also help us calculate the profit of the supplier generated in the various stages of the supply chain.

The profit equation for the supply chain is given by substituting equations (14) and (16) into equation (8):

$$\begin{aligned}\Pi(q) = {} & [\varnothing(p - v) + g_r]S(q) + \varnothing v(q - S(q)) - q(w_r + c_r - v\varnothing) - \mu g_r \\ & + S(q)[(1 - \varnothing)p + g_s] + q(w_r - c_s) - g_s\mu\end{aligned} \tag{17}$$

That is,

$$\Pi(q) = (p - \varnothing v + g)S(q) - (c - \varnothing v)q - g\mu \tag{18}$$

Equation (18) gives us the total profit of a quantity q and this equation will be used to derive the optimum order quantity.

Suppose the optimal order quantity for the supply chain with revenue sharing contract is q^o, and suppose the profit for this quantity is positive, i.e., $\Pi(q^o) > 0$, where Π is strictly concave and the optimum order quantity is unique. Therefore,

$$\frac{\partial \Pi(q)}{\partial q} = (p - \varnothing v + g)\frac{\partial S(q)}{\partial q} - (c - \varnothing v) \tag{19}$$

However, since $\frac{\partial \Pi(q^o)}{\partial q} = 0$ so,

$$(p - \varnothing v + g)\frac{\partial S(q)}{\partial q} - (c - \varnothing v) = 0 \quad (20)$$

Subsequently,

$$\frac{\partial S(q)}{\partial q} = S`(q) = \frac{(c - \varnothing v)}{(p - \varnothing v + g)} \quad (21)$$

The derivative S`(q) may be used to calculate the local peaks in the plot of S against q. Those peaks will give the value of the maximum profit.

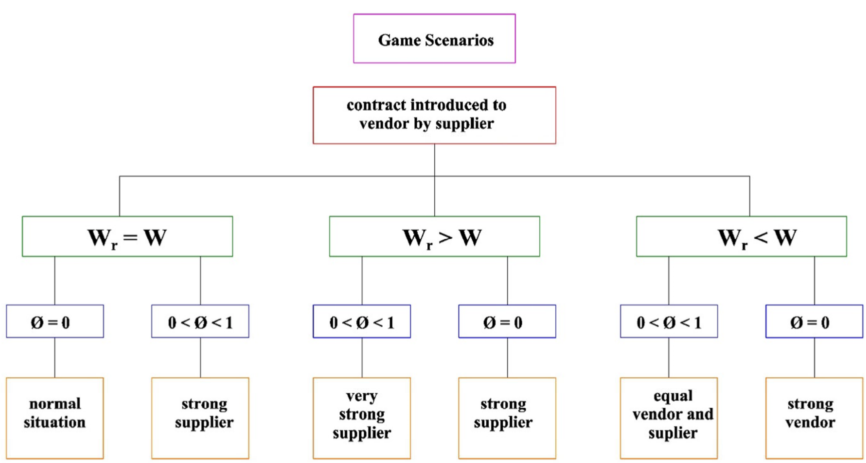
3.7 *Cases of product returns*

For every defect in the products or a violation to the technical terms of the contract, the vendor can return the defective products to the supplier.

4 Discussion

The terms of the contract depend on the strength of each party, so several scenarios may arise to describe the negotiation position of suppliers and vendors as shown in Figure 3 (authors own work). In total, this situation was understood using the game theory when using revenue-sharing contracts for supply chains of organic cotton products.

Figure 3 The game scenarios between vendors and supplier (see online version for colours)



Notes: Where w is wholesale price per unit before signing the contract, w_r is wholesale price per unit after contract and Ø is fraction of the revenue kept by the vendor.

