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Decision Support

Setting the right incentives for global planning and operations

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ABSTRACT

We study incentive issues seen in a firm performing global planning and manufacturing, and local demand management. The stochastic demands in local markets are best observed by the regional business units, and the firm relies on the business units' forecasts for planning of global manufacturing operations. We propose a class of performance evaluation schemes that induce the business units to reveal their private demand information truthfully by turning the business units' demand revelation game into a potential game with truth telling being a potential maximizer, an appealing refinement of Nash equilibrium. Moreover, these cooperative performance evaluation schemes satisfy several essential fairness notions. After analyzing the characteristics of several performance evaluation schemes in this class, we extend our analysis to include the impact of effort on demand.

1. Introduction

Today's global organizations consolidate their manufacturing and supply chain operations to benefit from assembly, inventory pooling, commonality, substitution and resource flexibility strategies. In these global organizations, local markets are supported by global manufacturing and supply chain activities and the local functions are limited to supportive secondary activities such as sales and marketing, finance, local logistics, warehousing and custom operations. These organizations rely on their regional business units to connect with their local markets. Regional business units know their customers' needs and local market conditions as well as how to run the local operations. This local market knowledge is important for a wide range of globally controlled decisions such as global planning of capacity, production and inventories. Setting the right incentive mechanisms for the local units to reveal the local market information truthfully is essential for global planning of operations and performance of the whole supply chain. In this paper, we study this issue.

The decentralized structure of local demand management coupled with global manufacturing and planning is typical for telecommunication equipment manufacturers. The primary customers of these firms are the major service providers in each country. As the customers and their buying behavior show large differences over different countries and drastic changes within each country, the firms often segment their business units according to the countries and each business unit has a special sales force focusing on the major service providers in the country. Standard forecasting techniques are not capable of forecasting the buying behavior of these big customers and the firms mainly rely on the insider information of the regional units to forecast future demand. On the manufacturing side, it is typical that final products require customer specific customization and calibration before it can be delivered. Once the products are assembled for a specific customer they cannot be used to satisfy the demand of another customer. For effective resource allocation and responsive order fulfillment, the manufacturing is mainly performed in two stages. The capacity build-up, material procurement and component production are done make-to-stock (MTS) fashion whereas final assembly of customer specific products are performed assemble-to-order (ATO) fashion after exact orders arrive from the customer. Component commonality, resource flexibility and production postponement are the common production strategies employed by these firms to move MTS-ATO boundary for cost reduction and delivery performance improvement. The effective management of the MTS part of these manufacturing systems heavily relies on the accuracy of the forecasts provided by the business units. To motivate the business units to collaborate in these activities, it is important to provide incentives that make sense economically and to ensure the business units that they are treated fairly. This setting is not specific to telecom industry and it can be observed

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in other industries in which the companies are selling to big customers having hard to predict buying behavior. An example is a computer manufacturer like Dell selling to big corporations.

We consider a model in which a firm sells a group of products that require the same production technology and share resources (i.e., components and production capacity) through multiple regional business units. The demand in each region is stochastic and best observed by the regional units. The firm is engaged in global planning and manufacturing activities and relies on the regional units' forecasts for planning of capacity investment and component manufacturing, i.e., common resources (MTS part of the manufacturing system). In this decentralized setting, the firm faces several possible problems. Firstly, the information asymmetry, i.e., the regional units have superior information about the demand in their region, can create an adverse selection problem. If the firm does not have the right incentive structure that motivates the regional units to reveal their private information truthfully, global planning won't be effective because of poor forecasts, and the firm's profit drops. A common incentive scheme seen in practice is that the regional units are compensated proportionally to regional book profits. Although at first sight it may seem direct and reasonable, such mechanisms can create conflicts between individual units' goals (achieve the maximum local performance) and the company's goal (maximize the total system profit) if the company cannot find a way to effectively allocate the cost of undedicated resources which requirement is assessed based on regional forecasts. Perceiving that the available units will depend on their forecasts, business units usually inflate their forecasts to ensure adequate supply for their customers (see Mentzer and Moon, 2005, page 158). This behavior is well observed in many companies performing global planning activities. As a common reaction, the global planners try to estimate and incorporate this bias in business units' forecasts in their final forecast for global planning. However, this results in constant gaming between the business units and the global planners. Secondly, business units should be treated fairly while being motivated for cooperative actions. This is especially important because unfair treatment might create wrong incentives and even result in irrational behavior among the business units. Although fairness can have different interpretations in different contexts, in our global planning context, basic expectations of the business units include that they are not worse of by being involved in global planning activities and no business unit has an a priori advantage, i.e., all business units should be treated the same. This is hard to guarantee every planning period under information asymmetry and fluctuating market conditions from one period to another. Finally, a moral hazard problem may arise. When the demand can be improved by extra effort of the business units, the firm would like the business units to exert an appropriate level of effort to stimulate demand. Without knowing the market conditions, the firm cannot effectively judge how much effort is put by the business units to achieve total customer orders. Hence, the effort level cannot be observed directly, nor indirectly via the communicated demand information. Many direct mechanisms are open to business units' forecast manipulation who would like to signal bad market conditions and high effort level. A good design of mechanism should overcome all these problems.

