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Master's Thesis

Efficient supply chain performance in biogas production – from raw-material sourcing till residue placing

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ABSTRACT

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The objective of this Master's Thesis was to identify areas that decrease supply chain performance efficiency in biogas production, and to develop improvement ideas based on the findings. The focus was on logistics, raw-material sourcing, and residue placement operations. Theoretical background was gathered, a qualitative single case study conducted, and interpretations were made. The purpose of the research was evaluative, it had a deductive approach, and the time horizon was cross-sectional. The data was collected through six semi-structured interviews, which were divided into themes: background, supply chain operations, supply chain relationships, and industry trends and future. A biogas plant visit was also done.

Multiple (21) improvement ideas were recognized. It would be important to create performance metrics, have a holistic biogas plant network view, and align strategy. Delivery schedules should be deployed, material flow tracked, trash-gauges installed, and supplier coordination emphasized. It was noticed that contracts need to be reviewed and possibly modified. Supply chain relationships and information sharing need attention and, for example, partner's actions could be developed. Due to changes in the industry, future trends were discussed. Managerial implications were proposed to disclose benefits that implementing these ideas could generate.

TIIVISTELMÄ

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Tämän Pro-Gradun tavoitteena oli tunnistaa osa-alueita, jotka alentavat toimitusketjun performanssin tehokkuutta biokaasun tuotannossa, ja luoda kehitysideoita löydösten perusteella. Työssä keskityttiin logistiikkaan, raaka-aineiden hankintaan ja jäännösten sijoitukseen. Teoreettinen tausta kerättiin, ja laadullinen tapaustutkimus toteutettiin sekä dataa vertailtiin ja tulkittiin. Tutkimuksen tarkoitus oli arvioiva, siinä oli deduktiivinen lähestymistapa, ja poikkileikkauksellinen ajanjakso. Aineisto kerättiin pitämällä kuusi puolistrukturoitua haastattelua, jotka olivat jaoteltu teemoihin: taustatiedot, toimitusketjun toiminnot, suhteet, sekä toimiala trendit ja tulevaisuus. Lisäksi yhdellä biokaasu tehtaalla vierailtiin.

Useita (21) kehitysideoita huomattiin. Olisi esimerkiksi tärkeää luoda toiminnan mittarit, tarkastella biokaasulaitos verkostoa holistisesti, ja linjata strategia. Tulisi ottaa käyttöön toimitus aikataulut, seurata materiaalivirtaa, asentaa jäte-mittarit, ja keskittyä toimittajien koordinointiin. Sopimukset tulisi käydä läpi ja tehdä muutoksia. Yhteistyösuhteet ja tiedonjako tarvitsevat huomiota, ja esimerkiksi kumppaneiden toimintaa voisi kehittää. Toimiala muutosten takia trendejä tarkasteltiin. Lopuksi ehdotettiin päätelmiä, jotka sisälsivät hyötyjä, joita ideoiden toteutus voisi tuottaa.

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I started the Master's Programme in LUT two years ago. Along the way, I met the most amazing friends, and learned a lot. Time flew so fast, and soon became time to write my thesis. The research process was more time-consuming than I expected but I made progress all the time. I was determined but above all I got incredible support from my friends, family, and university. I want to thank my supervisor Jukka Hallikas for beneficial advices when I faced challenges. I am thankful for my LUT friends from peer support, and to my other lovely friends for cheering me. I appreciate that my family listened my everlasting explanations about my thesis, believed in me, and were always willing to help.

I am grateful for the case company which enabled me to conduct this research. I especially want to thank the finance unit. They always had time to have meetings and give advices when those were necessary during the thesis process. I also want to praise the employees who I interviewed. They openly told about their work, experiences, and opinions which ensured that I could get plenty of data for my analysis. Additionally, it was a privilege to be able to visit a biogas plant, since it helped me to understand the supply chain operations and biogas production processes more. Thank you!

Now I have finished my thesis, and I am graduating. I will miss this wonderful time of my life but I am still more than happy to finally be ready to look for new adventures.

3.9.2018
Annika

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1 INTRODUCTION

It is argued that supply chain performance is currently one of the most critical matters in multiple industries. The importance is high, for instance, because supply chains are involved in the whole product life cycle. (Balfaqih, Nopiah, Saibani, Al-Nory, 2016) It is also claimed that, at some point, competing will happen between supply chains, and no longer between separate companies (Horvath, 2001; Fawcett, Magnan, 2002), which highlights the importance of the subject in question. Supply chains mean operations and operators involved in moving commodities from raw-materials all the way to finished products or services that are distributed to end-users. The actors are, for example, raw-material producers, retailers, and transportation and information processing companies. The activities include, for instance, sourcing, scheduling, manufacturing, and warehousing. (Brewer, Speh, 2000). Supply chain performance in turn, signify the way how the above-mentioned operations are executed.

Supply chain is an essential element to examine when improving companies' effectiveness, competitiveness, customer management, and profitability. Globalization and outsourcing has become popular, and increased amount of companies rely on supply chain and logistics when selecting how to manage operations. Companies have also realized that to be able to achieve an efficient supply chain, performance of supply chain management need to be investigated. (Gunasekaran, Patel, Tirtiroglu, 2001) In previous literature, multiple authors have recognized areas, which to enhance to achieve successful supply chain performance. For example, Brewer and Speh (2000) disclosed that the focus could be on effective process coordination, customer value creation, reduction of costs, and building performance metrics. Commonly the trend has been to explore supply chains from diverse perspectives when aiming to enhance overall business operations, which also support the claim that the importance of supply chain performance is high.

Supply chain performance in this research is studied from biogas perspective. Weiland (2010) state that, in the future, bioenergy will be the most significant

renewable energy source because it is an attractive substitute to fossil fuels. Utilizing bioenergy, for instance, greenhouse gas emission can be reduced, and sustainable development of energy supply enhanced (Weiland, 2010). It is also claimed that biomass demand is growing, and therefore transport distances increase, and supply chain complexity grow (Fiedler, Lange, Scultze, 2007). This implies that the importance of supply chain management in the industry also increase. Since both the supply chain performance and bioenergy are current issues, this context gives an opportunity to conduct a meaningful research.