4.1 *First scenario: $w_r = w$ while $Ø = 0$*

This scenario represents the general case and shows the initial situation before any contract where the profits can be calculated using the following equations:

The profit of the vendor is given using the following equation:

$$\pi_r(q) = (p - v + g_r)S(q) - (c_r - v)q - g_r\mu - wq \quad (22)$$

The profit of the supplier is given using the following equation:

$$\pi_s(q) = g_s S(q) - c_s q - g_s\mu + wq \quad (23)$$

Therefore, the total profit is given by the equation:

$$\Pi(q) = (p - v + g)S(q) - (c - v)q - g\mu \quad (24)$$

4.2 Second scenario: $w_r = w$ while $0 < Ø < 1$

This scenario describes the situation where a strong supplier offers a special product, so the supplier can imposes a fixed price on the product and claim a fraction of the vendor revenue. In revenue sharing contracts, such a revenue fraction should be distributed fairly between all the suppliers of organic cotton and the manufacturers who faced costs while processing organic cotton. The optimum shares have to be distributed between the members of the supply chain according to the responsibility born by each of them in achieving the technical requirements for organic cotton products. This scenario is the closest to reality.

Suppose that the responsibility of suppliers is based on the additional cost (in comparison to the cost of processing non-organic cotton) resulting from the achievement of the technical requirements of organic cotton products. Therefore, the revenue share and the additional profit (in comparison to the profit of processing non-organic cotton) for each member of the supply chain can be calculated using Table 1.

Table 1 Profits of the members of supply chain of organic cotton in second scenario

Stage of supply chain	*Additional cost*	*Revenue share*	*Additional profit*
Organic cotton supplier	C_1	$\varnothing_1 = \frac{C_1(1-\varnothing)}{C_1+C_2+C_3+C_4}$	$\pi_{s2} = \pi_{s1} + Ø_1\pi_r$
Yarn spinning	No additional cost to the cost of processing non-organic cotton	Not participant in the additional revenue	$\pi_{m12} = \pi_{m1}$
Fabric making: weaving or knitting	C_2	$\varnothing_2 = \frac{C_2(1-\varnothing)}{C_1+C_2+C_3+C_4}$	$\pi_{m22} = \pi_{m2} + Ø_2\pi_r$
Dyeing, printing and finishing	C_3	$\varnothing_3 = \frac{C_3(1-\varnothing)}{C_1+C_2+C_3+C_4}$	$\pi_{m32} = \pi_{m3} + Ø_3\pi_r$
Sewing, embroidering and ready-garment making	C_4	$\varnothing_4 = \frac{C_4(1-\varnothing)}{C_1+C_2+C_3+C_4}$	$\pi_{m42} = \pi_{m4} + Ø_4\pi_r$
Distribution	No additional cost to the cost of processing non-organic cotton	Not participant in the additional revenue	π_D
Vendor: seller or retailer	No additional cost to the cost of processing non-organic cotton	Not participant in the additional revenue	$\pi_{r2} = Ø\pi_r$

This table shows the effect of this scenario on the various stages of the supply chain taken into account if there are changes in costs, prices and the profit generated.

4.3 Third scenario: $w_r > w$ while $Ø = 0$

In this scenario the supplier is also strong and offers a special product, so the supplier can imposes a new price $w_r > w$. This scenario is close to the second scenario. The profits can be calculated using the following equations.

Table 2 Profits of the members of supply chain of organic cotton in the third scenario

Stage of supply chain	*Additional cost*	*New price share (w_r)*	*Additional profit when* $q_3 > q\frac{w - c_s}{w_r - c_s}$
Organic cotton supplier	C_1	$w_1 = \frac{C_1(w_r - w)}{C_1 + C_2 + C_3 + C_4}$	$\pi_{s3} > \pi_{s1}$
Yarn spinning	No additional cost to the cost of processing non-organic cotton	Not participant in the additional revenue	$\pi_{m13} = \pi_{m1}$
Fabric making: weaving or knitting	C_2	$w_2 = \frac{C_2(w_r - w)}{C_1 + C_2 + C_3 + C_4}$	$\pi_{m23} > \pi_{m2}$
Dyeing, printing and finishing	C_3	$w_3 = \frac{C_3(w_r - w)}{C_1 + C_2 + C_3 + C_4}$	$\pi_{m33} > \pi_{m3}$
Sewing, embroidering and ready-garment making	C_4	$w_4 = \frac{C_4(w_r - w)}{C_1 + C_2 + C_3 + C_4}$	$\pi_{m43} > \pi_{m4}$
Distribution	No additional cost to the cost of processing non-organic cotton	Not participant in the additional revenue	π_D
Vendor: seller or retailer	No additional cost to the cost of processing non-organic cotton	Not participant in the additional revenue	$\pi_{r3} < \pi_r$

