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Incentive System Framework for Information Sharing in Value-Adding Networks

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Abstract

To meet current market requirements and improve their competitive position, companies cooperate with their partners in value-adding networks. To exploit potential performance improvements, it is essential for companies to increasingly share Production Planning and Control-related data. Financial and non-financial incentives are beneficial to foster the inter-company exchange of such data. This paper proposes an approach for designing an application-specific incentive system framework, forcing information sharing in value-adding networks. The framework is based on a requirements analysis towards both value-adding networks and Production Planning and Control. The outcome of the approach is the possibility of deriving concrete incentive systems. The approach developed was applied and verified in a use case.

Keywords

Value-adding networks; production planning and control; incentive systems

1. Introduction

The tightening of global competition, e. g. through new entrants disrupting entire industries with innovative business models, and the customer`s requirement for individualised products being delivered within short times are only some of the market trends manufacturing companies are facing in the 21st century [1, 2]. Focussing on core competencies and collaborating in inter-firm value-adding networks is a key enabler for enhancing performance and, hence, staying competitive within this volatile economy [3-5]. The evidence that supports pursuing inter-company functionalities may even be indispensable in the future to allow companies to remain partners in an existing value-adding network [6].

To meet the customer`s requirements, special significance needs to be assigned to the sharing of information related to Production Planning and Control (PPC). Information sharing can be seen as the heart of inter-company collaboration, and thus forms the basis for efficiency improvements in Supply Chain Management (SCM) [7]. A potential barrier to information sharing across companies is a lack of incentives caused by imbalances in benefiting [8]. Therefore, finding suitable incentives for partners, e. g. through gain sharing mechanisms, may be a solution to foster the sharing of data [9, 10]. This publication provides a conceptual model that supports designing a suitable incentive system for information sharing and herewith facilitates practical implementation. In order to validate its functionality, the approach was applied and verified in a use case.

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2. Information sharing in value-adding networks

The concept of cooperating with legally independent partners in supply chains and value-adding networks respectively in order to achieve both individual and common goals is crucial for remaining competitive in customer-centric business ecosystems that include both suppliers and customers (see Figure 1) [11, 12]. Porter [13] established the concept of reducing operational inefficiencies during the value creation of a product, however, the goal of improving cross-company production processes has evolved significantly since Croom et al. [14]. Companies tend to focus on their core competencies in order to reduce their real net output ratios and offer specialised products and services in value-adding networks. Competition shifts from a firm to a network level [15]. Within supply chain management, emphasis is placed especially on the value added in every step, in contrast to the cost incurred [16, 17]. Collaborative-based SCM initiatives mainly include the sharing of information about demand and operations, joint planning and joint decision making, incentive alignment, resource sharing, collaborative communication and joint knowledge creation [18]. Examples of this are Vendor-Managed Inventory, Efficient Consumer Response and Collaborative Planning, Forecasting and Replenishment. Collaborative planning, knowledge transfer and replenishment activities between the entities enable operational efficiency improvements of the value-adding network performance, which can lead to financial and operational benefits for every firm in the network. Financial benefits include reduced costs or increased sales, while operational benefits are less tangible, such as higher customer satisfaction, greater flexibility in the value-adding processes, increased product availability, reduced batch sizes, lower lead and replenishment times or shorter reaction times to changed demand [11, 19].

Due to its importance for inter-company collaboration, a definition of information sharing is given that is highly appropriate for this publication:

> *"Information sharing refers to the extent to which a firm shares a variety of relevant, accurate, complete, and confidential information in a timely manner with its supply chain partners"* [18, p.166].

In greater detail, downstream information sharing by a target company means vertical sharing of information with the organisation that is located at a later stage in the value-creating process, e. g. a retailer is located downstream of a manufacturer. Accordingly, upstream information sharing by the target company refers to vertical information sharing to an organisation that is producing a good prior to the value-creation process at the target company, e. g. the target company shares information with its supplier. Finally, horizontal information sharing refers to the sharing or receiving of information from an organisation that operates at the same stage of the production process, e. g. competitors. See Figure 2 for a detailed overview of the directions of information sharing.

