example in the electronics industry[1]. There are similar such examples in the pharmaceutical and textiles industries. In this paper we investigate the competition between two different firms of similar end products targeting the same market. Both the firms order from a common supplier to fulfill their own customer demand. We consider two distinct supply chain structures: decentralized and partially integrated. In the case of decentralized supply chain all the entities are independent. In partially integrated structure the supplier owns the first firm and these two firms together form a vertically integrated entity; the second firm operates independently. Similar situation arises when one firm markets her product simultaneously through an 'independent traditional retail channel as well as through a firm-owned direct online channel' (Ryan, Sun & Zhao, 2013) or when a monopolist supplier enters a new demographic market, modifying an existing product to meet local needs, she needs to find a local retailer for selling of the product (Corbett, Zhou & Tang, 2004). The sI sIf i ˝O i Oγ δ

relationship between a supplier and a buyer. In our work we are going to address these two issues – in case of determ

3. The model

We consider a supply chain network consisting of a single supplier and two buyers. The buyers procure a common raw material or component or semi-finished goods from the supplier and subsequently each of them produce one finished p

Here we consider four different types of contracts: whole-sale price contract, linear two-part tariff contract, nonlinear two-part tariff contract and quantity discount contract. Quantity discount and nonlinear two-part tariff are distinctive contract types; wholesale price and linear two-part tariff contracts stem from them respectively as special cases.

We adopt the quantity discount contract structure of Cachon and Kök (2010) for our paper; the corresponding transfer payment function is given as follows

$$J5K,\ 6 = L \begin{cases} K - \frac{'}{-}M^{\ 8} & \ldots !H \ \leq \ = \frac{K->}{M}\ W \\ J\,O\frac{K->}{M}P + >Q - \frac{K->}{M}R \ \ldots & ST\mathit{h}UVK!>U \end{cases}$$

where K and M designates per-unit price and quantity discount rate respectively; $M \in [0, \bar{M}6$ and $\bar{M} = \min 5\frac{8]_{\wedge}}{]_{\_}}, \frac{8]_{\backprime}}{]_{\_}}6$ and $,_a = ,_{:},_8 + .5,_{:} + ,_8 6$. The quantity discount is assumed to be continuous, differentiable and concave. If the order quantity is more than , the supplier sells the excess units at a per-unit price equal to her own marginal production cost >. By setting $M = 0$, we obtain wholesale price contract, where the transfer payment function assumes a simpler form: $J5K,\ 6 = K.$ with K representing the per-unit wholesale price.

In linear two-part tariff contract, the supplier extracts per-unit price K as well as a per-period fixed fee c from buyer !; but K and c are independent of the order quantity . In nonlinear two-part contract $\{K5\ 6, c\ 5\ 6\}$, the per-unit price and fixed fee are both functions of the order quantity . Transfer payment of two-part tariff contract is given by: $J5K,\ , c\ 6 = K. + c . '_{[f_g h a]}\ ,gi$

M

holes art

profit function $m_v = \$ - 5K - \frac{\vdots}{8} M\ ^8 6 -$ over . Since $=)* - , \$ + ./\$_0 - \$ 1$, the solution to this is given by $5\$|_{}\sim , q_{}\sim 6$ for the $!^{"\#}$ buyer and is expressed by equation (5) and (6).

$$\$|_{}\sim = {}_{}\sim + ¡_{}\sim 5K + 6 \ldots 5¢6$$

$$q_{}\sim = \frac{, + .}{£} ¤ {}_{}\sim - /' - ¡_{}\sim 15K + 6¥ \ldots 5¦6$$

where,

$${}_{}\sim = \frac{).£ £_0 +)* £ ¤. + ,_0/' + £_0 1¥}{§^8_{9:} 5' + £ 65. + , 6 - .^8 §^8_{9:} £}, ¡_{}\sim = \frac{5. + , 6¤.£ + 5. + , 6/' + £_0 1¥}{§^8_{9:} 5' + £ 65. + , 6 - .^8 §}$$

