J Intell Manuf (2010) 21:301–309
DOI 10.1007/s10845-008-0181-6

A multi-criteria model for the evaluation of business benefits in horizontal collaborative networks

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Received: 2 September 2008 / Accepted: 2 September 2008 / Published online: 9 November 2008

Abstract Despite many advantages that could be gained through belonging to enterprise networks, only a few networks continue running businesses after the governments stop their funding. One of the reasons is the lack of a model that evaluates the benefits from the firm's point of view. The objective of this work is to develop a model that estimates the benefits in horizontal collaborative networks, for a considered business opportunity, and determines the optimal network configuration in terms of the selected enterprises. We propose a method for evaluating the profits for a collaborative network based on a combination of product realisation graph and core competences identification. Through the case study of a Swiss horizontal collaborative network, the proposed approach proves its efficiency in selecting the optimal network of partners and evaluating their corresponding turnover and profits.

Keywords Horizontal collaborative networks · Business share · Trust · Product realisation graph · Partner selection

Introduction

The enterprises today are aware of the potential benefits related to their membership in enterprise networks. Although different objectives can be pursued, most of the companies present the advantages of cost reduction and market penetration as the main objectives of joining a network (Gruber et al. 2005; Warner and Witzel 2004). Many of those companies that have joined or built a network with the help of governmental funding did not continue the experience after that the local governments stopped their financial help. This may be related to the lack of knowledge about the tools and methods that could have helped the companies in estimating their business profits and costs when deciding to join a network. Some research work has been carried out to identify the advantages of taking part of virtual enterprises and collaborative networks (Chituc and Nof 2007; Varamäki 2005; Gomes-Casseres 2003), focusing more on the performance evaluation than on the financial business aspects. Indeed, the current estimation models focus more on the end user performances and less on the benefits from the firms' point of view. This is even true in the case of horizontal collaborative networks. Collaborative networks are considered as a group of legally-independent companies linked through formal and informal relationships in order to coordinate their actions in achieving a common objective, that cannot be reached without this collaboration. A collaborative network evolves dynamically over time and so, the selected enterprises differs from one business opportunity to another in order to react correctly and efficiently on the evolution of the market demand. As opposed to vertical collaborative networks where the competences of the enterprises needed to achieve a project are complementary and could be considered as combinations of different dynamic supply chains, the companies belonging to horizontal collaborative networks are acting on the same competence areas. Thus, one can easily imagine that trust, profit sharing and concurrence all have to be considered in the horizontal collaborative network (HCN). It is, therefore, important to address the question of business profit estimation and selection of the companies participating in a business opportunity.

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This paper first gives an overview of the current modelling techniques of collaborative networks, their principal contributions and their limits. In the second step, a new approach for the estimation of business share for a manufacturing company considering its involvement in a new business opportunity is introduced. This approach is based on the combination of the simplified product realisation graph and the identification of the core competences. The advantages of the developed model are, on the one hand, its simplicity and the aptitude to be used for partners' identification and selection on the other hand. Finally, a real example of a business opportunity representing dustbins to be designed and produced within the Swiss HCN 'Virtuelle Fabrik Nordwestschweiz-Mittelland' is considered as a validation case for this work.

Modelling business activities and performance evaluation in collaborative networks

The previous developed models have been focusing mainly on "Vertical networks" or "Hub and spoke networks" (Löh et al. 2005). Few by them are oriented to "Horizontal collaborative networks" due to their complex dynamics and the duality of trust and competition to be considered at the same time (as the enterprises operate in the same competence areas). To address this complexity, there is a need for a benefit estimation model in order to evaluate the best network configuration (selection of enterprises and their corresponding business share) based on cost optimisation.