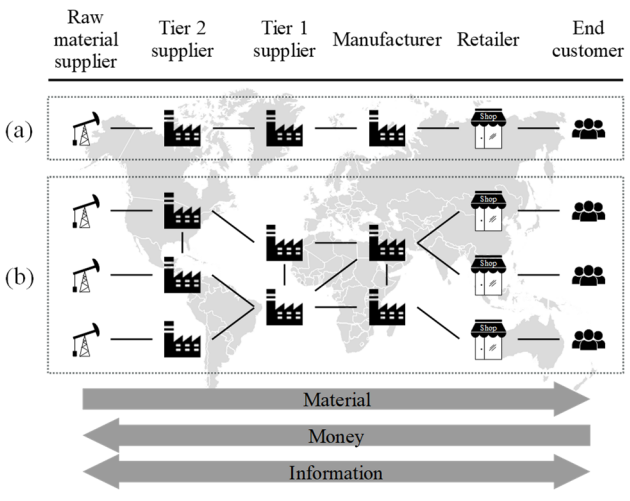

Figure 1: (a) Supply chain;
(b) Value-adding network [20]

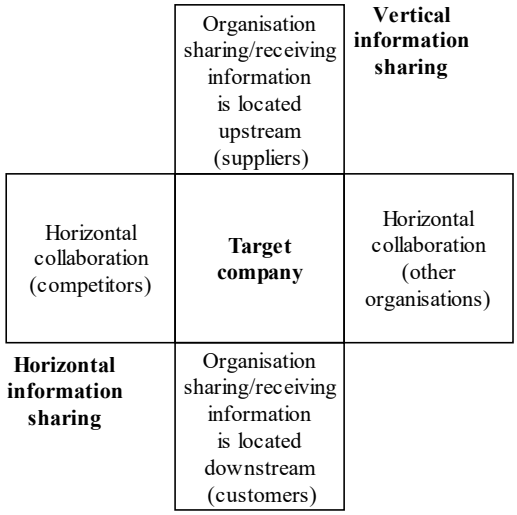

Figure 2: Typology of information sharing types adapted from Barrat [21]

3. State of research into incentive systems fostering information sharing

Researchers have already been investigating the effects of incentive systems for information sharing in value-adding networks and revenue models. Based on the relevant work presented, the research motivation for this work is derived below.

As information sharing improves the performance of a value-adding network under certain conditions [10], incentives are needed for stable cooperation in terms of solving the issue of a fair distribution of gains [22], i. e. appropriate rewards. The prerequisite for being able to align incentives among partners is assessing the gains that are to be shared [18], as well as revenue models in terms of "incentive schemes such as pay-for-performance and pay-for-effort" [23, p. 264].

Feldmann and Müller [24] suggested an incentive scheme for companies to share true information within value-adding networks as they identified actively falsified information as a major deficit of information-sharing concepts. Their incentive scheme is based on financial rewards for sharing true information, and penalties for sharing falsified or manipulated information. No incentive schemes are presented that incentivise value-adding network partners to intensify information sharing in the first place.

Wang et al. [25] created an incentive model for information sharing in the context of value-adding networks to enhance coordination among partners and improve the overall network performance. To estimate the impact of information-sharing initiatives in value-adding networks, they introduced an index that is based on the four incentive mechanisms "value-adding network contracts", "team trust", "joint decision making" and "information technology coalition", all of which can be calculated by simulating values for diverse indicators of each. However, concrete recommendations are missing that would indicate which form of the four incentive mechanisms should be specifically applied in a concrete setting, e. g. which value-adding network contract would be most suitable for which kind of information-sharing structure.

Simatupang and Sridharan [23] introduced the integrative framework for value-adding network collaboration suggesting taking into account the following five core dimensions to plan and operate inter-company collaboration initiatives: "collaborative performance system", "decision synchronisation", "integrated value-adding network processes", "incentive alignment" and "information sharing". Their framework allows collaborative initiatives to be evaluated towards a company's effectiveness in improving its SC performance, as well as actions to be defined on how to design, implement and run value-adding network collaboration.

Gassmann et al. [26] provide an overview of 55 business model types, including the underlying revenue model, which can in part be used to design incentive schemes for value-adding networks. Amongst others, they introduce the business model types "add-on", "crowdfunding", "freemium" or "pay-per-use".

Even though scientific studies exist that deal with how to distribute earnings among the value-adding network partners through gain-sharing mechanisms [27], an approach to design a specific incentive system has not been modelled yet. In fact, this work follows up on a publication by Zipfel et al. [20], who suggested developing an incentive system for fostering information sharing.