The research gap is to analyze different angles of supply chain performance, and through that to suggest improvement ideas that include multiple perspectives of supply chains. The perspectives are integration, material flow, collaborative relationships, information sharing, and supplier development. In addition, performance measuring is utilized to reveal improvement needs. Pervious researches related to supply chain relationships commonly include collaboration, information sharing, and supplier development aspects but operational viewpoints, such as, integration and material flow are not usually studied along with the relationship aspects. Therefore, even though numerous studies concerning supply chain performance can be found, this combination is new according to conducted search. Additionally, the biogas context is unique. The combination was selected based on literature review, and on the researcher's own interpretation that the aspects are crucial in aiming towards efficient supply chain performance. Example arguments that affected the decision are presented next.

Gunasekaran et al. (2001) state that measuring supply chain performance is essential when a company's target is to improve supply chain processes, and to gain efficient and effective supply chain. Brewer and Speh (2000) argue that Integrated activities can lead to cost reductions, for example, in transportation, warehousing and in inventory. Bartlett, Julien and Baines (2007) highlight that collaboration across organizational boundaries is necessary to gain supply chain excellence. Chen and Huang (2007) in turn, claim that effective communication and coordination of complex supply chain system elements and functional areas affect significantly on supply chain performance. Finally, Krause and Ellram (1997a) state

that since costs to switch a partner are usually high, and finding a better source is uncertain, supplier development becomes an intriguing option.

This introduction chapter will continue as follows. Next, a brief introduction to utilized researches is executed in the literature overview section but closer literature examining will be conducted in the chapters 2 and 3. The objectives, the main research question, and three sub-questions are also disclosed. After that, research methodology is explained, limitations identified, and key concepts defined. Finally, the structure of the research is expressed, and the descriptive framework of the study is presented.

1.1 Literature overview

Previous literature related to this research is multidimensional, because the aim is to analyze supply chain performance from diverse perspectives. As mentioned above, the perspectives are; performance measuring, integration, material flow, collaboration, information sharing, and supplier development. The material flow part includes transportation, delivery, inventory, and total cost of logistics aspects. The aim in the material flow part is to gather information about the subject, not to compare distinct researches. To collect information, for example, a book written by Gudehus and Kotzab (2009), and articles conducted by Wilson (2007), Sahin, Yilmaz, Ust, Guneri, and Gulsun (2009), and Forslund and Jonsson (2010) were utilized. Otherwise, previous researches have been reviewed, and analyzed to get thorough understanding and multiple viewpoints about the perspectives, and to be able to compare how those actualize in a case company.

Stewart (1995) has conducted a supply chain performance benchmarking research, which revealed keys to supply chain excellence. The author states that delivery performance, flexibility and responsiveness, logistics cost, and asset management are the keys to achieve a successful supply chain. Whereat, most of those are related to material flow. Brewer and Speh (2000) studied supply chain performance measuring, but also constructed a supply chain management (SCM) framework, which consists of SCM improvement ideas and goals, and financial and end-

customer benefits. SCM improvement ideas include process innovation, partnership management, enhanced information flows, and anticipation for emerging substitutes or threats from competitors.

Beamon (1999) conducted a research about measuring supply chain performance, and the author identified three measurement groups; resource, output and flexibility measures. Gunasekaran et al. (2001) came up with quite similar performance measures, and adds that measurement systems should be classified to strategic, tactical and operational level measures. Chan (2003) also studied performance measurement in a supply chain, and the author argues that there are seven important attributes to measure; cost, resource utilization, quality, flexibility, visibility, trust, and innovativeness.

Agarwal and Shankar (2002) studied alternatives for improvements in supply chain performance, and they constructed a model for that. The authors argue that process integration, market sensitiveness, and information-driven aspects are needed to achieve their suggested improvement ideas. Humphreys, Li, and Chan (2004) investigated the impact of supplier development on buyer-supplier performance, and Li, Humphreys, Yeung, and Cheng, (2012) the impact of supplier development on buyer competitive advantage. Combined studies about supplier development and supply chain performance in its entirety was not found. Nevertheless, since it is known that supplier development can be effective this is a good opportunity to include it into this research.

Chen, Daugherty and Roath (2009) conducted a study about defining supply chain process integration. According to the authors, connectivity and simplification are the most essential elements of integration. Flynn, Huo, and Zhao (2010) studied the impact of supply chain integration on performance, and they found that internal integration and customer integration affect the most to performance improvement. Before that, in contrast, Frohlich and Westbrook (2001) found that supplier and customer integration have the most significant effect. Simatupang, Wright and Sridharan (2002) found that logistics synchronization, information sharing, collective learning, and incentive alignment are crucial aspects in supply chain integration.

Prajogo and Olhager (2012) investigated integration from long-term relationships, information and logistics integration perspectives, and identified also that all the aspects influence supply chain integration and performance.

Multiple authors have studied collaborative relationships in supply chains. For example, Hoyt and Huq (2000) studied transition from arms-length relationships to collaborations, Boddy, Machbeth, and Wagner (2000) focused on implementing that type of cooperation between companies, and Horvath (2001) conducted a research about collaboration as well, and argues that it is the key to value creation in SCM. Furthermore, Barratt (2004) investigated the meaning of collaboration, and Cao and Zhang (2011) studied how close cooperation affect firm performance. General opinion seems to be positive about collaborations but, for example, Vereecke and Muylle (2006) are skeptical about its effectiveness. The authors found only weak positive correlation between performance improvement and structural collaboration with suppliers. However, the expectation in this research is that collaboration with strategic partners can be beneficial and support supply chain performance improvement.

Yu, Yan and Edwin Cheng (2001) found benefits in information sharing with supply chain strategic partners. The authors argue that uncertainties among supply chains arise because members are lacking information about others. Zhao, Xie and Zhang (2002) discovered that information sharing and ordering co-ordination have notable impact on total costs and service levels of supply chains. Zhou and Benton (2007) studied information sharing from three different perspectives: information sharing support technology, information content, and information quality.

Krause and Ellram (1997b) state that successful supplier development requires buying companies to expect more from suppliers, actively communicate with them, and overall put great effort to increase the performance of suppliers. Later, Routroy and Pradhan (2013) also studied critical success factors of supplier development, and the identified top four factors were long-term strategic goal, proximity to manufacturing base, top management commitment, and information sharing. Handfield, Krause, Scannell and Monczka (2000) identified the most common

pitfalls in supplier development. Additionally, for example, Modi and Mabert (2007) connected supplier development and knowledge transfer, Wagner and Krause (2009) combined it with communication, and Nagati and Rebolledo (2013) studied supplier development from suppliers' point of view.

