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A Methodology to Share Profits and Costs in Non-Hierarchical Networks

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Abstract The creation of Non-Hierarchical manufacturing Networks (NHN) will allow SMEs to reach innovative and agile networks. Some of the existing problems associated with collaborative processes among networked SMEs are reminded in this paper. Amongst the collaborative problems we have focused on share profits and costs problem due to it is a relevant problem to achieve collaboration in decentralized networks and it has not been satisfactory solved in NHN context. The aim of the paper is to provide a methodology for enabling SMEs to manage the share of costs and profits when decentralized and collaborative relationships are established.

Keywords non-hierarchical networks, share profits and costs, SMEs

1.1 Introduction

The importance of collaboration has increased in supply networks; thus, the number of so called non-hierarchical manufacturing networks (NHN) has also increased (Poler 2010). NHN are characterized by equally powered partners and decentralized decision making (DDM). In NHN all the partners are involved in the business processes management in a collaborative way. NHN require close collaboration, extensive exchange of information and changes over the behavior of the networked partners.

Andrés and Poler (2011) identify the major needs to promote collaboration in non-hierarchical networks (table 1.1).

Amongst the collaborative problems this paper focuses on share profits and costs problem. This paper proposes a methodology for sharing costs and profits in NHN and aims to fill the gap of designing an effective methodology to ensure the

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equitable sharing among networked partners for achieving the needed collaboration and trust.

Table 1.1 Relevant Problems for Collaborative Business Processes according to the strategic, tactical and operational decision making levels (S/T/O) (Andrés and Poler, 2011)

Level	Strategic	Tactical	Operational
Relevant Collaborative Problems to Provide Solutions	Decision System Design Partners Selection Strategy Alignment Partners Coordination Product Design Coordination Mechanisms Design	Knowledge Management Uncertainty Management Contracts Share Profits and Costs Coordination Mechanisms Management	Inventory Management Process Connection

1.2 Share costs and profits problem

Amongst all the problems with inefficient solutions, the *share costs and profits* problem, classified at the tactical decision level, is selected (Table 1.1). Next section provides a solution to solve this problem. The chosen problem has a significant importance for establishing collaborative processes with partners of the same network.

Providing solutions in any of the three solution categories (models, guidelines and tools) is a challenge. The literature review provides models and guidelines for addressing the share costs and profits problem (Table 1.2). The research carried out shows that the guidelines do not successfully adapt to the NHN context. Furthermore, there is a lack of a tool to deal with the share costs and profits problem.

The found solutions have a common gap that means the provided solutions do not address the problem in the decentralized decision making context. Concluding, there is an absence of a methodology that enables networked SMEs to share costs and profits within the collaborative non-hierarchical partners.

Table 1.2 Models and Guidelines to overcome the sharing costs and profits problem

Goyal y Gupta (1989)	The arrangement to share costs can be achieved by the vendor through giving the buyer a price quantity discount and enticing him to buy larger quantities. Integrated models are classified in: (i) Models which deal with joining economic lot sizing policies (ii) Models which deal with inventory coordination by simultaneously determining the order quantity of the buyer and vendor (iii) Models which deal with integrated problems but do not determine simultaneously the order quantity of the buyer and vendor (iv) Models which deal with buyer-vendor coordination through marketing considerations
Chen et al. (2003)	A multiproduct, multistage, and multiperiod production and distribution planning model to achieve multiple objectives such as maximizing the profit of each network participant and ensuring a fair profit distribution. The model is formulated as a multiobjective mixed-integer non-linear programming (MOMINLP) problem. The fuzzy-set theory is used to attain a compromise solution among all participant companies of the supply chain
Caldentey y Wein (2003)	S1: Nash equilibrium S2: Contracts based on transfer payments between the two players that coordinate the system. Each player transfers a fixed fraction of its own cost to the other player S3: Stackelberg games, where one agent has all the bargaining power
Giannoccaro et al. (2004)	SC contract model, to coordinate the SC, based on the revenue sharing mechanism. This model allows the system efficiency and improves the SC actors profits, by tuning the contract parameters.