In the literature, there are two research orientations; the first focuses on network management and the second addresses the question of how to set up the network through breeding environments. In the first orientation, the developed models measure the past performance of the network, based on balanced scorecard, and consider mainly the end user (Bourgault et al. 2002). The limitations of the traditional business performance evaluation in the case of partner or supplier selection are addressed in the literature (Boyer 1999; Soukup 1997; Willis et al. 1993). The first issue associated with weighted point methods is the determination of the appropriate or optimal weights in the evaluation of a specific indicator for partner performance. A similar idea is the cost ratio approach that consists of estimating the cost of each identified criteria as a share of the total purchases for the partner, but this requires the development of analytical accounting procedures, heavy to handle and to update. Li (1997) develop a standardised unitless rating through the combination of qualitative and quantitative scores used for the performance evaluation and the choice of a partner in a supply chain. On the side of evaluating supplier performance, several methods are designed, based on total cost of ownership (Ellram 1995), human judgement models (Patton 1996) and data envelopment analysis in which Narasimhan et al. (2001) integrate different partner inputs and outputs in the estimation of the efficiency of a considered partner. On the other hand, aiming to produce exclusively quantitative data from quantitative and qualitative inputs, fuzzy logic-based techniques are developed in order to assess the ratings for the qualitative information, such as quality measure (Jeong and Lee 2002). A much more sophisticated approach relies on an evolutionary fuzzy-based approach for the performance measure of a supplier in supply chains where fuzzy rules are generated based on a genetic algorithm (Ohdar and Ray 2004). However, the potential application to a network of collaborative enterprises is low due to its complexity. Camarinha-Matos and Abreu (2007) build up a model for the quantification of advantages in horizontal networks. This model is based on benefits that can be self benefits, received benefits or contributed benefits. This decomposition allows a better understanding of how the network runs and which firm is the most beneficiary. However, from a practical point of view, it is hard to measure these different benefits due to information privacy. There are several attempts to propose global modelling frameworks that address the complexity of collaborative networks (Hermann 2007; Camarinha-Matos and Afsarmanesh 2007; Vanderhaeghen and Loos 2007; Wu and Su 2005) but they are either too general to cope with specific business evaluation in horizontal collaborative networks or too IT-oriented that do not answer the business needs.

The aim of the second orientation of research is to develop predictive methods to evaluate the performance of different alternatives. Some authors have defined different modelling approaches for designing value chain in Virtual Enterprises. Kim et al. (2006) combine enterprise modelling and simulation in "Hub and spoke networks". A similar approach can be found in a model based on SCOR approach where particular key performance indicators are proposed (Seifert and Eschenbaecher 2004). Confessore et al. (2006) develop a model for supporting the potential decision of getting new business opportunities. This model is based on competences and activities. Even if this approach is interesting, it is not appropriate for HCN. In fact, the latter is characterised by the similarity of the core competences among the firms and the selection of different alternatives cannot be evaluated only from this point of view. Chu et al. (2002) develop a model that permits setting up of a preferential alternative based on the Group Technology approach. The drawback of this method is the long audit time to determine what kind of components the companies can produce. This approach is more oriented for assembly business and takes a lot of resources to estimate the advantages to set up a collaborative network. However, the idea of designing an iterative process composed of a Product Requirement Analysis, Product Function Design, Product Layout, Partner-type Synthesis and Partner-Instance Synthesis is a major inspiration for our model.

From this review, we draw the conclusion that none of the developed models permits the estimation of the business share for an enterprise in the frame of a horizontal collaborative network, in terms of financial optimisation.

Business benefits estimation in horizontal collaborative networks

The proposed model is based on four different phases (see Fig. 1). The first phase consists of the estimation of the opportunities that can be generated by the network. The second phase is the development for a product realisation graph for each opportunity and its related operation sequences. The third part is the research of the best combination of firms to realize a customer's order. The last step consists of summing the costs for the selected members of the network and for all the opportunity products, in order to evaluate the global cost for the network. Our approach is original and differs from the previous research work in the following ways:

- it integrates an activity merging process in order to simplify the work load distribution and to focus on the enterprise core competencies. This process is inspired from Wu and Sun (2002) who develop an approach based on activity grouping to identify the core competences needed to develop a new product. They identified two types of activities: key activities that require core competences, and non-key activities that can be performed by any member of a network,
- the model considers quantitative as well as qualitative information in order to estimate the precedence link intensity between activities,
- the model takes into account different criteria in the identification of the best configuration of the network (best selection of enterprises).

