Fair Distribution of Efficiency Gains in Supply Networks from a Cooperative Game Theory Point of View

Stephan Zelewski, University of Duisburg-Essen, Germany
Malte L Peters, Center for Education and Science of the Federal Finance Administration, Germany

ABSTRACT

In this paper, the authors address the distribution of efficiency gains among partially autonomous supply network actors in a manner they will accept as fair and as an incentive to cooperation. The problem is economically significant because it requires substantiating efficiency gains in an understandable manner. Moreover, supply networks suffer from a conflict potential because the partially autonomous actors seek to maximize their own shares of the efficiency gain. The method applied appropriates a model from cooperative game theory involving the τ-value. The special nature of the τ-value ensures that it seems rational to the actors to cooperate in the supply network. The proposed method for the distribution problem offers a fair distribution of efficiency gains in the supply network and ensures that the distribution results can be communicated easily.

Keywords: Efficiency Gains, Fairness, Game Theory, Planning Models, Supply Chain Management, Supply Networks, τ-Value

INTRODUCTION

Over the past several years, a considerable amount of research has been carried out in the area of supply chain management (e.g., Croson & Donohue, 2006; Krol et al., 2005; Wu et al., 2007; Zokaei & Simons, 2006). One principal aim of this research is to find ways of realizing efficiency gains by coordinating the activities of all actors in a supply chain or, more precisely, in a supply network. Since this paper’s findings are not restricted to supply chains, but also apply to supply networks, the latter term will be used throughout.

Several effects must be considered as sources of efficiency gains. The most prominent effect is the so called bullwhip effect (Lee et al., 1997; see also Croson & Donohue, 2006; Krol et
The bullwhip effect describes especially how companies build inventory buffers based on the demand of their customers: the further the company is from the final customer the greater the “safety stock” is in times of rising demand. The cost of capital invested in oversized inventory buffers in the stocks causes inefficiency and thus efficiency gains can be realized by avoiding or reducing the bullwhip effect. Evidence of the practical relevance of the bullwhip effect to supply chain management is provided by studies of its financial consequences (McCullen & Towill, 2002; Metters, 1997). Based on available estimates of the cost of the bullwhip effect, companies should be able to increase their profits—depending on the source—by 8.4 to 20.1% (McCullen & Towill, 2002) or by 10 to 30% (Metters, 1997) by avoiding it.

When efficiency gains are realized in supply networks, a distribution problem arises. The cooperating actors know that they are realizing the efficiency gains by mutually coordinating their activities. Moreover, each actor is interested in maximizing his own gain at the expense of the other actors in the supply network. Thus, supply networks suffer from a built-in conflict between cooperation and defection. The problem lies in distributing efficiency gains among partially autonomous actors in a manner that the actors will accept as fair and advantageous to cooperation. If, on the other hand, it would be advantageous for at least one of the actors to leave the grand coalition, the supply network would collapse. With this scenario in mind, a stability requirement can be posited for the solutions of efficiency gain distribution problems. These problem solutions are regarded as desirable only, if they ensure that all actors in a supply network are willing to cooperate with each other. The fulfillment of this stability requirement is often circumscribed by the actors’ acceptance of the distribution of the efficiency gains as fair.

In economic literature, significant research efforts have been devoted to developing concepts of fairness (e.g., Fehr & Schmidt, 1999; Pazner, 1977; Varian, 1976). Unfortunately, to the knowledge of the authors, these concepts have not yet been adapted to solve the distribution problem outlined above. Furthermore, cooperative game theory offers a number of solution concepts for distribution problems worthy of closer consideration. These are especially the Shapley value (Shapley, 1953; see Derks & Tijs, 2000) and the Nucleolus (Schmeidler, 1969; see also Meertens & Potters, 2006). Yet these solution concepts suffer from a serious drawback. The fairness of the distribution results is hard to justify, since the ‘logic’ of these approaches is difficult to communicate. The central issue of this paper is to present a solution concept from cooperative game theory for the problem of distributing efficiency gains in supply networks that aims at distributing efficiency gains in a fair manner. From a management point of view, this concern is motivated by the fact that the (game) theoretic solution concepts have to withstand acceptance problems in management practice, since they are not intuitively comprehensible. This is why there is a considerable management demand for solutions of the efficiency gain distribution problem that are both theoretically sound and involve an easily, if not intuitively comprehensible operationalization of fairness. The issue of an intuitively and easily comprehensible fairness of efficiency gain distributions is tackled by means of cooperative game theory. In contrast to the literature, no “completed” solution concepts are taken as starting points and analyzed with respect to their theoretical characteristics. Furthermore, no abstract mathematical axioms are taken as bases for showing then that a certain game theoretic concept is implicated. Instead, a novel and primarily economic, argumentation is presented. This argumentation seeks to derive a known solution concept – the so-called τ-value – from economically plausible assumptions by means of which the space of possible solution concepts is restricted until the τ-value results as the solution concept for the fair distribution of efficiency gains.

The main results of this paper concern three aspects which serve to advance the findings in the pertinent literature. Firstly, the τ-value solution concept is derived in a novel, non mathemati-
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