The profit of the vendor is given using the following equation:

$$\pi_{r3}(q) = (p - v + g_r)S(q) - (c_r - v)q_3 - g_r\mu - w_r q_3 < \pi_r \quad (25)$$

The profit of the supplier is given using the following equation:

$$\pi_{s3}(q) = g_s S(q) - c_s q_3 - g_s\mu + w_r q_3 > \pi_s(q) \quad (26)$$

$$g_s S(q) - c_s q_3 - g_s\mu + w_r q_3 > g_s S(q) - c_s q - g_s\mu + wq \quad (27)$$

The profit in this scenario will be higher than that of the general case if $\pi_{s3}(q) > \pi_s(q)$. Therefore, the quantity that generates a higher profit in comparison with the general case should

$$q_3 > q\frac{w - c_s}{w_r - c_s} \tag{28}$$

Therefore, the total profit is given by the equation:

$$\Pi_3(q) = \pi_{r3}(q) + \pi_{s3}(q) \tag{29}$$

Similar to the second scenario, suppose the responsibility of the members of the supply chain (suppliers) is based on the additional cost resulting from the achievement of the technical requirements for organic products. Consequently, the additional cost, the new price share and the additional profit are calculated using the equations given in Table 2. This table shows the effect of this scenario on the various stages of the supply chain taken into account if there are changes in costs, prices and the profit generated when $q_3 > q\frac{w - c_s}{w_r - c_s}$.

4.4 *Fourth scenario: $w_r > w$ while $0 < Ø < 1$*

This scenario combines the case of both the second and the third scenarios and it is the case of a very strong supplier. The revenue shares and the additional profits are given in the equations of Table 3.

Table 3 Profits of the members of the supply chain of organic cotton in the fourth scenario

Stage of supply chain	*Additional cost*	*Revenue share*	*Additional profit*
Organic cotton supplier	C_1	$\varnothing_1 = \frac{C_1(1-\varnothing)}{C_1+C_2+C_3+C_4}$	$\pi_{s4} = \pi_{s3} + Ø_1\pi_{r3}$
Yarn spinning	No additional cost to the cost of processing non-organic cotton	Not participant in the additional revenue	$\pi_{m14} = \pi_{m1}$
Fabric making: weaving or knitting	C_2	$\varnothing_2 = \frac{C_2(1-\varnothing)}{C_1+C_2+C_3+C_4}$	$\pi_{m24} = \pi_{m23} + Ø_2\pi_{r3}$
Dyeing, printing and finishing	C_3	$\varnothing_3 = \frac{C_3(1-\varnothing)}{C_1+C_2+C_3+C_4}$	$\pi_{m34} = \pi_{m33} + Ø_3\pi_{r3}$
Sewing, embroidering and ready-garment making	C_4	$\varnothing_4 = \frac{C_4(1-\varnothing)}{C_1+C_2+C_3+C_4}$	$\pi_{m44} = \pi_{m43} + Ø_4\pi_{r3}$
Distribution	No additional cost to the cost of processing non-organic cotton	Not participant in the additional revenue	π_D
Vendor: seller or retailer	No additional cost to the cost of processing non-organic cotton	Not participant in the additional revenue	$\pi_{r4} = Ø\pi_{r3}$

4.5 *Fifth scenario: $w_r < w$ while $Ø = 0$*

In this scenario the vendor is strong, so the vendor can imposes a new price $w_r < w$. The profits can be calculated using the following equations:

The profit of the vendor is given using the following equation:

$$\pi_{r5}(q) = (p - \nu + g_r)S(q) - (c_r - \nu)q_5 - g_r\mu - w_r q_5 > \pi_r(q) \tag{30}$$