Estimation of opportunities

There are three kinds of opportunities to be considered:

- Introduction of a product into new markets
- Increasing sales in current markets for a given product
- Introduction of a new product

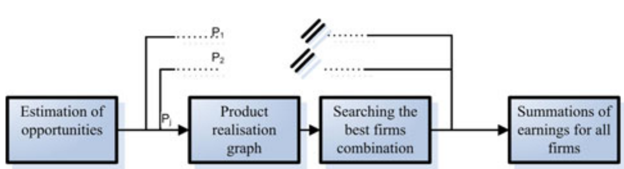

Fig. 1 General modelling approach

These opportunities can be generated through the network which brings some advantages like the increase of know-how, flexibility, production capacity, etc. For each opportunity, we determine a production volume per product.

Criteria considered for cost estimation

For a given opportunity, the incurred costs for a company due to its participation to the business opportunity differ from the other companies of the HCN. On the other hand, even if there are some similarities on the competences between the enterprises, the proposed quotes for the realisation of a specific task can differ from one enterprise to another. In order to select the best configuration, the model then takes into account several criteria:

- Common objectives
- Resource availability (personnel, machines…)
- Technical competences of the enterprises
- Production performances
- Focus on key competences for every enterprise
- Confidence/trust between partners
- Geographical proximity

The proposed approach is then a multi-criteria one where quantitative as well as qualitative criteria are considered and used in the identification of the best configuration (selected partners) for a given opportunity based on business benefits optimisation. In fact, the problem is equivalent to a cost optimisation approach within the network where the quantitative criteria are transformed into cost criteria. In addition, as one of the objectives of this work is to develop a simple model to be used for companies and networks, the following assumptions are made:

- The production performance depends mainly on the efficiency of the internal enterprise processes. This is then taken into account in the quotes fixed by the company to achieve a given activity (or a group of activities).
- Trust and geographical proximity are taken into account directly in the model as additional costs incurred by the network.
- For clarity reasons, only one kind of product is considered in a business opportunity.

Product realisation graph

A product realisation graph is built for each opportunity. This graph represents the sequence of activities/operations required to realise the final product considered in the opportunity; it is composed of activities, arcs and linguistic variables

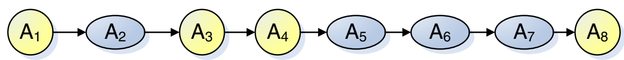

Fig. 2 Example of a product realisation graph

(Wu and Sun 2002). An arc represents the antecedence link between two activities. In order to limit the number of production alternatives, it is assumed that there is only one possible operation sequence to realise the final product. Figure 2 shows an example of a product realisation graph where two different kinds of activities are represented, the key activities, represented by ellipses (A_2, A_5, A_6 and A_7) and the non-key activities, drawn as circles (A_1, A_3, A_4 and A_8). A key activity requires a specific competence for accomplishment, while a non-key activity does not require any specific competence and can be performed by any member of the considered network.

To take into account the company ability to perform two consecutive activities A_i and A_j, we introduce on the corresponding arc a linguistic variable w_{ij} as an indicator of the antecedence link intensity. This variable is independent from the selected company and can take one value of the set {none, weak, medium, strong, absolute}:

- 'none' means that two consecutive activities are totally independent and can be easily performed by two different companies without any specific condition,
- 'weak' indicates that the two activities are weakly dependent,
- 'medium' means that there is a dependence between the activities. The achievement of these activities by two different companies is possible but needs some specific conditions,
- 'strong' means that the link between the two activities is important and it will be difficult to perform them by two different companies,
- 'absolute' means that it will be impossible to perform the two activities by two different companies.

In order to estimate the variablew_{ij}, different factors are taken into account such as the transportation difficulties from the product's point of view, the packaging, the required information to be transferred and the nature of the activity A_i compared to A_j and vice-versa.