To the best of our knowledge, no prior research has been found that formulates a model especially suited to incentivise value-adding network partners via concrete, individual financial or non-financial rewards to boost information sharing.

4. Approach for an incentive system for information sharing in value-adding networks

The application-specific incentive system framework developed for information sharing in value-adding networks consists of five steps (see Figure 3). The first four steps lay out the requirements for PPC-related information sharing, whereas in step five, the incentive schemes are derived from the requirements. The five building blocks of the framework are presented in greater detail in the subsequent sections 4.1 - 4.5.

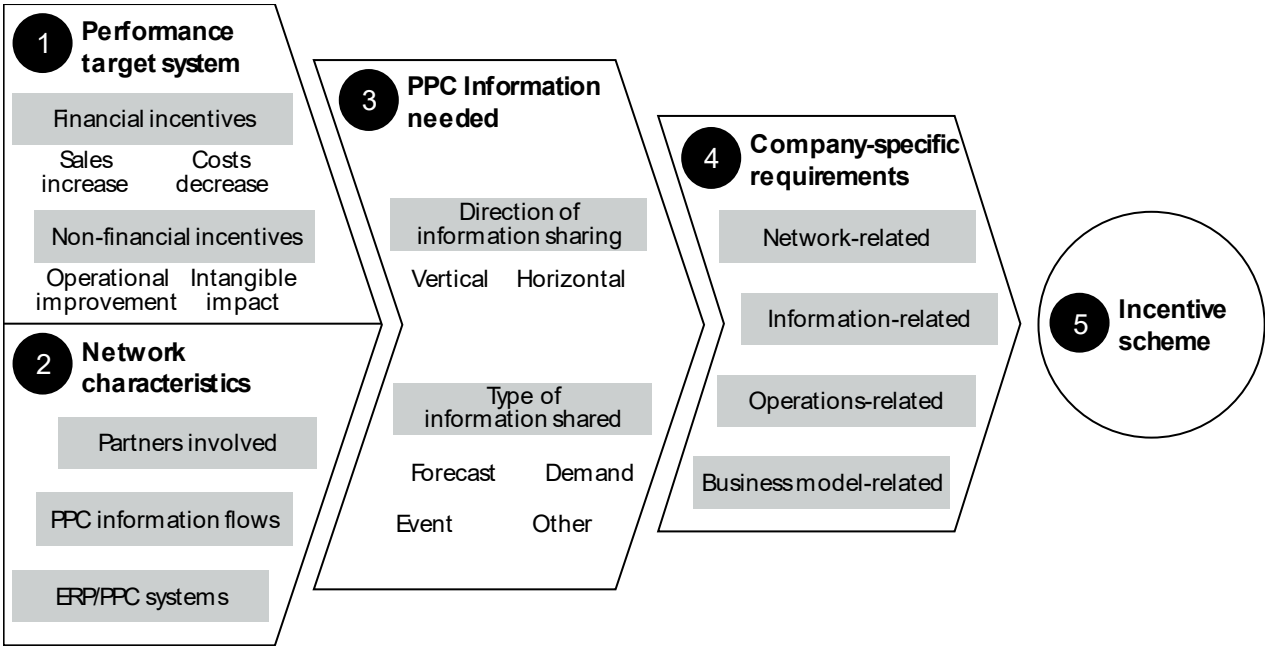

Figure 3: Incentive system framework for information sharing

4.1 Defining the performance target system

To set the goal of each information-sharing initiative, in a first step, the application-specific performance target system needs to be defined. Originating from Wiendahl's PPC target system [28] that includes the two dimensions logistics performance and logistics cost, the value-adding network performance target system is divided into the two dimensions of financial and non-financial targets [29]. The financial targets are further divided into sales increase and cost decrease, whereas the non-financial targets are operational improvements or of intangible impact. As operational improvements, smaller batch sizes, shorter lead times or a higher adherence to delivery times may be mentioned, for example. Performance targets with rather intangible impact include, for instance, greater customer satisfaction.