The profit of the supplier is given using the following equation:

$$\pi_{s4}(q) = g_s S(q) - c_s q_5 - g_s\mu + w_r q_5 > \pi_s(q) \tag{31}$$

$$g_s S(q) - c_s q_5 - g_s\mu + w_r q_5 > g_s S(q) - c_s q - g_s\mu + wq \tag{32}$$

To change the contract to suit this scenario instead of the general case, the profit should be higher in this scenario, i.e., $\pi_{s5}(q) > \pi_s(q)$. Therefore, the quantity of product should be greater than the general case, that is,

$$q_5 > q\frac{w - c_s}{w_r - c_s} \tag{33}$$

Therefore, the total profit is given by the equation:

$$\Pi_5(q) = \pi_{r5}(q) + \pi_{s5}(q) \tag{34}$$

Therefore, this scenario will be beneficial to the vendors and the suppliers. Further, in this scenario, there will be additional profits only if the demand q_5 satisfies equation (33).

4.6 Sixth scenario: $w_r < w$ while $0 < Ø < 1$

In this situation the vendor pays a new price $w_r < w$, and shares a fraction of revenue with the supplier. The profits can be calculated using the following equations:

The profit of the vendor is given using the following equation:

$$\pi_r(q) = [\varnothing(p - \nu) + g_r]S(q) - q(w_r + c_r + \nu\varnothing) - \mu g_r \tag{35}$$

The profit of the supplier is given using the following equation:

$$\pi_s(q) = S(q)[(1 - \varnothing)p + g_s] + q(w_r - c_s) - g_s\mu \tag{36}$$

When $\pi_{r6}(q) > \pi_r(q)$:

$$\begin{aligned}&\varnothing pS(q) + \varnothing\nu(q_1 - S(q)) - q_1 w_r - q_1 c_r - g_r(\mu - S(q)) \\ &> pS(q) - \nu(q - S(q)) - g_r(\mu - S(q)) - c_r q - wq\end{aligned} \tag{37}$$

$$\begin{aligned}&\varnothing pS(q) + \varnothing\nu q_1 - \varnothing\nu S(q) - q_1 w_r - q_1 c_r - g_r\mu + g_r S(q) \\ &> pS(q) + \nu q - \nu S(q) - g_r\mu + g_r S(q) - c_r q - wq\end{aligned} \tag{38}$$

$$\begin{aligned}&\varnothing pS(q) + \varnothing\nu q_1 - \varnothing\nu S(q) - q_1 w_r - q_1 c_r \\ &> pS(q) + \nu q - \nu S(q) - c_r q - wq\end{aligned} \tag{39}$$

$$\begin{aligned}&\varnothing[pS(q) + \nu q_1 - \nu S(q)] - q_1(w_r + c_r) \\ &> pS(q) + \nu q - \nu S(q) - q(w + c_r)\end{aligned} \tag{40}$$

$$\varnothing > \frac{pS(q) + vq - vS(q) - q\left(w_r + c_r\right) + q_1\left(w + c_r\right)}{pS(q) + vq_1 - vS(q)} \tag{41}$$

Therefore, the profit share Ø which should be kept by the buyer must satisfy equation (41) if the buyer in this scenario is to gain a profit that is greater than the case of not having a new contract.

When $\pi_{s6}(q) > \pi_s(q)$

$$\begin{aligned} &q_1 w_r + (1-\varnothing)pS(q) + (1-\varnothing)v\left(q_1 - S(q)\right) - q_1 c_s \\ &-g_s\left(\mu - S(q)\right) > wq - c_s q - g_s\left(\mu - S(q)\right) \end{aligned} \tag{42}$$

$$q_1 w_r + (1-\varnothing)pS(q) + (1-\varnothing)v\left(q_1 - S(q)\right) - q_1 c_s > wq - c_s q \tag{43}$$

$$(1-\varnothing)\left[pS(q) + v\left(q_1 - S(q)\right)\right] > wq - c_s q + q_1 c_s \tag{44}$$

$$\varnothing\left[pS(q) + v\left(q_1 - S(q)\right)\right] < pS(q) + v\left(q_1 - S(q)\right) - wq + c_s q - q_1 c_s \tag{45}$$

Therefore, the profit share which should be kept by the buyer Ø:

$$\varnothing < \frac{pS(q) + v\left(q_1 - S(q)\right) - wq + c_s q - q_1 c_s}{pS(q) + v\left(q_1 - S(q)\right)} \tag{46}$$

This means that the profit share which should be kept by the buyer (Ø) must satisfy equation (46) if the supplier in this scenario is to make a profit greater than the case of not having a new contract.