Generally, customer orders concern complex products with long cycle times (Pouly et al. 2005). Thus, activities can be grouped together in order to:

- share the key resources which is one important goal of the collaborative networks,
- reduce the business opportunity complexity and simplify the material management and handling inside the network.

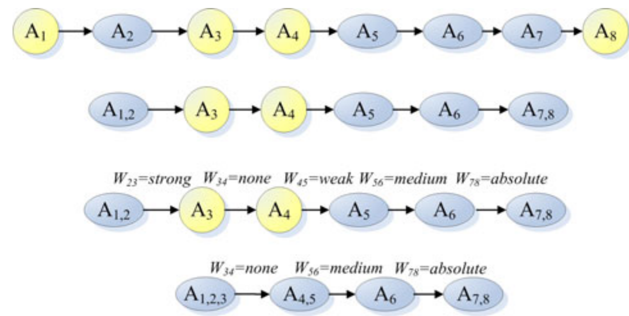

Fig. 3 Activity merging process

We merge, then, non-key activities with key activities in order to obtain a Simplified Product Graph as shown in Fig. 3 for example. The merging process is the following:

1. merge all non-key activities, which are upstream of the product realisation graph, with the first key activity encountered along the graph,
2. merge all non-key activities, which are downstream of the product realisation graph, with the last key activity encountered along the graph,
3. along the graph, group every non-grouped non-key activity with the key activity with which it has the strongest link value w_{ij} (in Fig. 3, we obtain then the group $A_{1,2,3}$),
4. repeat step 3 until the graph obtained is constituted only of key activities.

The process of activity merging stops when all the remaining activities are key activities or key-grouped activities. The graph obtained is called Simplified Product Graph.

Search of the best firms combination

The third part of the model is the search of the best network configuration to realize a customer's order. The Inputs for this part of the model are the Simplified Product Graph and the activity achievement quote matrix for all companies of the HCN and all activities. The output is the best configuration in terms of selection of partners and the corresponding global cost (Fig. 4).

The first step consists of grouping all the activities of the Simplified Product Graph into one big activity. This step means that all the activities will be performed by one firm which is the best case in order to avoid all the costs due to activity transfers from one enterprise to another. The second step is the potential partner selection based on the competences of each firm. These core competences have to match with the competences required to perform a given activity. Although different levels of required or acquired competences can be considered (Pépiot et al. 2007), to make it