1.2 Objectives and research questions

The objective is to reveal improvement needs that may exist in a supply chain of biogas production. The focus is on three supply chain phases, which are logistics, raw-material sourcing, and residue placement. Supply chain performance measuring, supply chain operations, and relationships are especially analyzed in relation to the selected phases. Additionally, background, industry trends, and future of biogas business are considered. Shortages are identified through comparing theory and practice, and by combining opinions, ideas, and observations of employees of the case company. The aim is to disclose areas which decrease supply chain performance efficiency as comprehensively as possible. The target is to present results both in a form of text and graphics. Based on the findings, the case company can create an implementation plan for the enhancements, which can lead to more efficient performance, and through that, for instance, to decreased costs and increased quality.

The research problem is divided into one main question, and into three sub-questions. The main question expresses the aim of the study, and the question is:

MQ: How to improve supply chain performance in biogas production?

The sub-questions are formed to frame the study, and to divide the main problem into smaller pieces. The sub-questions are:

SQ1: What is the current state and future orientation of the case company?

Current state is critical to analyze when the aim is to create improvement ideas, and disclosing it extends to the whole research. However, this question about current state refers especially on examining the background of the case, and on supply chain performance measuring. Performance measuring reveals efficiency and quality improvement needs in fields, where results are unsatisfactory (Chan, 2003). Trends and future are also interesting, because biogas industry is growing and changing rapidly, which is why the aim is to disclose what lies ahead.

> *SQ2: How could supply chain operations be enhanced to improve the overall supply chain performance?*

Supply chain operations in this study refer to integration, and to material flow. It is argued that the most successful manufacturers are the ones that have integrated their processes (Frohlich, Westbrook, 2001), which is why integration level of the case supply chain is examined. Material flow efficiency has also a significant role, because it proceeds from suppliers to producers and finally to end-users, so it encompasses the whole supply chain. Material flow weaknesses are searched from transportation, delivery, inventory, and from total cost of logistics viewpoints.

> *SQ3: What are the case company's relationships like, and are there possibilities for development?*

It will be figured out whether the case company has transaction-oriented or collaborative relationships (or both) with its supply chain partners. In addition, it is also disclosed does the partners performance fulfill expectations. According to answers in those, development areas can be suggested. For example, if expectations are not fulfilled, supplier development can be considered because partner switching costs are usually high, and finding a better source is uncertain (Krause, Ellram, 1997a). Relationship are also analyzed from information sharing perspective, because effective communication and coordination of complex supply chain system elements and functional areas affect significantly on supply chain performance (Chen, Huang, 2007).

1.3 Research methodology

This research is a qualitative single case study. Qualitative research is narrative, and it analyzes experiences. Sample sizes are small, and which scientific criteria is quality not quantity. (Eskola, Suoranta, 1998) The sampling is purposive, and the aim of data collection is rather to get data and do interpretations that fit a certain situation than to be able to generalize results. (Lapan, Quartaroli, Riemer, 2012, 263, 3) Case study is an investigative approach, and it is utilized when the goal is to describe a complex phenomenon in a greater depth (Lapan et al., 2012, 243). In this research, the case is only one organization, which makes it a single case study. This research assesses performance of a certain supply chain, and compares it to theoretical recommendations, which fulfills evaluative purpose (Saunders, Lewis, Thornhill, 2016, 176). Theoretical decisions were made before the qualitative research, which indicates that the research has a deductive approach (Saunders et al., 2016, 51).

The main primary data collection technique is interviewing, and more specifically semi-structured interviewing. Semi-structured interviews are non-standardized, and the interviews are based on themes (Saunders et al., 2016, 390-391). The themes of interviews in this study are: background, supply chain operations, supply chain relationships, and industry trends and future. Example questions were formed, but as typical for semi-structured interviews, the same questions were not asked from every interview participant. Selection of questions depended on a person's position in the case company, and on the flow of conversation.

Six individual interviews were conducted, and all the interviews were held over a short period of time, and those concerned a particular subject, which makes the time horizon cross-sectional (Saunders et al., 2016, 200). Employees of the case company who were assumed to know most about the research topic were selected purposively and interviewed. Additionally, primary data was collected through a biogas plant visit, which was guided by a site manager. Secondary data that was utilized are journal articles, and e-books. The theoretical part, and basic facts about

biogas were built based on previous researches. Additionally, the findings in the case study are compared to previous literature as well.

Analysis in this study was executed by first transcribing interviews based on audio-recordings. Transcribing was done without silent elements, for example, intonations. After this, relevant data was highlighted but codes were not used. Similar topics were aggregated based on the previously mentioned themes and asked questions. Information were written down in Microsoft Office Word, but any computer-aided qualitative data analysis software was not used. Gathered information was compared to the collected literature because comparison enables reviewing a topic in distinct ways, and finding out a range of possible meanings (Corbin, Strauss, 2008, 75). Finally, interpretations were made and presented.

1.4 Limitations

After biogas is produced in a biogas plant, remaining residues are placed and biogas distributed to end-users. That biogas distribution is limited out from this research, and the focus is only on the supply chain operations from raw-material sourcing till residue placement. The two paths include different characteristics and challenges, which would have resulted a too wide topic, and therefore, one had to be selected. Additionally, only raw-material delivery and storing are considered when analyzing biogas plant operations. The production procedures, and other technical aspects are left out.

Sometimes suppliers are delivering their suppliers waste but analyzing specifically those second-tier suppliers is excluded from this research. Finally, the target of this research is to identify improvement ideas but implementation drafts are not included. This enables identification of shortages comprehensively rather than focusing on a few main weaknesses.

1.5 Key concepts

The key concepts of the study are explained in this section. Explanations include references to previous literature, and reporting what the concepts mean in this study and in the taken perspective.

Biogas

Biogas is renewable energy, that can be used in heat and power generation and as vehicle fuel. Utilization of biogas is one way to substitute the use of fossil fuels. Benefits are, for example, reduced greenhouse emissions, and secured energy supply. (Weiland, 2010)

Collaborative relationships

A collaboration is a form of a relationships where two distinct companies from the same supply chain are targeting a long-term and close co-operation (Boddy et al., 2000). Collaborating companies make decisions together, have common goals, and are willing to share information and resources (Cao, Zhang, 2011). In a well implemented collaboration one's achievements are also another's achievements (Ploetner, Ehret, 2006).

Material flow

Material flow indicates the movement of material from suppliers to producers and finally to end-users.

