



Hybrid contracting within multi-location networks

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ABSTRACT

The expansion of hybrid organisations during the past 30 years makes the analysis of planning in these organisations indispensable. Hybrid organisations are often applied in food industries or at retailers, which deal with seasonal or perishable goods. Despite the large amount of papers discussing hybrid organisations, a newsvendor approach which fits hybrid organisations has not yet been published. The application of centralised or decentralised approaches in these organisations causes problems, such as conflicts between global standards and local goals, high effort of data management or low result quality. Therefore, the aim of this paper is to develop a mathematical approach to determine production quantities in multi-location supply chains with respect to the privacy of local information. The findings of the paper prove that the suggested hybrid multi-location contracting process leads to optimal results, even if local cost information is not public and even if the decentralised sites act mainly independently.

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1. Introduction

Product variety, focus on inventories, and extending the planning scope have turned flexibility into one of the key attributes of manufacturing systems (Buzacott and Mandelbaum, 2008). An adequate organisation ensures and increases the flexibility in production networks. The coordination type of organisations allows a classification of organisations into three classes: Hierarchical organisations, heterarchical organisations, and hybrid organisations. Recent developments in organisation theory overcome strict hierarchy. Internal markets, which link heterarchical negotiations with hierarchical interventions, become increasingly popular (Shane, 1996; Zenger and Hesterly, 1997; Egelhoff and Frese, 2009). Unlike heterarchical organisations, in hybrid organisations (especially internal markets within enterprises) a central unit monitors and support negotiation processes. (Williamson, 1991; Hennart, 1993; Ménard, 2004; Picot et al., 2008: 42–47)

The coordination type influences planning methods directly. Heterarchical coordination averts centralised planning since global optimal planning results, which are inconsistent with local objectives, cannot be enforced (Ross, 1973; Fama, 1980).

Centralised planning policies may be suggested for planning within hierarchical coordinated production networks. However, even if plans were enforced and a global network optimum was achieved in a hierarchical planning environment, problems

including excessive data volume and limited flexibility would occur (Chen, 1999). In order to overcome these problems, decentralised planning methods for heterarchical environments have recently been published (Sucky, 2004; Dudek, 2009). They are designed for networks of autonomous production units. Global intervention by a central unit is not intended. Therefore, decentralised policies do not consider global goals. However, both contracts about quantities and transfer payments may improve goal alignment (Cachon, 2003). Combinations of centralised and decentralised policies, matching the requirements of hybrid organisations, have been neglected so far. Hybrid approaches overcome the impediments of both, centralised and decentralised approaches. In particular, they have the following advantages compared to decentralised methods:

- Centralised influence to establish global goals of an organisation is possible.
- A global optimal solution can be reached.
- The efficiency of the negotiation process may be positively influenced by an objective central unit.

Hybrid approaches improve centralised models regarding the following aspects:

- The autonomy of decentralised units causes a higher readiness to take on responsibilities and improves the motivation of those units.
- The autonomy of decentralised units ensures a high flexibility of the global organisation.

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→ The data management effort and complexity are reduced for the central unit.

Hybrid organisations exist in various industries and business sectors. Supply chain planning models have to be adapted to industry and company-specific requirements. In industries with perishable or seasonal goods, the newsvendor model fits best for the disposition of production quantities as it considers overage cost. Overage costs are incurred, when the goods could not be sold during the season or until the due date.

The planning problem becomes complex when the number of locations exceeds two sites. In supply chains with two sites, a main kind of relationship has to be considered: a typical supplier–customer relationship, which is denoted as vertical link between two sites. In multi-location networks, the advantages in coordinating two or more competitive sites on the same level of the supply chain have to be analysed (horizontal interaction). Moreover, high data volume in multi-location networks increase the planning complexity and impede centralised approaches. The application of hybrid or decentralised approaches becomes more attractive with increasing complexity.

With respect to the proliferation of internal markets, the strengths of hybrid approaches and the lack of research concerning hybrid models, the intention of this paper is to develop a hybrid approach for determining the production quantities in a multi-location, hybrid organisation for perishable or seasonal goods considering stochastic demand. The approach aims to benefit from the advantages and to overcome the impediments of both.

Our paper is organised as follows: Section 2 summarises selected models for centralised and decentralised multi-location newsvendor problems. Thereafter, hybrid approaches for vertical and horizontal networks are developed and applied (cf. Sections 3 to 5). Finally, the most important findings are recapitulated and further research fields are outlined.