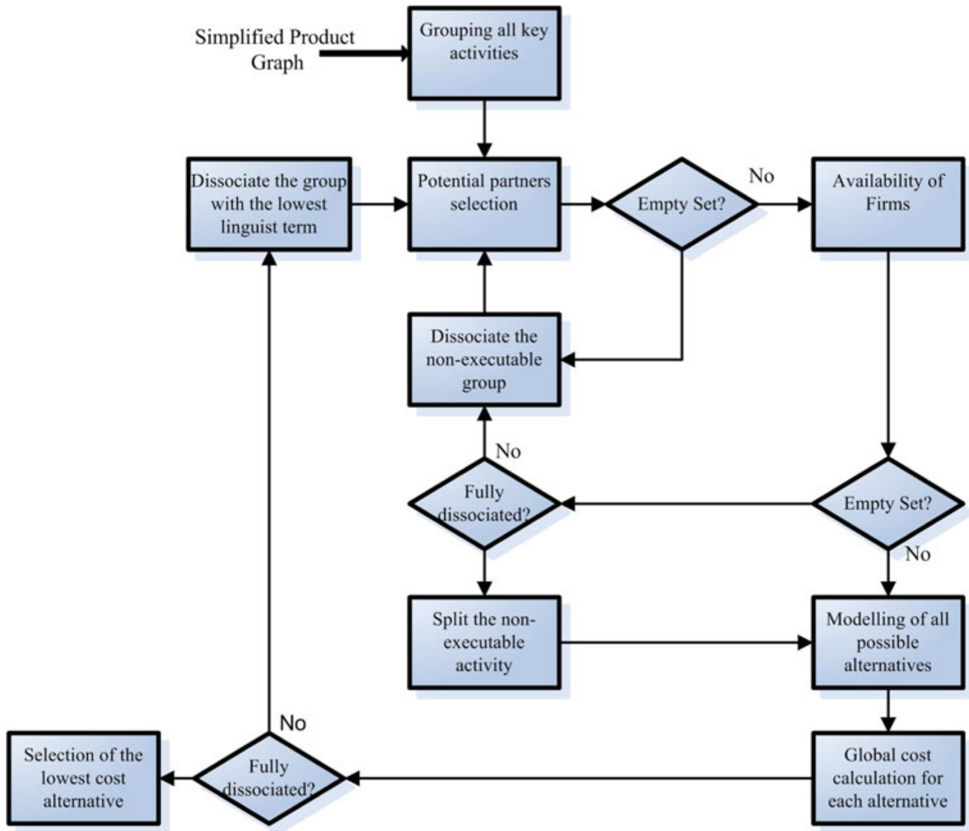

Fig. 4 Algorithm of search for the optimal configuration

more simple in the following developments, only one level of competence is considered. Among this set of enterprises, we identify the ones that are available to perform the activity or the group of activities. Among this subset, all the possible alternatives alt_y to realise the product are identified for which we estimate the global achievement cost of the full process. If, during one of these previous steps, an empty set is detected (no possible configuration), the model dissociates the group of activities which are unsolved following the Simplified Product Graph. If there is still no solution when a model is totally dissociated, the unsolved activity is split in order to perform this activity in two different companies. Once we have obtained the global costs of alternatives, the model dissociates the group of activities with the lowest w_{ij}. The iterative process stops once the original simplified product graph is obtained. Among all alternatives, we consider the best one as the alternative with the lowest global cost. The calculation of the global cost is the sum of the prices of realization of the activities or groups of activities and the additional costs that are dependent on the network.

Realisation price of the activities and groups of activities

The global price of realisation of an activity is calculated on the basis of the quotes proposed by different enterprises for the groups of activities and the costs inherent in activity sharing between the enterprises:

- transportation costs: there are considered as independent from the activity to be processed,
- administrative and control costs: these are related to order verification, order integration, billing process, etc. In the proposed model, variations of these costs are highly correlated to trust between partners,
- knowledge transfer costs: these are constituted of the costs inherent in preparation of the internal resources before performing an activity.

Consider the following notations:

Pr Matrix of realisation prices (n*a). Pr_{FxAz} is the price of activity group A_z proposed by firm F_x
n number of firms of the HCN
a number of activity groups
$\mathbf{A}^y$ Matrix of distribution of the activities among partners for the alternative alt_y (n*a). Each column represents an activity and each line represents an enterprise. The value of the term $A^y{}_{FxAz}$ is 1 if the activity group A_z is fully realised by the firm F_x and 0 if not. However, if an activity group is split among partners, the component $A^y{}_{FxAz}$ can take any value between 0 and 1. The only

condition is that the sum of terms for a column is equal to one.

The total realisation price TRP for an alternative alt_y is then calculated as (Eq. 1):

$$TRP(alt_y) = tr\left(\mathbf{Pr}\cdot(\mathbf{A}^y)^T\right) = tr\left(\begin{bmatrix} Pr_{F1A1} & Pr_{F1A2} & \dots & Pr_{F1Aa} \\ Pr_{F2A1} & Pr_{F2A2} & \dots & Pr_{F2Aa} \\ \dots & \dots & \dots & \dots \\ Pr_{FnA1} & Pr_{FnA2} & \dots & Pr_{F_nAa} \end{bmatrix} \cdot \begin{bmatrix} A^y_{F1A1} & A^y_{F1A2} & \dots & A^y_{F1Aa} \\ A^y_{F2A1} & A^y_{F2A2} & \dots & A^y_{F2Aa} \\ \dots & \dots & \dots & \dots \\ A^y_{FnA1} & A^y_{FnA2} & \dots & A^y_{FnAa} \end{bmatrix}^T\right) \tag{1}$$

'tr' is the matrix trace operator.