Raw-materials

Raw-materials that are utilized in producing biogas are, for example, organic waste and sewage sludge. Any biomass can be used if it contains carbohydrates, proteins, fats, cellulose, and hemicellulose. For example, wood cannot be used to produce biogas. Suitable source is, for instance, food waste. (Weiland, 2010)

Residues

After the biogas has been produced there remain residues, for example, nutrients and fertilizers that should be disposed or sold. Residues can be, for example, utilized in agriculture. The supply chain in question ends to this residue placement.

Supplier development

Krause and Ellram (1997a) defined supplier development as “any effort of a buying firm with its supplier(s) to increase the performance and/or capabilities of the supplier and meet the buying firm’s short- and/or long-term supply needs”.

Supply chain performance

Citing Hult, Ketchen and Slater (2004) “a supply chain is a network of actors that transforms raw materials into distributed products”. The supply chain performance term indicates the way a supply chain executes the mentioned operations.

1.6 Structure of the study

The research will be structured as follows. First, theoretical background is constructed, and it is divided into two main chapters, which are supply chain performance and supply chain relationships. After that, the research design and methods are explained. Then, analysis about the case is conducted and findings are presented. Finally, conclusion about the research is made. The structure and the basis of the research is illustrated in the figure 1. below. The framework is descriptive because it is not based on any existing theoretical framework. The picture is construed based on literature review and interpretations.

All the items are inside one big circle which illustrates that supply chains are entities and their performance is dependent on every actor and action in it. Supply chain phases of the research case are simplified into three steps: raw-material sourcing, biogas plant and residue placement. The biogas plant step includes only raw-material receiving process, not any production procedures. The rectangle signifies performance measuring, which should concern the whole supply chain. The two arrows below the supply chain demonstrate the supply chain operations and supply

chain relationship chapters. After assessing all these aspects inside the circle, it is expected that improvement ideas can be found. SD in the figure 1. refer to supplier development.

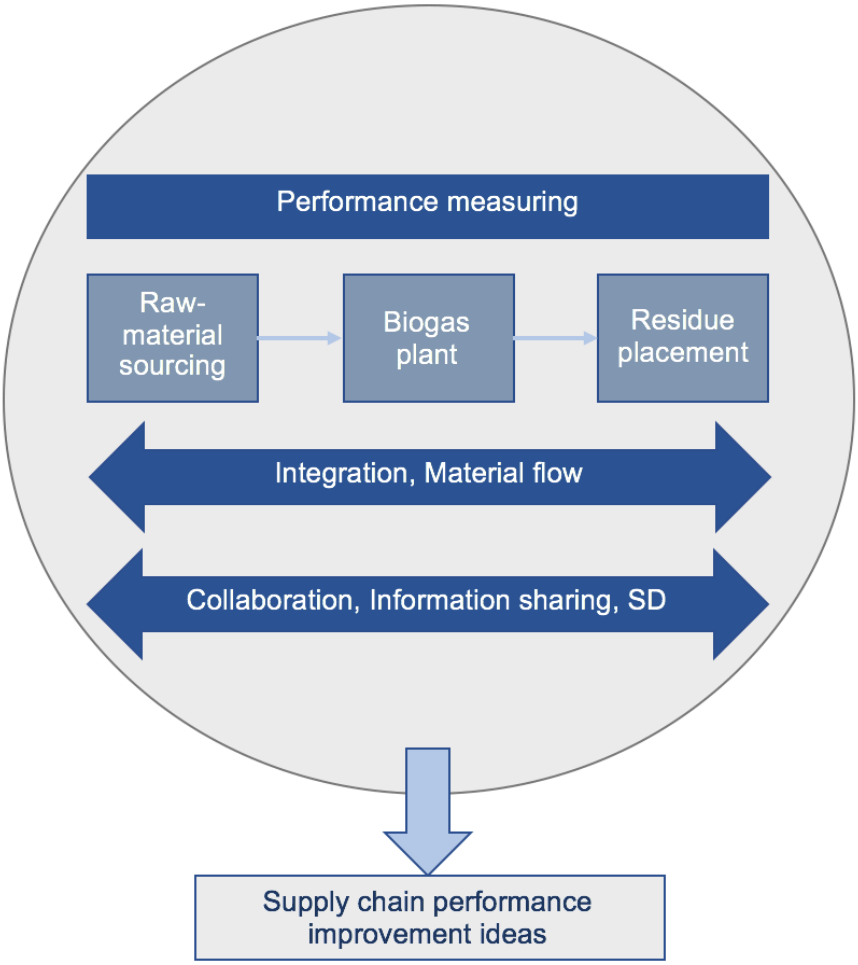

Figure 1, Descriptive framework.

2 SUPPLY CHAIN PERFORMANCE

Supply chain consists of actors that co-operatively transform raw materials into products (Hult et al., 2004), and it is considered as a single chain because it enables the flows of material, cash, and information be efficiently managed to correspond to certain business requirements (Agarwal, Shankar, 2002). In this chapter, aspects which can influence supply chain efficiency and competitiveness are introduced in the possible improvement areas chapter. After that, current performance measuring is reviewed, and supply chain operations are analyzed by examining integration and material flows.

2.1 Possible improvement areas

Companies should learn and innovate continuously (Brewer, Speh, 2000) and be responsive to changes (Agrawal, Shankar 2002). Next, possible supply chain improvement areas, to start or keep up the required development, are presented. Multiple ideas are brought forth, but the supply chain improvement as a subject is widely studied, and therefore the review will not be inclusive. The aim is to do an introduction to the subject, and then execute a more detailed analysis about a few selected fields later in this study.

Brewer and Speh (2000) have constructed a supply chain management (SCM) framework, which consists of SCM improvement ideas and goals, and financial and end-customer benefits. SCM improvement ideas include process innovation, partnership management, enhanced information flows, and anticipation for emerging substitutes or threats from competitors. SCM goals are, for example, waste reduction, flexible response and unit cost reduction. Financial benefits that can be gained are higher profit margins, improved cash flow, revenue growth and higher return on assets. End-customer benefits are improved quality, timeliness, flexibility, and value.