4.2 Describing the value-adding network characteristics

The framework is based on a value-adding network with multiple entities, including suppliers, manufacturers and retailers, to serve the final customers' needs. To set up an application-specific incentive system, the number of partners participating in the sharing agreement and the direction of the information flows is highly relevant. For instance, if safety stocks cause high inventory costs at multiple retailers of one manufacturer, the incentive system to be set up should consider all relevant partners. Furthermore, existing data flows between value-adding partners and ERP/PPC systems have a direct influence on the design and implementation of incentive systems, as existing data streams facilitate enhanced information exchange. This characteristic becomes especially important if implementation effort is compared with the expected outcome of setting up an incentive system for information sharing.

4.3 Identifying the PPC information needed

The next step requires the potential of different types of information to be isolated in order to attain the desired performance improvement targets. This building block is, hence, based on two factors: the type of information shared and the direction of information sharing. Information types derived from prior research can be categorised as demand (e. g. order size, due date or deviations), forecast (e. g. planning of machine capacities and batch sizes) and event (e. g. machine breakdowns or rush orders). The direction of information sharing is divided into upstream, downstream and horizontal information sharing (see Chapter 2). See Table 1 for an exemplary overview of typical effects of information sharing on the performance targets.

Table 1: Effects of information sharing on the performance targets

Performance target	Improving information-sharing mechanism	References
Sales increase	- Upstream demand for information sharing (UDIS) weakens double marginalisation and avoids missed stock-outs - Downstream forecast of information sharing leads to better retail prices	[9, 30-32]
Costs decrease	- UDIS weakens bullwhip effect, thus enabling inventory cost savings, reduces overproduction and leads to unit production cost savings - Downstream information sharing (DIS) of shipping data reduces safety stocks while the sharing of product-related event data reduces inventory costs	[19, 32-38]
Operational improvement	- UDIS sharing can lead to shorter lead times and smaller batch sizes - DIS of shipping data can lead to a higher level of timeliness	[19, 34, 37]
Intangible impact	- UDIS can incentivise the manufacturer not to establish a direct selling channel and lead to higher customer satisfaction due to fewer stock-outs - Upstream and horizontal sharing of forecast information can lead to a higher capacity of production	[11, 32, 39, 40]

4.4 Assessing further company-specific requirements

The fourth step for designing incentive systems covers the identification and assessment of company-specific requirements. This building block allows to identify specific conditions in a standardised, structured and comparable manner. The requirements are derived from four dimensions, namely network-, information-, operations- and business model-related requirements. Each dimension covers multiple indicators that take into account the specific needs of an enterprise towards an incentive system for information sharing. In order to classify the company-specific requirements, a five-level scoring system was developed. Table 2 exemplarily introduces the scoring system for the network-related requirement “degree of flexibility”.

Table 2: Scoring system for the indicator “degree of flexibility”

Dimension	Indicator	Score 1	2	3	4	5
Network-related requirements	Degree of flexibility	Very low, when future adaptions are very unlikely	Low, when future adaptions are rather unlikely	Intermediate, when future adaptions are rather likely	High, when future adaptions are likely	Very high, when future adaptions are very likely

4.5 Selecting the incentive scheme

After having set all relevant prerequisites (see Chapters 4.1 - 4.4), the fifth step is to select an adequate incentive scheme for each value-adding partner. Based on a literature review, ten incentive schemes have been identified as particularly suitable for the purpose of information sharing [10, 19, 26, 29, 41-44]:

- *Add-on:* A value-adding network firm offers its partner basic information for a specific price with an add-on option for further information at an additional cost.
- *Barter:* Partners in the value-adding network exchange and trade equivalent information among themselves.
- *Cost sharing:* Two forms of cost sharing might be applicable to information exchange: On the one hand, the cost of gathering the additional data is shared among the partners and on the other hand, the reduced cost and the resulting benefits incurred through information exchange might be shared.
- *Freemium:* A firm shares basic data for free with its partner, however, a premium option is available for sharing additional, more detailed data.

- *Open data model:* Firms collaborate by sharing information with each other for free to use and analyse, which leverages the whole network's competitive position against other networks.
- *Pay-per-use:* A firm offers its partner information under the payment mechanism pay-per-use when needed, which means costs accrue only after relevant data has been exchanged and used.
- *Pay-with-data:* A physical or intangible product or service offered by one partner is paid for by the other partner providing certain information instead of money.
- *Revenue sharing:* The additional revenue realised through information sharing is shared according to a specific percentage among the partners contributing to achieving such revenue.
- *Subscription:* The firm sharing information offers its partners the opportunity to subscribe to information flows, hence, to get access to relevant data by paying a weekly, monthly or yearly fee.
- *Trade credit:* By sharing information with upstream network partners, companies may be granted approval for a longer payment period and, hence, a so-called trade credit.