Additional costs evaluation

The additional costs include transportation costs, administrative costs and knowledge transfer costs. The transportation costs are dependent on the two partners involved; we assume that this is time-independent. The administrative costs depend on the trust between the two partners involved; this parameter can change with the evolution of the network. The knowledge transfer costs depend on the stage of activities, and we assume that these costs do not depend on the partner involved. All of these parameters are represented by some matrices in the aim of computation resolution (Piot et al. 2007). The additional costs AC of an alternative alt_y is estimated as:

$$AC(alt_y) = tr\left(\mathbf{TpC}\cdot(\mathbf{T}^y)^T\right) + \left(\overrightarrow{KC}\cdot\overrightarrow{t}\right) + \alpha\cdot tr\left(\mathbf{Trust}\cdot(\mathbf{T}^y)^T\right)$$
$$= tr\left(\begin{bmatrix} 0 & TpC_{F1F2} & \dots & TpC_{F1Fn} \\ Sym. & 0 & \dots & TpC_{F1Fn} \\ Sym. & Sym. & \dots & \dots \\ Sym. & Sym. & Sym. & 0 \end{bmatrix} \cdot \begin{bmatrix} T^y_{F1F1} & T^y_{F1F2} & \dots & T^y_{F1Fn} \\ T^y_{F2F1} & T^y_{F2F2} & \dots & T^y_{F2Fn} \\ \dots & \dots & \dots & \dots \\ T^y_{FnF1} & T^y_{FnF2} & \dots & T^y_{FnFn} \end{bmatrix}^T\right)$$
$$+ \left(\left(KC(A_1\ A_2);\ KC(A_2\ A_3);\dots;KC(A_{a-1}\ A_a)\right)\cdot\left(t(A_1\ A_2);\ t(A_2\ A_3);\dots;t(A_{a-1}\ A_a)\right)^T\right)$$
$$+\alpha\cdot tr\left(\begin{bmatrix} 0 & Trust_{F1F2} & \dots & Trust_{F1Fn} \\ Trust_{F2F1} & 0 & \dots & Trust_{F2Fn} \\ \dots & \dots & \dots & \dots \\ Trust_{FnF1} & Trust_{FnF2} & \dots & 0 \end{bmatrix} \cdot \begin{bmatrix} T^y_{F1F1} & T^y_{F1F2} & \dots & T^y_{F1Fn} \\ T^y_{F2F1} & T^y_{F2F2} & \dots & T^y_{F2Fn} \\ \dots & \dots & \dots & \dots \\ T^y_{FnF1} & T^y_{FnF2} & \dots & T^y_{FnFn} \end{bmatrix}^T\right) \tag{2}$$

where:

TpC Transport costs matrix (n*n). CTp_{FiFj} is the transportation cost from the enterprise F_i to the enterprise F_j

T^y Matrix of interactions between partners. $T^y{}_{FiFj}$ is the interaction variable between F_i and F_j. $T^y{}_{FiFj}$ ° [0, a−1]. If its value is =0, there is no direct exchange between the two enterprises. If the value is a-1, exchange of successive activities between the two companies is possible

KC Vector of knowledge transfer costs between successive activities A_i and A_{i+1}

t Vector of activities interaction of 2 successive activities achieved in 2 different enterprises

α Value of the average administrative cost for an invoice

Trust Matrix (n*n) of trust between partners. $Trust_{Fi\ Fj}$ is the trust estimation between the firms F_i and F_j. $Trust_{Fi\ Fj} \in [0, 1]$. The value '0'means that there is an absolute trust (The enterprises considered can interact for an opportunity without materials control or administrative procedure set-up). The value '1' indicates that trust between F_i and F_j does not exist (the administrative costs are similar to those induced from business with a subcontractor outside the network).