Using equations (41) and (46) it is found that:

$$\begin{aligned} &\frac{pS(q) + v\left(q_1 - S(q)\right) - wq + c_s q - q_1 c_s}{pS(q) + vq_1 - vS(q)} \\ &> \varnothing \frac{pS(q) + vq - vS(q) - q\left(w_r + c_r\right) + q_1\left(w + c_r\right)}{pS(q) + vq_1 - vS(q)} \end{aligned} \tag{47}$$

Therefore, in this scenario, if the contract ensures optimum profits for all members of the supply chain, the profit kept by the buyer Ø must satisfy equation (47).

4.7 Managerial implications

The managerial implications of this approach can be better clarified as follows. A comparison between the approaches of revenue-sharing and working as individual entities shows that revenue-sharing contracts in any supply chain provide for the operational managers a forum for improving the co-operation and coordination between the various members of such a supply chain. The benefits of which are improving the sales and also profits in each stage of the supply chain. Although the results may be different in relation to the actual situation and the capability or negotiation position of each member of the supply chain, many studies confirmed the ultimate benefits for revenue-sharing contracts in comparison to traditional methods of dividing the profits.

It is true that some operation managers may look at revenue-sharing contracts as ways that reduce their direct profit as it becomes shared with other member of the supply chain.

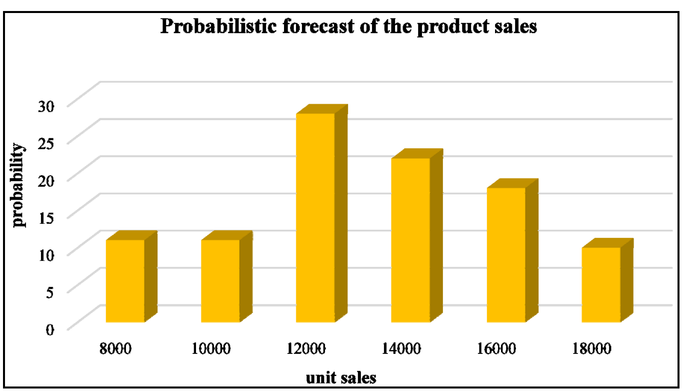
However, since these contracts are expected to provide higher volumes of sales, as a result of information sharing and also providing products that meet the standards or requirements, the higher sales may eventually result in profits higher than would otherwise be the case in the traditional model. Although distributors focus their efforts to convince retailers to buy the products, their efforts in revenue-sharing contracts will be more focused on convincing/persuading the consumer/final buyer to buy the product, as this will guarantee their fair share of the final profits. This will also be positively reflected on the retailers as well who sell the product directly to the consumer.

The working frame of this approach provides managerial instructions to define the priorities of having a strategy to improve the revenue of supply chains. Such a strategy must be based on the results of evaluation of the aforementioned scenarios. Based on that, managers should have a deep knowledge and clear administrative vision of the weakness and strengths of their organisations, as well as the competitiveness of their products to ensure effective management of all operations related to the various stages of the supply chain; therefore, they can select the optimum product price for the case of whole sales and the profits that can be shared amongst the various members of the supply chain.

4.8 Numerical application of the study to validate its results

The sixth scenario of this study was validated using a numerical example as follows. Assuming that the vendor price p = \$125/unit, the leftover inventory salvage value v = \$20/unit, the wholesale price per unit before signing the contract w = \$80/unit, the suppliers cost per unit c_s = \$35/unit, the fixed cost f_c = \$100,000, the new wholesale price per unit after signing the contract w_r = \$60/unit, while the proportion from the revenue kept by the vendor/retailer Ø needed to be calculated. For this example, the probabilistic forecast will be given in Figure 4.