To select the best-fitting incentive scheme in accordance to a certain use case, two process steps are required. Firstly, the general applicability of the incentive schemes has to be analysed at a high level (see Chapters 4.1 - 4.3). For this purpose, all incentive schemes were evaluated with regard to the type and direction of information needed and the number of partners involved in the network setting. Table 3 gives an exemplary overview of the evaluation results for the incentive scheme pay-per-use. By comparing the evaluation results with the scenario conditions given, a pre-selection of potential incentive schemes can be made.

Table 3: Evaluation results for the incentive scheme pay-per-use

Incentive scheme	Type of information shared				Direction of information sharing			# partners involved	
	Demand	Forecast	Event	Diverse	Downstream	Upstream	Horizontal	Single	Multiple
Pay-per-use	-	-	x	-	x	x	-	x	-

Secondly, the characteristics of the remaining incentive schemes need to be contrasted with the company-specific requirements identified (see Chapter 4.4). By analysing the incentive schemes' capabilities, amongst others by conducting a pairwise comparison, the incentive schemes that are best suited to meet the requirements resulting from the indicators could be derived. The analysis results are shown in Table 4.

Table 4: Overview of preferred incentive schemes for company-specific requirements

Dimension	Indicator	Preferred incentive schemes for highly scored indicator
Network-related requirements	Degree of flexibility	Add-on, freemium, open data model, pay-per-use
	Dependency on trustworthiness	Add-on, subscription, pay-with-data, pay-per-use, barter
	Strength of ties among the partners	Revenue or cost sharing, pay-with-data, barter
Information-related requirements	Acceptable uncertainty about the outcome	Revenue or cost sharing, pay-per-use, open data model
	Importance of the value of information shared	Add-on, subscription, revenue or cost sharing, pay-with-data, barter
Operations-related requirements	Ease of implementation	Trade credit, open data model, freemium
	Performance measurement	Add-on, subscription, revenue or cost sharing, pay-with-data, pay-per-use
Business model-related requirements	Degree of monetary incentives	Add-on, revenue or cost sharing, subscription, pay-per-use
	Level of integration into the company's own business model	Revenue sharing, cost sharing, pay-with-data

5. Use case

For evaluation purposes, the developed framework was applied in a specific use case. The use case deals with series production of an e-scooter manufacturer M, who produces a maximum daily output of 50 (see Figure 4). This size differs from the batch size of the wheel supplier S2, which produces in batches of 400 due to the economic use of its production machinery. This is because the order release is based on actual consumption by end customers, i.e. orders are placed when a current stock of final products falls below a certain limit. In this case, the next batch of 400 wheels is produced and shipped resulting in stocks becoming available at the manufacturer's plant. Furthermore, so that the buyers' needs can be serviced in a timely manner, high safety stocks of wheels are maintained along the value chain. The unfavourable high stocks therefore result not only in high processing times, but also in extra administration and capital commitment cost. Hence, the hypothesis formulated is that an increase in information sharing between the retailers, manufacturer and suppliers can facilitate planning and reduce stocks. The incentive system shall be implemented with R2 first and rolled out later to other critical steps in the production process. According to M, the outcome should be focussed on financial benefits, which means that decent effort in setting up the collaborative system is acceptable if the likelihood of financial success is high.