Within a supply chain, functional integration, sharing and cooperation are needed to achieve, for example, above mentioned waste reductions (Brewer, Speh, 2000). In

other words, the target of, for example, integrating processes, systems and actions is to minimize non-value-add activities (Steward, 1995). If processes among a supply chain are not integrated, there are tasks, which might be done multiple times. Harmonized activities could lead to cost reductions, for example, in transportation, warehousing and in inventory. (Brewer, Speh, 2000) When investment and operating costs are reduced, it can lead to greater customer responsiveness and to better supply chain flexibility (Steward, 1995). Agarwal and Shankar (2002) also emphasize the importance of process integration. In their study, investments in high technology and in manufacturing resource planning, and reduction of cycle time are improvements that the authors suggest. In addition to process integration, market sensitiveness (i.e. delivery speed, new product introduction) and information-driven aspects are needed to achieve the improvements.

Information sharing is important, because it, for instance, helps to avoid operating irrelevant activities. To enhance up-to-date and relevant information sharing, it is recommended that every participant in a supply chain, would utilize a same software, for instance, to plan production and logistics. (Brewer, Speh, 2000) Bartlett et al. (2007) suggest that internet-based platform would be the best option for exchanging information between supply chain partners, because integrating IT systems could be too complex. Key data, for example, about customers, suppliers, orders, and inventory should be available (Steward, 1995). The visibility of information among a supply chain is essential to achieve long-term competitiveness and improved supply chain performance (Bartlett et al., 2007).

Stewart (1995) has conducted a supply chain performance benchmarking research, which revealed keys to supply chain excellence. The author states that delivery performance, flexibility and responsiveness, logistics cost, and asset management are the keys to achieve a successful supply chain. The logistics costs include, for instance, order management, material acquisition, inventory carrying, supply chain finance, and planning costs. In the same research, Steward (1995) did observations about excellent supply chains. In the management level, fact-based decisions should be made quickly, consistently, and based on those impact on operations and on stakeholders. Continuously measured goals should be established and

communicated, and the quality of the management team should be respected by employees. In a successful supply chain, cross-operational teams are an essential part of organizational structure, and each team and its members should have designated targets and responsibilities, access to information, and understanding about performance measuring metrics. Finally, processes should be constructed to run most of volume in a simple and standard way.

Gunasekaran et al. (2001) identified that controlling capacity utilization can be beneficial in improving supply chain performance because it can improve, for example, flexibility and lead-time. The authors continue that sufficient scheduling techniques for operations are also essential, because those have a significant impact on performance of supply chains. For example, purchasing, throughput time, and batch size can be improved. Scheduling can be effectively done, for example, by utilizing information provided in companies' Enterprise Resource Planning (ERP) systems.

It is also highlighted that collaborations across organizational boundaries is necessary to gain supply chain excellence. Collaboration in this context means performing activities cooperatively with suppliers, partners and customers. (Bartlett et al., 2007) Through collaboration, companies can, for example, utilize human knowledge base better (Brewer, Speh, 2000). Additionally, in respect to relationships within supply chains, supplier development can also affect supply chain performance. For example, Humphreys et al. (2004) investigated the impact of supplier development on buyer-supplier performance, and Li et al. (2012) the impact of supplier development on buyer competitive advantage.

The introduced literature related to supply chain performance improvement areas mostly focus on process integration, information flow and sharing, stakeholder and especially partnership perspectives, and to themes related to material flow, such as transportation costs, and scheduling techniques. Goals to reduce costs, minimize waste, and maximize flexibility and responsiveness arose as well. Deeper analysis about the found themes will be conducted. In this section, integrated processes and material flows will be further analyzed. Before that, performance measuring is

examined because continuously measured goals are necessary to establish (Steward 1995).

2.2 Performance measuring

Measuring supply chain performance is essential when a company's target is, for example, to improve supply chain processes, and to gain efficient and effective supply chain (Gunasekaran et al., 2001). Performance measuring reveals the efficiency and quality improvement needs in fields, where results are unsatisfactory (Chan, 2003). Performance measurement systems also provide information whether a performance of a supply chain fulfills expectations (Brewer, Speh, 2000). Additionally, measures are necessary in testing viability of strategies (Gunasekaran et al., 2001), and in tracking waste, bottlenecks, and progress (Balfaqih et al., 2016).

Measuring techniques should be carefully selected, and it is critical that performance measures are related to strategic (Beamon, 1999) and to supply chain goals (Gunasekaran et al., 2001), and are affected by supply chain improvements (Brewer, Speh, 2000). A single measurement style is seldom enough, since it cannot be inclusive and it might ignore critical aspects (Beamon, 1999). However, neither a large number of performance measures is favorable, because addressing all those is difficult (Gunasekaran et al., 2001). Therefore, forming an adequate combination of performance measurement practices is important.

Both financial and nonfinancial measures should be included in measuring systems (Brewer, Speh, 2000). Chan (2003) argue that measuring supply chain by only costs should be discarded. However, the author also recognizes that nonfinancial measures have also weaknesses. Qualitative measurements are usually conceptual ideas, that are evaluated by one's own understanding, which might lead to inconsistency, confusion, or biased judgements. Gunasekaran et al. (2001) note also the importance to expand the measurement methods, and they state that traditional cost accounting method is changing to a technique, which considers cost of activities and impacts on functions, such as, asset utilization, productivity, and on quality.

Beamon (1999) identifies three measurement groups; resource, output, and flexibility measures. In that case, flexibility measures a supply chain's ability to react to uncertainty. Chan (2003) argues that there are seven important attributes to measure supply chain performance, which are; cost, resource utilization, quality, flexibility, visibility, trust, and innovativeness. Both authors have come up with quite similar conclusions about supply chain performance measures. Additionally, Gunasekaran et al. (2001) adds that measurement systems should be classified to strategic, tactical and operational level measures. The three measuring techniques are presented more closely below.

The mentioned Beamon's (1999) measurement groups include multiple measuring techniques. The resource measures consist, for example, of personnel requirements, equipment utilization, and energy usage. Furthermore, resource performance measures costs, such as, total cost of resources used, transportation and handling, manufacturing, labor, maintenance, held inventory costs, and return on investment. One of the goals is to minimize the use of resources. The output measures include, for instance, quality, profit, and the number of on-time deliveries. Finally, the flexibility measures the ability to adapt, for example, to schedule fluctuations from suppliers.

Gunasekaran et al. (2001) divide measuring techniques to strategic, tactical and operational level and to financial and non-financial groups. The authors have identified 40 different measuring techniques. 67,5 per cent are non-financial, 15 per cent financial, and 17,5 per cent include both financial and non-financial characteristics. Examples of the strategic techniques are; variations against budget, buyer-supplier partnership level, and level of supplier's defect free deliveries. Tactical measures, for instance, accuracy of forecasting techniques, responsiveness to urgent deliveries, and effectiveness of distribution planning schedule. Finally, operational techniques are, for example, driver reliability for performance, cost per operation hour, total inventory as incoming stock level, and capacity utilization.