$$\mathbf{K}_{\text{-}\circledR:} = \sum \{5:^{-}\circ v_g 65\pm_g{}^{2\,3} v_g 6\}^{-}{}' \sum_g{}^{`} \quad v_g$$

$$K = \frac{'}{(5, + .6}À.\ Á\frac{)}{(,} - \ \hat{A} + 5(, + .6>Ã$$

$$\dot{c}\ = 5, + .6Ä\frac{5(, + .6)* +).}{5(, + .65(, + x.6} - \frac{,}{(5(, + .65, + .6}Å\frac{.)}{(,} - 5(, + .65> + \ 6ÆÇ^{8} - m_v$$

In Case CF4, the supplier offers a flexible contract through nonlinear two-part tariff structure. In Case CF3, it is evident that the supplier is able to extract all profit beyond the reservation level m_v

$$\dot{c}_{,-\circ\frac{3}{4}} = 5, \quad + .6.[\quad \cdot \quad - \; \text{¡} \cdot \quad . \frac{\sum_{g\mu\wedge}^{`} 5]_g^{-} \cdot 6\{^{\circ} \, \text{»}_g 5: {}^2 8\frac{1}{4} \, \text{»}_g 6^{-}\frac{1}{4} \, \text{»}_g 5' {}^2 \text{È} 5^3 6^{-} 8^3 \, \text{É}_g \hat{\text{E}} 6\}}{8 \sum_{g\mu\wedge}^{`} \frac{1}{4} \, \text{»}_g 5: {}^2 \frac{1}{4} \, \text{»}_g 65]_g^{-} \cdot 6}]8 \; - \; \text{m}_{\text{v}}$$

Proposition 7. In Case CA4, the optimal contract is given by the following per-unit price $5\text{K}_{-\circ 1}6$ and subsequent condition on the franchise fee $5\dot{c}_{,-\circ 1}6$

$$\text{K}_{-\circ 1} = \sum_{9:}^{8} \quad \cdot \quad 5' - \text{¡} \cdot 65, \quad + .6 + \sum \quad \text{¡} \cdot 5, \quad + .6\{> - \quad + \text{¡} \cdot 5 \quad + \frac{\text{I}\,5\;6}{\text{H}5\;6}$$

Again by putting M = 0 in these optimal values of price and order quantity, we obtain the optimal solution 5$|í ¨ , qí ¨ 6 for wholesale price contract, as expressed by equation (13) - (16).

$|í ¨ : = ¨ : + 5' − ¡ ¨ :65> + 6 + í ¨ :5K − >6 ... 5'x6

qí ¨ : = 5, : + .6{ ¨ : − ¡ ¨ :5> + 6 + í ¨ :5K − >6} ... 5'{6

$|í ¨ 8 = ¨ 8 + 5' − ¡ ¨ 865K + 6 − í ¨ 85K − >6 ... 5'¢6

qí ¨ 8 = 5, 8 + .6{ ¨ 8 − ¡ ¨ 85K + 6 − í ¨ 85K − >6} ... 5'¦6

where í ¨ = .5,0 + .6«5{ ,a + x . 86. Results obtained through equation (13) – (16) will be used for the purpose of wholesale price contract, linear two-part

buyer i.e. buyer 2. In this section, we compare various outcomes to discuss the effect of supply chin structure, market share, cutoff policies and value of information on different contract types. We also discuss the impact of different contract types on the profit level of individual players with the help of a numerical example.

6.1. Effect of supply chain structure on the profit level

In this section, we explore se

Figure 2 shows how the profit level of the supplier varies under similar setting. In the case of partially integrated structure supplier profit designates the total profit of the partially integrated chain. In the case of decentralized setting the supplier profit increases rapidly as cross-price sensitivity increases. In other words, as the competition between the two buyers increases the supplier can extract higher wholesale price leading to increase in more profit. From a supplier's perspective lower price-sensitivity of demand leads to more profit irrespective of the supply chain structure. These observations about the supplier and the buyer are consistent with the results discussed in Anderson and Bao (2010) that the profit level of buyer is strictly decreasing as cross-price elasticity increases.