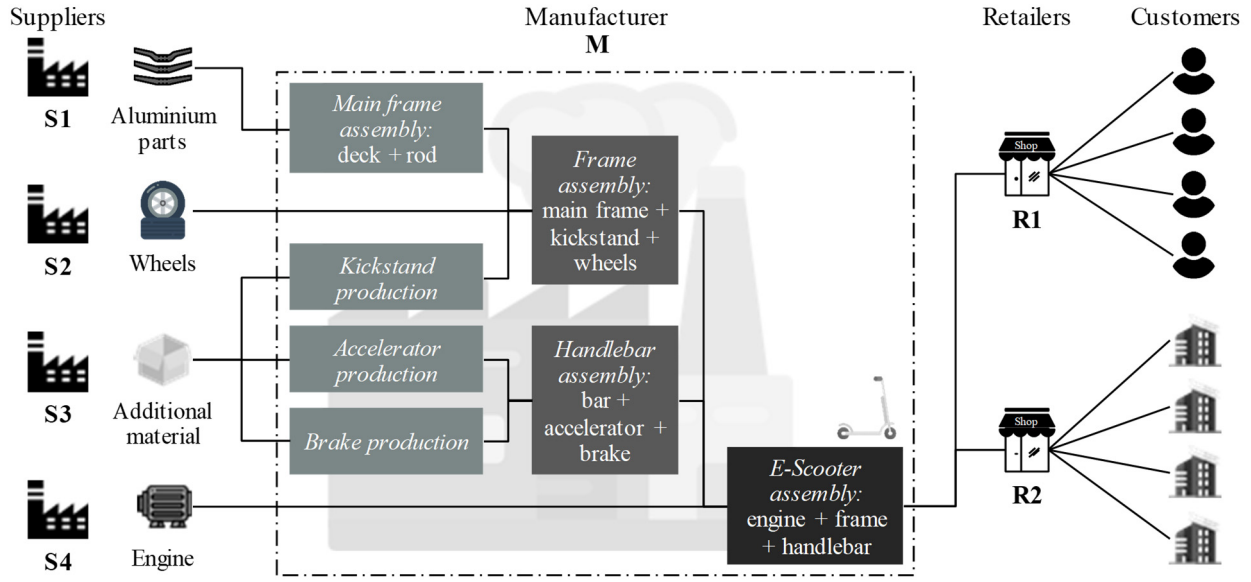

Figure 4: Exemplary e-scooter value-adding network structure

To find the most suitable incentive system that allows M to reduce its stocks, the approach developed was applied. Once the inventory cost to be reduced had been defined as the performance target and the value-adding network characteristics had been analysed, the upstream demand information from R2 could be identified as the PPC information needed to be able to reduce inefficient high safety stocks. Hence, the incentive schemes trade credit, open data model and pay-per-use could be excluded from the final incentive scheme list, due to the information type and direction of information sharing. As a fourth step, the company-specific requirements were assessed and scored as either low, intermediate or high. For example, as the degree of flexibility with regard to future internal or external changes is not of upmost importance for company M, this indicator was rated low. However, as M strives for short-term financial benefits, the degree of monetary incentives could be rated high. Once all indicators had been assessed and rated for this particular use case, the requirements implicitly imposed could be compared with the capabilities of the incentive mechanisms in the following fifth step to identify the one that fits best. As an outcome of the analysis the incentive scheme revenue sharing was proposed as the most suitable for incentivising R2 to share upstream demand information so that M could lower inventory levels, reduce searching and administration times and finally achieve a higher output. Therefore, as decreasing costs was one of the goals formulated by M, it is fair to say that the obvious incentive scheme – in this case, cost sharing – is not always the best-fitting one.

6. Conclusion and outlook

Sharing of PPC-relevant information among partners in value-adding networks is a key factor in remaining competitive in the 21st century, since specific PPC information can have a positive effect on the performance of the whole value chain. Incentive systems make it possible to influence the behaviour of third parties, and thus foster inter-organisational information exchange. However, to date, too little conceptual research has been conducted on incentive frameworks for information sharing in value-adding networks. This study provides an approach for designing application-specific incentive systems fostering the exchange of PPC-relevant information among partners: Firstly, the performance targets of the improvement initiative and, secondly, network characteristics need to be defined. Once the basis is set, the relevant PPC information required needs to be identified in a third step. Once further company-specific requirements have been assessed, the incentive scheme most suitable to the use case can be selected.

In order to improve the applicability of the approach presented, expert interviews and further use cases will be conducted in the near future. These will, in particular, enable more customised recommendations for action to be included, such as adding industry-specific assessment criteria or further innovative incentive schemes. Moreover, it would be interesting to broaden the scope of the framework towards more complex settings, such as conflicting interests of partners that are part of various value-adding networks. Finally, it would be highly beneficial to include a mechanism for assessing the monetary value of information shared among the network partners, in order to be able to estimate the amount of the different rewards.

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Biography

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Prof. Dr.-Ing. Gunther Reinhart (*1956) holds the chair for Industrial Management and Assembly Technology of the *iwb* at the Technical University of Munich. Since 2016, he has also been Director of the Fraunhofer IGCV. Furthermore, Prof. Reinhart is a board and council member for several companies.