As mentioned, Chan (2003) has collected performance measurements to his paper, and divided those in quantitative (cost, resource utilization) and qualitative techniques (quality, flexibility, visibility, trust, innovativeness). An example from each section in the above order is; distribution cost, customer dissatisfaction, labor cost, volume, time to get new manners to practice, consistency, and new use of technology. Additionally, the author has explained the performance measurement styles in more detail, for example, the last one is about measuring the percentage decrease in time necessary for producing a same product after utilizing, for example, new technology.

2.3 Supply chain operations

In this supply chain operations section, the importance of integrated processes and operations is emphasized, and procedures how to improve the integration are presented. Material flows from suppliers to end-users are also examined from diverse viewpoints.

2.3.1 Integration

As it was brought up before, multiple authors have recognized that integration of operations within a supply chain is important. It is argued that the most successful manufacturers are the ones that have linked their processes with suppliers and customers (Frohlich, Westbrook, 2001). Suppliers and customers' integration into the value chain processes is critical for supply chain performance, for example, because competition is increasing all the time (Prajogo, Olhager, 2012), and it is even claimed that, at some point, competing will happen between supply chains, and no longer between separate companies (Horvath, 2001; Fawcett, Magnan, 2002).

There have been contradictions and a lack of proper definition for process integration, and therefore Chen et al. (2009) conducted a study about defining supply chain process integration. According to the authors, connectivity and simplification are the most essential elements of integration. Furthermore, an

internal-external perspective and a process view are critical aspects to consider when implementing supply chain integration. Later, Flynn et al. (2010) in turn, defined supply chain integration as: “the degree to which a manufacturer strategically collaborates with its supply chain partners and collaboratively manages intra- and inter-organizational processes, in order to achieve effective and efficient flows of products and services, information, money and decision, to provide maximum value to the customer.”

To enhance process integration, Chen et al. (2009) identified actions that companies could do to achieve better internal and external connectivity, and simplification. According to the authors, internal connectivity can be enhanced through development of, for example, employee skills in coordinating business processes, common goals, and of communication capabilities. External connectivity can also be improved through coordination, consistency, and communication. In line with other authors, also Chen et al. (2009) state that both internal and external simplification can be executed, for example, by reducing complexity and unnecessary activities and steps.

Different authors have examined the degree and direction with whom to integrate within a supply chain. Frohlich and Westbrook (2001) found that companies, which have extensively integrated with both suppliers and customers have the most significant performance improvement rates in their research. The authors highlight that focusing only on suppliers or customers’ side is not enough. In contrast, Flynn et al. (2010) state that supplier integration affects less to the performance improvement than internal and customer integration. However, the authors also recognize that supplier integration is relevant to performance, and they conclude that internal integration, which Frohlich and Westbrook (2001) did not consider at all, forms the foundation, and customer and supplier integration are built upon that.

Supply chain integration have been studied from multiple angles and, for example, Prajogo and Olhager (2012) investigated the subject from information and logistics integration perspectives. The authors also considered long term relationships and their effects on supply chain performance. Prajogo and Olhanger (2012) identified

that both material flow from suppliers to manufacturers (logistics integration) and information flows, including information technologies, from manufacturers to suppliers are critical for supply chain integration and performance. When material flows are integrated with information flow, the supply can be guided by the demand. Prajogo and Olhager (2012) further explained that logistics integration influence on operations performance, information technology and sharing effect on logistics integration, and long-term relationships have both direct and indirect impact on performance. The authors argue that supply chain integration is a challenging task, and it can only be managed with long-term supply chain partnerships.

Simatupang et al. (2002) have also found that logistics synchronization and information sharing are crucial aspects in supply chain integration. Furthermore, the authors also state that collective learning and incentive alignment should be included in the integration process. Simatupang et al. (2002) called the four aspects as coordination modes, where information sharing enhances visibility, learning improves capability, incentives motivate distinct members, and logistics synchronization acts as a value creation loop, which offer the focus for performance improvement. The authors claim that the coordination modes have an impact, for example, on customer service, inventory velocity, speed of responsiveness, and on lead-times. Through the operational performance, the modes also affect financial performance, for instance, logistics costs, and cash conversion time.

2.3.2 Material flow

Material flow proceeds from suppliers to producers and finally to end-users. The aim is to move and store materials as smoothly and cost-efficiently as possible. In the improvement areas and process integration sections, material flows were touched but now reviewing will be continued. Material flow aspects that are briefly examined are transportation, delivery, inventory, and total logistics cost.

A transport system planning can consist designing, dimensioning, organizing, setting up, and scheduling. The designing includes selecting transport means and elements, deciding optimal paths and tracks, and connecting all to transport

network. The dimensioning comprises defining transport lengths, capacities, and determining the amount of equipment utilized. This planning should be done by considering certain spatial, time, and technical limitations. The spatial limit is location, the time limits are pickup, delivery, and transport times, and the technical limits consist of properties, capacities, and performance limits. Additionally, the aim is to perform transports at minimal costs. (Gudehus, Kotzab, 2009, 625) Risks in transportations are, for instance, distinct disruptions, which are occasions that disturb or stop a material flow between two echelons in a supply chain. If disruptions are likely to occur in the most important transportation phases, risks can be minimized through anticipation by, for example, identifying alternative routes and transportation modes. (Wilson, 2007)

Aspects that have an effect on delivery performance are, for example, delivery channel, vehicle scheduling, and warehouse location. Additionally, information exchange, especially information quality and diction, influence delivery performance significantly. (Gunasekaran et al., 2001) Da Silveira and Arkader (2007) found evidence that also both supplier and customer coordination investments are "positively related to delivery performance improvements in manufacturing". The authors utilized speed, reliability, and lead-time as dependent variables. Evaluation of delivery performance can be difficult, since operation environment is dynamic (Gunasekaran et al., 2001). When orders are not changed often in a supply chain, on-time delivery is a valuable metric that can be used to assess delivery performance. Performance management of on-time delivery can include four steps; deciding metrics, setting goals, measuring, and analyzing. (Forslund, Jonsson, 2010)