Figure 2. Supplier profit (Cases: CF2 t wIntm car (Ơ o

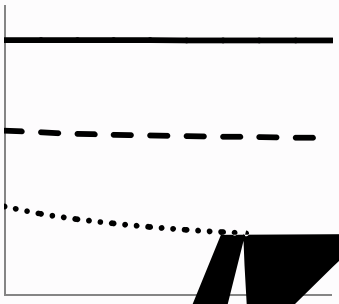

Figure 3. Supplier or Parti[illegible]in Profit (Cases: CF3 and

Next we consider the va[illegible]n overall supply chai[illegible] market share. F[illegible]gure 4 [illegible] the variation of o[illegible] variation of m[illegible]rket sh[illegible]uyer 1. We comp[illegible] different su[illegible]y chain [illegible]. Cases CF2 and[illegible]n Cases CF3[illegible] PF3. In[illegible] profit of vert[illegible]s taken a[illegible]chmark[illegible]uct type; th[illegible] a perce[illegible]of that p[illegible]e of two-[illegible] of the [illegible] chain st[illegible]ion in[illegible] of [illegible]e price co[illegible]t sh[illegible]low [illegible]rtially inte[illegible]

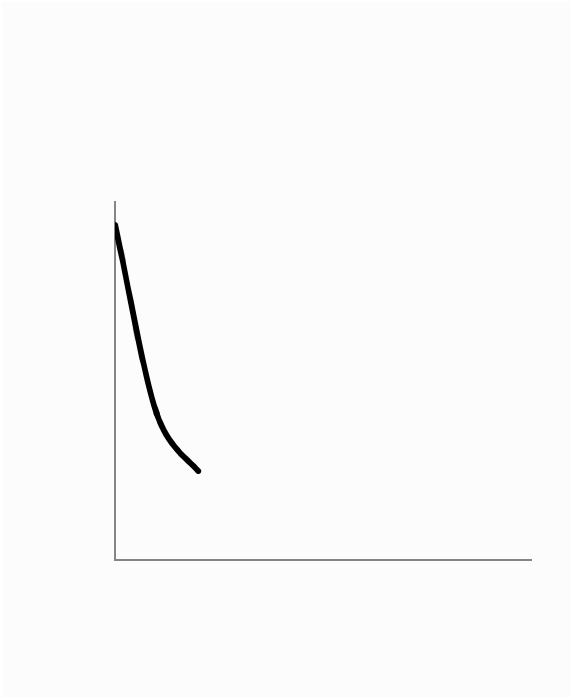

Figure 4. Overall supply chain profit (Cases: CF2, CF3, PF2 and PF3)

Buyer profit strictly decreases as the competition intensity increase. Decentralized supply chain works in the advantage of the supplier in the case of wholesale price contract. However if the cross-price elasticity is low or the independent buyer has higher market share, then it helps the supplier to charge more per-unit wholesale price in the case PF2 compared to the case CF2, as evident from figure 5.

Figure 5. Wholesale price with cross-price elasticity and market share

When the competition among the buyers increases, the profitability of the supplier also increases. In partially integrated chain, if the independent buyer captures the majority of the market share the overall supply chain profit decreases for wholesale price contract; the overall supply chain behaves inefficiently compared to its decentralize

centralization is given by Ú5K6 ¨ í in the case of wholesale price contract under availability of full information. Then Ú5K6

buyer) will refuse to trade. We discuss the cutoff policies for wholesale price contract under full and asymmetric information in detail.