2. Literature review about multi-location newsvendor models

Interaction in multi-site networks can be divided into two groups: vertical interaction and horizontal interaction. In literature, contradictory definitions of both kinds are found. Spengler (1950) defines vertical integration as the integration of different production stages, whereas horizontal integration refers to the same value stage, but different organisations with complementary or equal competences. Transferred to the categories of interaction, vertical interaction is the interaction between organisations of different value stages and horizontal interaction is the interaction between organisations on the same value stage. This definition is adopted by Durham (2000: 207), Lazzarini et al. (2001: 7–8), and Christopher (2008: 17). In contrast, few authors distinguish between a horizontal structure consisting of links between the value stages and a vertical structure as the number of and relations between organisations on a single value stage (Min and Zhou, 2002; Lambert et al., 1998). In this paper we refer to Spengler's and Lazzarini's understanding of vertical and horizontal interaction, although the concept of Min and Zhou (2002) and Lambert et al. (1998) is comprehensible as well.

Both, vertical and horizontal interaction, influence the supply chain success. If supply chains lack in coordination, problems of double marginalisation (Spengler, 1950) and inventory fluctuation (Lee et al., 1997) arise. The coordination is mainly carried out by the application of planning mechanisms. In the context of the newsvendor model, a high number of papers have been published for multi-location newsvendor models. The majority refer to centralised models, few papers refer to decentralised models, and hardly any refer to hybrid models. See Khouja (1999) or

Cachon (2003) for extensive literature reviews about the newsvendor model. The following overview of stochastic multi-location models should give an insight in the current state of research. Although it cannot claim to be complete, it indicates a high diversity of analysed supply chain structures. However, in contrast to our approach research nearly always based on the assumption of full information.

The models can be divided into three groups: multi-retailer-models, assembly-chain-models, and multi-echelon supply-chain-models.

The majority of multi-location models, which we define as models of supply chains with more than two sites, rely on a network structure, in which one manufacturer supplies goods to many retailers (*multi-retailer models*). Thus, competition, information sharing and inventory management are taken into consideration (Khouja, 1999). Eppen (1979) introduces this supply chain structure and analyses the effects of inventory centralisation at the retailer in comparison to decentralised inventories without any coordination. Kouvelis and Gutierrez (1997), Rudi et al. (2001), and Hartman and Dror (2005) base upon this idea with some adaptations.

An *assembly-chain*-structure consists of $N-1$ supply sites and only one assembly site N (Jiang and Wang, 2010). Schmidt and Nahmias (1985) and Gurnani et al. (2000) suggest order policies for a two stage assembly system with two complementary components and one assembly line. They suggest a separate order and assembly policy. *Multi-echelon supply-chain-models* are derived from multi-echelon models, which consider different value stages mostly within organisations (Clark and Scarf, 1960; Federgruen and Zipkin, 1984). This kind of newsvendor models is applied for analysing inventory and production policies (Gerchak and Zhang, 1992; Eynan and Rosenblatt, 1995; Moon and Choi, 1997). The relevant centralised literature is summarised in Table 1.

All of these models are based on the assumption of full information and a central planning unit. The centralised planning organisation induces impediments, such as missing planning flexibility, conflicts between global standards and local goals, and high effort of data management. Decentralised planning systems avert these impediments (Lee and Whang, 1999).

Decentralised newsvendor models are strongly connected to the idea of contracting. Supply contracts (e. g. buyback contracts, revenue sharing contracts) “offer guidance in negotiating the terms of the relationship between buyer and seller” (Tsay et al., 2003: 303). Newsvendor contracts for horizontal interaction primarily refer to the centralisation of inventory in *multi-retailer* environments. They applied to the problem of profit allocation or the coordination of assembly-chains with substitutable or complementary components (Eppen, 1979; Padmanabhan and Png, 1997; Anupindi et al., 2001; Kouvelis and Gutierrez, 1997; Kouvelis and Lariviere, 2000; Rudi et al., 2001; Hartman and Dror, 2005; Agrawal and Smith, 2009). Decentralised *assembly-chains* with $N-1$ suppliers and one assembly site N are examined by Gerchak and Wang (2004), Jiang and Wang (2010), and Zhang (2006). Vertical interaction is considered by Lee et al. (1997). They developed a coordination scheme for a *multi-echelon supply chain* with a special focus on inventories and stock-outs. The scheme incorporates incentive mechanisms to overcome the organisational impediments in supply chains of autonomous units.

Although a typical attribute of decentralised planning environments is the self-responsibility of and the competition between the different sites, the authors assume all necessary cost information of each site is available for the whole supply chain. Nevertheless, some authors take into consideration the importance of information. Cachon (2003) proposes a multi-retailer structure. He shows that providing full information about the cost of all retailers to the supplier is sufficient for a global optimal solution.

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