Table 1.2 (continued) Models and Guidelines to overcome the sharing costs and profits problem

Corbet et al. (2005)	S1: Shared-savings contracts that typically combine a fixed service fee with a variable component based on consumption volume S2:Double moral hazard framework, in which both parties decide how much effort to exert by trading off the cost of their effort against the benefits that they will obtain from reduced consumption
Gupta y Weerawat (2006)	S1: Fixed-markup contract S2: Simple revenue-sharing contract: Under a simple revenue-sharing contract, M chooses a value of revenue-fraction and S responds by picking the target inventory level S3: Two-part revenue-sharing contract: Consider now the contract in which M offers different revenue-fractions depending on the choice of target inventory level by S.
Sarmah et al. (2006)	Surplus Dynamic Division among the decision networked members
Audy et al. (2010)	S1: Financial flow between the business units. The financial flow is based on a predefined incentive rule such as pricing agreements or quantity discount. S2: Sharing principle based on an economic model (i.e. cost allocation method) such as the Shapley Value, the nucleolus and the separable and non-separable costs. Such economic models, generally based on cooperative game theory, allocate the total cost of the common-solution among the partners. S3: companies previously agree with the sharing principle behind the Equal Profit Method (from Frisk et al., 2010), an economic model that aims to find a stable allocation such that the maximum difference in relative savings between all pairs of two collaborating companies is minimized. In a benefit sharing that the companies could agree on, a new constraint is added to optimize the problem. The new constraint states that each pair of companies must have the same relative savings. S4: The cost fixing takes into account the incurred cost to do the activity and the revenue associated with the activity. The benefit sharing is addressed with the financial flow between each company and the used resources of the other company.
Jähn (2010)	An algorithm calculates the profits and incentive payments within the networked partners. Assuring a minimal profit for each enterprise.

1.3. Proposed Solution Definition: SP-NHN methodology

In this section a methodology that enables SMEs to manage the sharing of costs and profits, when collaborative relationships are established, is proposed. The purpose of this section is to develop the "Share Profits in Non-Hierarchical Networks" (SP-NHN) methodology. The proposed approach assumes that the relations between participating companies are non-hierarchical and the decision making process is decentralized. The proposed approach defines 7 main phases for the methodology successful implementation at non-hierarchical networks of SMEs. Figure 1.1a shows the 7 phases that compose the *SP-NHN methodology*. The description of the phases is presented next. Furthermore an architecture associated with the methodology is modeled (figure 1.1b).

A set of tools must be considered to follow the stages defined by the proposed methodology and architecture. Therefore, the methodology must be complemented by an information architecture designed for SMEs to collect process and analyze the used information.

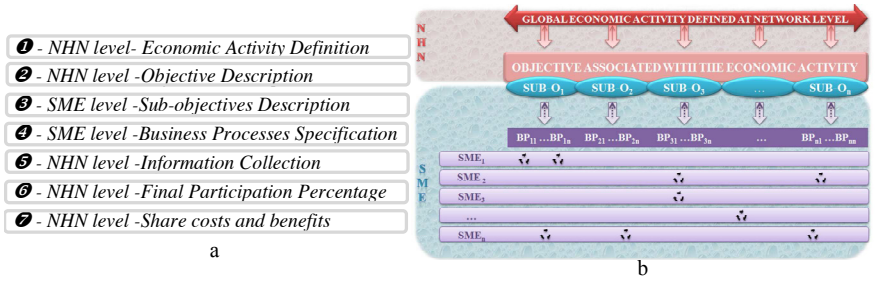

Fig. 1.1 a) 7 Phases b) Architecture of the SP-NHN methodology

PHASE 1. *Economic Activity Definition*. The NHN global strategy, mission and vision are defined at the economic activity level. The SMEs managers of the network come together to agree the economic activity to be performed. The network managers name the finance and communication managers.

PHASE 2. *Objective Description*. The global economic activity objective is described. The SMEs managers meet on a second round of meetings to define the global goal associated with the economic activity described in the previous phase.

PHASE 3. *Sub-objectives Description*. The global objective is projected at the local level (SMEs). The network objective consists of the SMEs sub-objectives. The sub-objectives are defined for each SME according to their resources and capabilities. The sub-objectives are defined to achieve the global objective.

PHASE 4. *Business Processes Specification*. Each SME develops the business processes in order to achieve the sub-objectives. The business processes generate data about costs, resources, investments and generated assets. The production, quality and finance department of each SME define the necessary business processes to achieve the sub-objectives defined in phase 3.

PHASE 5. *Information Collection*. Business processes provide a series of data that will help to obtain the final participation ratio of NHN partners. The information to gather is:

- *Resources* used by the SMEs to implement the process.
- *Investments* made by the SMEs to achieve the sub-objectives.
- *Costs* incurred in the process carried out by the SMEs to achieve the sub-objectives.
- *Generated Assets* for each networked NHN.
- *Participation Percentage* required for each networked partner.