Proposition 8a. In the case of wholesale price contract (Case CF2) under the assumption of full information and complete decentralization, different cutoff points are as follows,

(i) The !"# buyer's cutoff point $\ddot{a}_v$ is given by

$$\ddot{a}_{v,-\circledR 8} = \frac{(}{\dot{i}\cdot\cdot} \mathring{a}\ \cdot\cdot - \ae \frac{\overline{m_v}}{,+.} \c{c} - \hat{a}> + \frac{\sum_{9:}^{8} \cdot\cdot 5,+.6}{\sum_{9:}^{8} \dot{i}\cdot\cdot 5,+.6} \tilde{a}$$

(ii) The supplier's cutoff point $\ddot{a}_n$ is given by

$$\ddot{a}_{n,-\circledR 8} = \frac{\sum_{9:}^{8} \cdot\cdot 5,+.6}{\sum_{9:}^{8} \dot{i}\cdot\cdot 5,+.6} - \acute{e}> + \left(\hat{e}\overline{m_n\{ = \dot{i}\cdot\cdot 5,+.6\}}\right)\grave{i}$$

where m_n designates the reservation profit level of the supplier.

Both $\ddot{a}_v$ and $\ddot{a}_n$ are identically decreasing in >. Both the cutoff policies are decreasing in their respective reservation profit levels i.e. $\ddot{a}_v$ is decreasing in m_v and $\ddot{a}_n$ is decreasing in m_n. Supplier's cutoff point $\ddot{a}_n$ is absolutely increasing in) and buyer's cutoff point $\ddot{a}_v$ is increasing in) under the condition $\frac{8\{/8]_u^{-}\cdot 1Đ_g^{-}\cdot\}}{¼»g} > \frac{\sum_{g\mu\wedge}\{/8]_u^{-}\cdot 1Đ_g^{-}\cdot\}5]_g^{-}\cdot 6}{\sum_{g\mu\wedge}¼»g5]_g^{-}\cdot 6}$. If both the buyers have identical own-price elasticity then with increase in the market size), the cutoff point decreases for the buyer with lower market share.

Proposition 8b. In the case of wholesale price contract (Case CA2) under the assumption of asymmetric information and complete decentralization, supplier's cutoff point $\ddot{a}_{n,-\circledR 8}$ is given by the following condition,

$$p = 5,+.6\ \cdot\cdot - 5(K->6 = \overline{}^{8}$$
$$9:$$

$ L + #
#$

This paper focuses on the influence of competition, market structure and supply chain structure on the performance of the supply chain. We have also calculated the value to a supplier of different types of contract; in case of information asymmetry we have shown the value of obtaining more accurate information about the buy d

References:

Anderson, E. J., & Bao, Y. (2010). Price competition with integrated and decentralized supply chains. *European Journal of Operational Research,200*(1), 227-234.

Bernstein, F., & Federgruen, A. (2005). Decentralized supply chain with competing retailers under demand uncertainty. Management Science, 51(1), 18–29.

Cachon, G., & Lariviere, M. A. (2005). Supply chain coordination with revenue sharing contracts: strength and limitations. Management Science, 51(1), 30–44.

Charles J. Corbett, Deming Zhou, Christopher S. Tang. Designing Supply Contracts: Contract Type and Information Asymmetry. Management Science. Vol. 50 No. 4. 2004. pp. 550-559.

Chung, W., Talluri, S., & Narasimhan, R. (2010). Flexibility or cost saving? Sourcing decisions with two suppliers. *Decision Sciences*, *41*(3), 623-650.

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X. Li, Cheap talk and bogus network externalities in the emerging technology market, Marketing Science 24 (4) (2005) 531–543.

Y. Gerchak, Y. Wang, Revenue-sharing vs, wholesale-price contracts in assembly systems with random demand, Production and Operations Management 13 (1) (2004) 23–33

Y. Wang, L. Jiang, Z. Shen, Channel performance under consignment contract with revenue sharing, Management Science 50 (1) (2004) 34–47

Zhao, X., D.R. Atkins. 2008. Newsvendor under simultaneous price and inventory competition, *Manufacturing and Service Operations Management* **10**(3), 539-546.