Application of the model to a swiss horizontal virtual manufacturing network

The application of the approach in the frame of a case study permits the verification of the approach for industrial environments and gathering feedback from the enterprises. The model developed in this paper is applied to the Swiss horizontal collaborative network "Virtuelle Fabrik Nordwestschweiz-Mittelland". The concept of this network was established by the 'Institut für Technologiemanagement' of the University of Saint-Gallen (Häfliger 2000). The network was built in 1997 and contains today 19 firms (F_i, i = 1 … 19) and 1 public institution that collaborate only to organise and to coach the network in order to improve its working modes (it does not participate in business opportunities). The aim of this HCN is to create, develop and produce high-value products that integrate the following macro-competences: design, engineering, manufacturing, assembly, control and commissioning. The companies taking place in the network are manufacturers, product development engineers and consulting partners.

Few products have been developed up to now, namely a turning assembly table, a dustbin, etc. An application of our model is made for a dustbin called 'Abfallhai'. These dustbins are specially designed to resist particularly unfriendly environments and are developed through a partnership between some firms of the network. Without this partnership, none of the firms would have been involved in this opportunity. Actually, this product is one of the leader products developed by the network, and its worldwide commercialisation is bringing new profits. One of the requirements of the client is to have only one interlocutor to deal with and not negotiating with each participant in the network.

Prior to the application of the model, a study of the network structure, the intra-organisational as well as the inter-organisational design is made in order to identify the real competences of each company and to estimate the prices and costs with respect to the required information and data as presented in section "Business benefits estimation in horizontal collaborative networks". Table 1 gives the list of the considered competences within the network for mechanical engineering and mechanical operations. This information is obtained through unstructured interviews with the managers of the companies without taking into account the competences needed to achieve the 'Abfallhai' product. In a second phase, a correspondence is made between these competences and the different firms of the network, assuming that every company could propose different types of competence. The sequence of activities required to design, develop and produce the dustbin has been defined in accordance with the customer specifications. Table 2 present the results of the competence correspondence matrix as well as the required competences for each considered activity of the Simplified Product Graph.

Table 1 The considered competences for the "Virtuelle Fabrik Nordwestschweiz-Mittelland"

Abbreviation	Competence
C_1	Design
C_2	Computer aided Design
C_3	Milling
C_4	Turning
C_5	Assembly
C_6	Automation
C_7	Molding
C_8	Coaching
C_9	Firm financing
C_{10}	Laser cutting
C_{11}	Painting
C_{12}	Metal sheet working
C_{13}	Washing

Results

The first step in applying the model to the dustbin consists of building the Simplified Product Graph. The latter is composed of five key activities: design (A_1), engineering (A_2), sheet metal working (A_3), painting (A_4) and assembly (A_5). The Simplified Product Graph obtained is represented in Fig. 5; There are no specific requirements to achieve the design and engineering activities in the same enterprise. Thus, w_{12} = 'none'. The link importance between the activities A_2 and A_3 is medium, while those corresponding to the activity groups: sheet metal working (A_3), painting (A_4) and assembly (A_5) are strong. These estimations have been made by the engineers of different companies of the HCN.

The initialisation point considers a global activity constituted by all the activities A1, …, A5 for a volume of 40 units. The first iteration of the model confronts the available competences of the different enterprises and the required competences to achieve the activities. As a result, none of the firms can perform all these five activities (at the bottom of Table 2, the relations between the competences and a given activity is presented). A separation mechanism operates relying on the weakest link of the Simplified Product Graph. The activity A_1 is then retired from the group. The second iteration, which is based on a graph composed by the activity A_1 and a group G_1 of the four remaining activities, evaluates whether alternative (alt_1) is possible. The alternative alt_1 enrols two firms, F_{14} for the activity A_1 and F_5 which is capable to handle all activities related to the group G1 (Table 2). Once the availabilities of the enterprises are checked, the global costs of the alternative is then calculated at 71.7 kCHF:

$$\begin{aligned}\text{realisation Cost}\,(alt_1) &= \underset{F14A1}{\Pr} + \underset{F5G2}{\Pr} = 10 + 60\\ &= 70\,kCHF\\ \text{dependant costs}(alt_1) &= TpC(A_1G_2) + \alpha.Conf_{F14F5}\\ &= 1.5 + 0.2 * 1 = 1.7kCHF\end{aligned}$$