The information architecture proposed by Alfaro et al. (2010) can be used for exchange the SMEs information. Each SME provides the data required to feed the network level. Then, the requested information is transformed, stored and processed in a global meta-repository. The *bus* of exchange of global information al-

lows the information sharing from different SMEs repositories towards a global meta-repository. The information architecture must be used in parallel with the methodology.

A worker carries out the local repository tasks such as data collection, storage and transaction. The stored data in the local repository is transferred to the global meta-repository where the *BUS* manager performs the harvesting, processing, storage and analysis tasks.

PHASE *6.* *Final Participation Percentage*. This phase determines the SME's final participation in each business process to achieve the global objective. The final participation percentage is obtained through the data collected in the global meta-repository. In this case we take into account (i) the degree of coverage of each sub-objective relative to the global objective and (ii) the degree of participation of the business process performed by the SMEs to achieve the global objective.

The global objective is defined from the economic activity. To entirely complete the global objective the sub-objectives are needed. Thus, each sub-objective partially covers the defined global objective.

To calculate the percentage of participation of each SME, the degree of coverage of each sub-objective relative to the global goal is first defined (Table 1.3). This variable will determine the importance of each sub-objective to reach the global one.

Table 1.3. Degree of coverage of each sub-objective relative to the global objective

Sub-objective j does not cover the global objective
Sub-objective j covers between 1 and 25% of the global objective
Sub-objective j covers between 26 and 50% of the global objective
Sub-objective j covers between 51 and 75% of the global objective
Sub-objective j covers 100% of the global objective

Afterwards, we define the degree of participation of the business process performed by the SMEs to achieve the global objective (Table 1.4). Thus, a scale of SMEs participation degree is defined, which will determine the degree of SMEs participation to obtain the sub-objective. We have to take into account that each sub-objective is achieved by one or more business process (BP).

Table 1.4. Degree of participation of the business process performed by the SMEs

The SME i does not participate in the business process k for obtaining the sub-objective j
The SME i participates between 1 and 25% in the business process k for obtaining the sub-objective j
The SME i participates between 26 and 50% in the business process k for obtaining the sub-objective j
The SME i participates between 51 and 75% in business the process k for obtaining the sub-objective j
The SME i participates 100% in the business process k for obtaining the sub-objective j

Then all the degrees of participation by each SME for each sub-objective are added up → $\sum$ *Degree of Participation* SME_i *in* BP_k

Therefore, the data concerning to the (i) *degree of coverage of each sub-objective relative to the global objective* and the (ii) *degree of participation of*

each SME, allows to calculate the *final participation rate* of each SME, by equation 1.1:

$$\underset{Rate}{Final\ Participation} = \sum_{Sub-Objective_j} \left(Degree\ of\ Coverage\ SO_j * \sum Degree\ of\ Participation\ SME_i\ in\ BP_k \right) \forall SME_I \quad (1.1)$$

The global meta-repository calculates the final participation rate for each company taking into account the resources used to carry out the business processes. The *bus* manager communicates the SMEs managers the final participation rate result.

PHASE 7. *Share costs and profits*. The distribution of costs and profits is carried out based on the collected information (*phase 5*) and the calculated final participation percentage (*phase 6*). The more resources, investments and costs in each SME, the more profits proportion will be reaped. The NHN finance manager performs the profits distribution among the networked SMEs.

The share profits and costs methodology is based on equitable distribution. The equation (1.2) provides the percentage of each SME respect to the overall cost of the activity (equation 1.2).

$$\%\ SME_i\ cost = \sum_{sub-objective_j} \frac{SME_i\ cost}{Sub-Objective_j\ Total\ Cost} \times Degree\ of\ coverage\ of\ each\ Sub-Objective_j \quad (1.2)$$

The cost and profit sharing is done through the average of the *Final Participation rate of each SME* (equation 1.1) and *%SME cost* (equation 1.2) following equation 1.3.

$$Share\ costs\ in\ SME_i = \frac{Final\ Participation\ Rate\ of\ SME_i + \%\ cost}{2} \quad (1.3)$$

For better understanding we propose an example. Consider a NHN with 3 SMEs.