Inventories balance deviations between demand and supply, and, for example, safety stocks protect availability in cases of interruptions and delays on transportations or deliveries (Gudehus, Kotzab, 2009, 271). Inventories can include, for instance, raw-materials, assemblies, goods in transit, and finished products. (Gunasekaran et al., 2001) In this research, the focus is on raw-materials and residues, which are bio-wastes and sewage sludge, and nutrients and fertilizers. Inventories can be costly, need space and might be risky. However, when the right

quantities, in the right places, and the right articles are stored, the costs are minimal. (Gudehus, Kotzab, 2009, 271)

Commonly, inventory scheduling requires; forecasting demand, calculating optimal amounts of replenishment and safety stocks, determining reorder point, and executing replenishment orders (Gudehus, Kotzab, 2009, 272). However, in some industries, orders are more depend on suppliers than buyers, and stocks are fulfilled when suppliers deliver materials. As is the case in this study, raw-materials are delivered when, for instance, trash storages are full. For this type of situations, companies can utilize, for example, long-term procurement contracts. A contract can be made where prices, delivery, quality, and other necessary manners are agreed for a certain period of time (Logistiikan maailma, 2018).

In organizations, total logistic costs are determined and calculated in distinct ways (Gudehus, Kotzab, 2009, 129). It is argued that transportation costs cover half of the total logistics cost (Thomas, Griffin, 1996). The main components of transportation costs are capital, lubricants, fuel, and maintenance and operational costs. Additionally, external costs, such as, costs caused by transportation accidents, emissions and noise can occur. (Sahin et al., 2009) Other logistics costs are, for example, personnel, space and area, other than vehicle equipment, information technology (IT), insurance, planning, and inventory holding costs (Gudehus, Kotzab, 2009, 134-135). When cost reductions are needed, Pareto analysis (Gunasekaran et al., 2001), cause and effect analysis, or some other decision-making technique can support determining which costs to cut first. However, cost reduction decisions are multidimensional. For example, fast and expensive transportation mode might be a better option than cheaper and slower, because the high speed could reduce inventory costs enough to justify the increase in transportation cost (Gunasekaran et al., 2001).

3 SUPPLY CHAIN RELATIONSHIPS

Relationships between buyers and suppliers has changed from an antagonistic transaction-oriented to a win-win relationship-oriented perspective (Moeller, Fassnacht, Klose, 2006). A factor forcing for this change is, for example, a fact that companies are not able to respond to productivity, innovation, design, and quality improvement requirements without committed supply chain partner companies (Macbeth, 1994). Gunasekaran et al. (2001) argue that a win-win partnership leads to a supply chain that is more integrated and efficient. Prajogo and Olhager (2012) in turn, found evidence that long term relationships do have a direct effect on companies' competitive performance.

In this chapter, collaborative relationship between buyer and supplier is introduced, and some of its benefits and risks are disclosed. This type of collaboration is vertical, and it concerns upstream side of supply chains. For instance, supplier relationship management, common production scheduling, and collaborative transportations are examples about the collaboration in question. (Barratt, 2004) Analysis about information sharing and supplier development are also included. The importance of these were touched in the possible improvement areas section, and in this part the reviewing is continued.

3.1 Collaboration between buyer and supplier

A collaboration is a form of a relationships where two distinct companies from the same supply chain are targeting a long-term and close co-operation (Boddy et al., 2000). In practice, collaborative operating may include, for instance, common product development, joint system design (Agarwal and Shankar, 2002), or developing novel markets, technologies, or abilities (Ploetner, Ehret, 2006). Collaborating companies, for example, make decisions together, have common goals, and are willing to share information and resources (Cao, Zhang, 2011). In a well implemented collaboration one's achievements are also another's achievements. Mutual dependence is one characteristic of collaboration as well, and it means that neither party has power over the other, which could be used to dictate

the norms of the collaboration. (Ploetner, Ehret, 2006)

Development and maintenance of trust is a basic requirement for a successful collaboration. Commitment is important as well, and collaboration should be visible beyond buying-selling transactions. (Ploetner, Ehret, 2006) Collaborative relationships need effort, for example, high levels of communication, managerial assistance, and investments (Dyer, Cho, Chu, 1998). In collaboration, both partners share mutual respect, are willing to have multiple interactions, and agree that switching a partner is the last option (Macbeth, 1994). Collaborative relationship in a supply chain is not recommended for every supplier (Moeller et al., 2006), and it is encouraged to decide carefully with whom to partner with (Macbeth, 1994). Strategic suppliers, who have critical impact on core competence and competitive advantage (Dyer et al., 1998) are worth a close collaboration. It is beneficial to consider “soft” criteria, for example, organizational flexibility and cultural similarities when deciding about strategic importance of a supplier (Moeller et al., 2006). The number of collaborative relationships should be small (Barratt, 2004).

Another extremity and contrary example is shortly introduced to gain perspective. A buyer-supplier relationship can be also arm’s length, where the aim is to gain short-term benefits (Moeller et al., 2006). In arm’s length relationships, minimal amount of information is exchanged, and companies have low dependency (Jap, 1999). Usually actors in arm’s length relationships does not include trust or commitment to the relationships. It is also common that arm’s length partners are not willing to sacrifice their own benefit to help each other. (Liu, Li, Zhang, 2010) There is only one winner in this type of relationship, because other party’s success means loss to the other party (Ploetner, Ehret, 2006).

3.1.1 Advantages and risks of collaboration

A performance of a buyer’s firm can be improved by working more collaboratively with other organizations (Boddy et al., 2000). Advanced performance through collaboration can concern, for example, increased business synergy, flexibility and quality, and reduced inventory (Cao, Zhang, 2011). When two companies

collaborate, their nature can become inimitable, and competitive advantage (Jap, 1999) and firm performance can increase (Cao, Zhang, 2011). Additionally, both collaborating companies can focus on their core competencies, which leads to deeper specialization (Ploetner, Ehret, 2006).

Collaborative firms can achieve, for example, greater productivity (Liu et al., 2010), a faster time- to-market (Ploetner, Ehret, 2006), and improved process efficiency (Cao, Zhang, 2011). A collaboration can increase supplier responsiveness, like supply timing and quality. The greater responsiveness can be gained, for instance, through more involvement and communication. (Macbeth, 1994) In addition, as it was disclosed before that process integration is important, Agarwal and Shankar (2002) argue that collaborative operations between buyers and suppliers can lead to process integration, which is therefore beneficial.