Figure 4 Probabilistic forecast (see online version for colours)



Based on the case of the primary situation (first scenario), it is shown that q_o = 12,000 unit, $\pi_r(q)$ = \$470,000 while $\pi_s(q)$ = \$440,000. However, based on the sixth scenario (where $w_r < w$, $0 < Ø < 1$) it is shown that since q_{6o} = 14,000 unit, $\pi_{r6}(q) = Ø \times$ (\$722,500), while $\pi_{r6}(q) > \pi_r(q)$.

This means that Ø × (722,500) > 470,000, i.e., Ø > 0.65.

Further, since $\pi_{s6}(q) > \pi_s(q)$, this means:

$$[14,000\times(60-35)-100,000]+(1-\varnothing)\times 722,500 > 440,000$$
$$\text{or } 1-\varnothing > 0.26, \text{ i.e., } \varnothing < 0.73$$

So, the value of Ø∊ will be in the range [0.65, 0.73] and the optimal ratio for maximum profits Ø = 0.69.

Suppose that the responsibility of suppliers is based on the additional cost resulting from the achievement of the technical requirements for organic products and this cost. Based on that, the new values will be as given in Table 4. This table shows the shared benefit for all elements of the supply chain of organic textile products.

Table 4 Numerical example for the profits for each stage of the supply chain of organic cottons based on the sixth scenario

Stage of supply chain	*Additional cost ($/unit)*	*Revenue share*	*New profit ($)*
Organic cotton supplier	$C_1 = 8$	$\varnothing_1 = \frac{C_1 \cdot (1-\varnothing)}{C_1 + C_2 + C_3 + C_4} = 0.124$	$\pi_{s6} = \pi_{s1} + 89{,}590$
Yarn spinning	Not applicable	Not applicable	$\pi_{m12} = \pi_{m1}$
Fabric making: weaving or knitting	$C_2 = 2$	$\varnothing_2 = \frac{C_2 \cdot (1-\varnothing)}{C_1 + C_2 + C_3 + C_4} = 0.031$	$\pi_{m22} = \pi_{m2} + 22{,}397$
Dyeing, printing and finishing	$C_3 = 8$	$\varnothing_3 = \frac{C_3 \cdot (1-\varnothing)}{C_1 + C_2 + C_3 + C_4} = 0.124$	$\pi_{m32} = \pi_{m3} + 89{,}590$
Sewing, embroidering and ready-garment making	$C_4 = 2$	$\varnothing_4 = \frac{C_4 \cdot (1-\varnothing)}{C_1 + C_2 + C_3 + C_4} = 0.031$	$\pi_{m42} = \pi_{m4} + 22{,}397$
Distribution	Not applicable	Not applicable	π_D
Vendor: seller or retailer	Not applicable	Not applicable	$\pi_{r2} = 498{,}525$

5 Conclusions

In this study, the problem of encouraging more textile companies and firms to produce organic cotton products and to work in the field of organic textiles was tackled. It was suggested that those companies should work collectively in a well-establish supply chain. Therefore, the flow of materials and information between suppliers and vendors is controlled at all levels, and also achieved at both the lowest possible cost and the highest possible speed. Additionally, such a supply chain may help to prevent the errors of using any substance that affects the organic property of cotton fibres and products as stipulated by the OEKO-TEX 100 standards. It also presented the revenue-sharing contracts as a solution to encourage those textile companies to adapt such an approach because this kind of contract ensures a fair distribution of the benefit between all the members of the supply chain. The impact of this kind of contract on the different members of the supply chain of organic cotton was analysed. Following this, the game theory was used to analyse the various situations in which the negotiation power of the members of the supply chain is different; thus affecting the terms of the contract. Therefore, six different scenarios were proposed based on the values of the proportion of revenue kept by the vendor/retailer, the wholesale price per unit before signing the contract and the wholesale price per unit purchased after signing the contract. For each scenario, equations were introduced to calculate the total profit of the supply chain, and the revenue share and additional profit of each member of the supply chain.

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