The third iteration, which is based on a graph composed by the activities A1, A2 and a group of activities G2 (A_3, A_4, A_5), evaluates four possible alternatives (Table 3 gives the network configuration for each alternative). In this case, there are no transportation costs because there is still no physical product between activities A_1, A_2 and G_2. The global costs of alternatives, estimated using Eq. 1 and 1 are shown in the Table 4. The results of further iterations are not displayed and the global costs of these alternatives are more expensive due to the knowledge transfer costs and the administrative costs.

Table 2 Identification of firm competences

Firm/Comp.	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}
F_2		x	x	x									
F_3							x						
F_4								x	x				
F_5		x	x	x	x					x	x	x	x
F_6		x	x	x	x								
F_7			x	x						x			
F_8							x						
F_9										x			
F_{10}						x							
F_{11}		x											
F_{12}		x	x	x	x						x		
F_{14}	x												
F_{18}			x	x									
Required for	A_1	A_2			A_5						A_4	A_3	

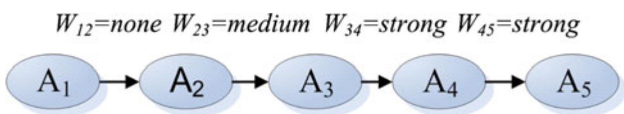

Fig. 5 The Dustbin's simplified product graph

Table 3 Alternatives to realise the opportunity 'dustbin'

		Alt_i			
Activity	Firm	2	3	4	5
A_1	F_{14}	1	1	1	1
A_2	F_2	1	0	0	0
	F_5	0	1	0	0
	F_6	0	0	1	0
	F_{11}	0	0	0	1
G_2	F_5	1	1	1	1

Table 4 Global costs of all alternatives

Alternative	Global cost (kCHF)
$Alt_1 = Alt_3$	71.7
Alt_2	68.8
Alt_4	74
Alt_5	78.3

The best alternative for the model is the alternative Alt_2, which involves the firms (F_{14}, F_2 and F_5) with a cost of 68.8 *kCHF*. If we compare these results to the actual realisation of the opportunity, only two firms (F_{14} and F_5) have been effectively involved in realizing the dustbin. The reality then matched with the configuration corresponding to the alternative Alt_1, which is the second best alternative according to our model (see Table 4). After discussion with the responsibles of the HCN, the reasons of this difference might be due to:

– the fact that the network did not look for the optimal alternative; the additional costs were then underestimated,
– reasons related to trust for the firm F_2 with respect to the network for this particular opportunity.

Furthermore, this solution is still acceptable by the network and shows the benefits for the firms to be part of one network. The application and the result analysis have been approved and validated by "Virtuelle Fabrik Nordwestschweiz-Mittelland". The model can be used for every opportunity to select the best membership candidatures, calculating the optimal cost, without generating privacy or autonomy problems among the future participants in the network.

Conclusion and future work

An estimation model for business benefits in horizontal collaborative networks is presented and developed. A real case study permits the application of the approach and its validation for a Swiss horizontal manufacturing collaborative network. Compared with pervious results, the enterprise selection process cannot be based only on core competences. In addition to those, we integrate the global price and the availability criteria for a better decision making. On the other hand, the activity merging process makes the model simple to apply, particularly for complex products (multi-component assembly products, products based on the same operations at different life times, etc.). The benefit evaluation model might help in strengthening the mechanism of trust building among the organisations and in focusing on some common objectives. Research directions concentrate on the introduction of the concepts of delays and risks related to the alternatives that would generate planning processes simultaneously with the enterprise selection procedures and business share estimation.

Acknowledgements The authors thank their partners the 'Virtuelle Fabrik Nordwestschweiz-Mittelland', in particular M. Adrian Plüss, and the Swiss Innovation and Promotion Agency, that funded this research, for their valuable contributions.

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