Table 1.5. Nomenclature Table

Sets	
{i}	set of SMEs
{j}	set of Sub-Objectives (SO)
{k}	set of Business Processes (BP)
Parameters	
α_j	degree of coverage SO_j relative to the global objective (○, ◔, ◑, ◕, ●)
β_{ijk}	degree of participation of SME_i to reach the SO_j in BP_k (▮, ▮, ▂, ▄, ▆)
C_{ij}	SME_i cost to reach the SO_j
TC_j	Total cost to reach the SO_j
R_i	Final Participation rate of SME_i
RIC_i	Resouces, Investment and Cost participation degree of SME_i
SC_i	Final Percentage cost to share among SME_i

Taking into account the defined parameters (Table 1.5) we proceed to calculate the participation rate of each SME according the equation (1.1).

Table 1.6 Participation rate of each SME (Example)

	SO_1	SO_2	SO_3	Equation 1	Participation rate
SME_1	β_{11}	β_{12}	β_{13}	$\alpha_1\times\beta_{11} + \alpha_2\times\beta_{12} + \alpha_3\times\beta_{13}$	**R_1**
SME_2	β_{21}	β_{22}	β_{23}	$\alpha_1\times\beta_{21} + \alpha_2\times\beta_{22} + \alpha_3\times\beta_{23}$	**R_2**
SME_3	β_{31}	β_{32}	β_{33}	$\alpha_1\times\beta_{31} + \alpha_2\times\beta_{32} + \alpha_3\times\beta_{33}$	**R_3**

Afterwards we calculate the SME percentage cost according the equation (1.2)

Table 1.7 SME percentage cost (Example)

	SO_1	SO_2	SO_3	Equation 2	Resources/Investment/Cost
SME_1	C_{11}	C_{12}	C_{13}	$\frac{C_{11}}{TC_1}\times\alpha_1 + \frac{C_{12}}{TC_2}\times\alpha_2 + \frac{C_{13}}{TC_3}\times\alpha_3$	**RIC_1**
SME_2	C_{21}	C_{22}	C_{23}	$\frac{C_{21}}{TC_1}\times\alpha_1 + \frac{C_{22}}{TC_2}\times\alpha_2 + \frac{C_{23}}{TC_3}\times\alpha_3$	**RIC_2**
SME_3	C_{31}	C_{32}	C_{33}	$\frac{C_{31}}{TC_1}\times\alpha_1 + \frac{C_{32}}{TC_2}\times\alpha_2 + \frac{C_{33}}{TC_3}\times\alpha_3$	**RIC_3**
Total cost SO_j	TC_1	TC_2	TC_3		

With the *final participation rate of each SME* (Table 1.6) and the *%SME cost* (Table 1.7) is calculated the total percentage of participation. Based on the total percentage of participation we obtain the final percentage to allocate the costs or profits, using equation 1.3 (Table 1.8)

Table 1.8 Total percentage of participation SMEi (Example)

SME_i	Final participation Rate	% Resources/Investment/Cost	Share costs in SMEs
SME_1	R_1	RIC_1	$SC_1 = \frac{R_1 + RIC_1}{2}$
SME_2	R_2	RIC_2	$SC_2 = \frac{R_2 + RIC_2}{2}$
SME_3	R_3	RIC_3	$SC_3 = \frac{R_3 + RIC_3}{2}$

Thus, **SME_1** accounts for SC_1% of the costs/profits, **SME_2** accounts for SC_2% of the costs/profits and **SME_3** accounts for SC_3% of the costs/profits.

1.4 Conclusions and Further Research

Amongst the relevant problems that do not have satisfactory solutions in NHN context (table 1.1), this paper begins a series of solution proposals that will enable us to establish a collaborative framework focused on NHN.

Particularly, the paper addresses the share costs and profits problem due to this problem has not been discussed in the literature from the decentralized view.

To deal with the problem a solution based on a *SP-NHN methodology* is proposed. *SP-NHN* is able to establish the participation percentage for allocating the profits and costs of the global economic activity conducted by the NHN.

The future research lines are focused on building a "Collaborative Framework for Non-Hierarchical Manufacturing Networks" that will focus with problems which current solutions do not provide satisfactory degrees of coverage in the NHN perspective. The expected contribution of the future dissertation research is to develop a framework that provides models, guidelines and tools for supporting collaborative processes, specifically in the non-hierarchical context (NHN). The main aim of the collaborative framework is to achieve a better understanding how SMEs deal with collaborative problems in NHN.

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