The main contribution of this paper is the development of a mechanism to calculate regional book profits, to which regional business units' compensation (or performance evaluation) will be tied. This mechanism has the following properties: It

- induces business units to share their private information truthfully (overcome adverse selection problem);
- induces business units to exert costly effort appropriately (overcome moral hazard problem);
- satisfies basic fairness requirements expected by the business units;
- is descriptive: it can be communicated with the business units at the start of the planning period without announcing any parameters based on any prior beliefs;
- does not require any external examiner or market maker;
- uses the information available for the global planning activities only.

Mechanisms based on observed system status only (e.g., demand, revenues and costs) would usually fail to create right incentives because collective system performance is hard to be separated from individuals' real contributions in this way, e.g., allocation of the cost of common resources. We develop and propose a class of performance evaluation schemes (called cooperative performance evaluation schemes, CPES for short) to do the job. The proposed mechanisms are inspired by cooperative game theory that deals with similar problems in different settings. We show that CPES's based on the Shapley value and Equal Surplus Division satisfy all the basic characteristics we listed above. Another important property of these CPES's is that they turn the business units' demand revelation game into a potential game in which truth telling is the potential maximizer, an appealing refinement of the Nash equilibrium concept. We also derive a set of sufficient conditions for a CPES to have this property. Moreover, we show that if the business units' effort improve the demand in an additive way, CPES's based on the Shapley value and Equal Surplus Division create the right incentives for the business units to work at least as hard as they would when working by themselves.

The remainder of the paper is organized as follows. Section 2 contains a brief literature review. In Section 3, we present the newsvendor networks. This is followed by Section 4, which considers the global planners problem after receiving the business units' signal about the demand. In Section 5, we present the business units' demand revelation game under a given performance evaluation scheme. The proposed performance evaluation schemes are introduced in Section 6 where we also analyze in detail the characteristics of these schemes. In Section 7, we extend our analysis to the setting with effort-dependent demand. We conclude in Section 8 with a summary and discussion of the results. The proofs are given in an online technical appendix together with an introduction to both cooperative and noncooperative game theory.

2. Literature review

Firms perform global planning and manufacturing activities in order to benefit from inventory pooling, component commonality, resource flexibility and substitution strategies. Potential benefits of these strategies have been extensively studied in operations management literature, e.g., see (Chang & Lin, 1991; Chen & Lin, 1989; Eppen, 1979) and (Robinson, 1993) for inventory pooling; Gerchak and Henig (1989) and Van Mieghem (2004) for component commonality; Van Mieghem (1998) and Rudi and Zheng (1997) for flexible manufacturing, and Bassok, Anupindi, and Akella (1999) and Netessine and Rudi (2003) for substitution. Van Mieghem and Rudi (2002) provide a unified framework (called newsvendor networks) to study these strategies in a stylized model and establish the structures of optimal inventory and capacity investment policies. We use their framework in this paper. This literature assumes central control under full information about the underlying demand process. In our study, we specifically study the adverse selection problem where the central controller (global planner in our case) does not have full information about demand processes but relies on the feedback from regional units.

Our research falls into a scarce but growing body of research in the area of "marketing-operations interface". Conflicts and