However, opinions about collaborations vary. For example, Vereecke and Muylle (2006) are skeptical about the effectiveness of collaboration, and they found only weak positive correlation between performance improvement and information exchange, and between performance improvement and structural collaboration with suppliers in their research. The authors state that collaboration is not a guarantee for success. However, the researchers still found strong support for the statement that companies that achieve strong performance improvement do show higher levels of information exchange and structural collaboration than other companies. Despite the critics, Vereecke and Muylle (2006) conclude that supply chain collaboration is a valuable approach for achieving superior performance.

One principal risk of co-operation is opportunism (Handley, Benton, 2012). If a company is practicing opportunism, it is seeking only self-interest (Handley, Angst, 2015). Opportunism is especially a threat in collaborations because an open book accounting is practiced, which means that partners, for example, have information about each other's cost structures, and any confidential information could be used to make profit (Ploetner, Ehret, 2006). Differences between partners may cause problems as well. There could be, for example, cultural differences (Boddy et al., 2000), which should be taken into account. Imbalanced relationship tensions, for

example, excessive cooperation versus competition, or long-term versus short-term views may cause problems (Fang, Chang, Peng, 2011). Additionally, since collaboration rely on the engagement of people, difficulties may arise through possible losses of important partnership promoters. Therefore, companies should make sure that collaborations are not relying only on a one employee. (Ploetner, Ehret, 2006)

A reason why criticism may also arise, is failing to implement collaboration correctly. Collaborations are hard to implement, and sometimes it is not understood when and with whom to collaborate. Collaborations tend to fail also because there is no trust between partners. To succeed, for example, collaborative culture, multiple strategic elements, change management, cross-functional activities, process alignment, and joint decision making and metrics should be considered. (Barratt, 2004)

3.2 Information sharing

Effective communication and coordination of complex supply chain system elements and functional areas affect significantly on supply chain performance (Chen, Huang, 2007). Adequate communication requires information sharing, and multiple authors have conducted studies about this among supply chains. In most of the researches reviewed, it is evident that information sharing has a significant impact on supply chain performance. Both internal and external communication are essential.

Zhou and Benton (2007) studied information sharing from three different perspectives: information sharing support technology, information content, and information quality. There were multiple hypothesis and results in the research, but only three examples will be introduced next. First, effective information sharing can improve effective supply chain practices (e.g. supply chain planning, JIT production, and delivery practices). Second, information quality and the type of information are critical. The greater the quality the stronger the positive impact on delivery performance. Third, it was disclosed that investment in information sharing support technology does not have direct impact on companies' performance. Finally, the

overall results from the study indicate that effective information sharing and supply chain practices are essential in accomplishing a superior supply chain performance.

As mentioned above, also noted by Prajogo and Olhager (2012), IT does not directly improve information sharing or companies' performance. However, it does support both. Prajogo and Olhager (2012) argue that IT can help to increase the amount and complexity of information that is shared. The authors continue that IT can enable producing real-time information, for example, concerning delivery status and inventory levels which ease the management and control of supply chain processes. Finally, the researchers state that IT can also enable better communication and coordination between supplier and buyer, for instance, in the alignment of forecasting and scheduling of operations. Even though Prajogo and Olhager (2012) highlight the importance of IT, they also recognize that the frequency, quantity and the earlier mentioned quality of information matters the most. On top of transactional data, the authors recommend exchanging strategic supply chain information as well.

Zhao et al. (2002) discovered that information sharing and ordering co-ordination have notable impact on total costs and service levels of supply chains. The authors state that it is beneficial to share both future order and demand information with suppliers. Yu et al. (2001) also found benefits in information sharing with supply chain strategic partners. The authors argue that uncertainties (e.g. delayed deliveries, order fluctuations, and machine breakdowns) among supply chains arise because members are lacking information about others, and to reduce uncertainties, the members should exchange more information. This way, each member can get benefits from information sharing, and the performance of the whole supply chain can be improved.

A research conducted by Cachon and Fisher (2000) revealed partly different results. They explained that demand information sharing did not have significant influence because "just as the retailer's demand information becomes most valuable to the supplier, the retailer is likely to submit an order, thereby conveying the necessary information without explicitly sharing demand data." However, the authors conclude that in a different case setting, the results could have been different. Cachon and

Fisher (2000), for example, state that if the demand information would have been unknown, the information sharing could have had stronger impact on supply chain performance. Even though there are diverse results about the impact of information sharing, the majority of the reviewed studies support the argument that information sharing has positive impact on supply chain performance, and it should be pursued in strategic partnerships.

3.3 Supplier development

Krause and Ellram (1997a) defined supplier development as “any effort of a buying firm with its supplier(s) to increase the performance and/or capabilities of the supplier and meet the buying firm’s short- and/or long-term supply needs”. If a buying company is not satisfied with a product or service provided by a supplier, the company can decide whether to search for substitute or to stick with the current supplier and try to improve its shortcomings. Because switching costs are usually high, and finding a better source is uncertain, supplier development becomes an intriguing option. (Krause, Ellram, 1997a) Supplier development as a field of study has become attractive also because manufacturing companies have recognized that supplier performance is critical in creating and maintaining their competitive advantage (Humphreys et al., 2004).

Supplier development can include activities, such as, supplier evaluation, recognition, feedback, performance improvement requests, and supplier’s personnel training. Even investments in supplier’s operations, or personnel placement at supplier’s premises can occur. (Krause, Ellram, 1997a) Information and knowledge sharing, and technical or managerial assistance can also be included (Wagner, Krause, 2009). Additionally, supplier development can contain onsite visits and work teams (Nagati, Rebolledo, 2013). Aims of these actions are improvements in, for example, quality, cost, delivery, inventory, and in lead time (Humphreys et al., 2004). It is important to set goals, determine how to achieve the goals (Wagner, Krause, 2009), and to build relation and trust before starting supplier development (Narasimhan, Mahapatra, Arlbjorn, 2008). Supplier development efforts are implemented with strategic suppliers (Nagati, Rebolledo, 2013).

A study conducted by Krause and Ellram (1997b) indicate that successful supplier development requires buying companies to expect more from suppliers, actively communicate with them, and overall put great effort to increase the performance of suppliers. Routroy and Pradhan (2013) also studied critical success factors of supplier development, and conducted a single case study. The authors identified 13 critical success factors, where the top four was long-term strategic goal, proximity to manufacturing base, top management commitment, and information sharing. According to the researchers, the second factor means that it can be valuable to focus on nearby suppliers rather than to suppliers far away from manufacturers.

In another study, Krause and Ellram (1997a) tested differences between buyers' relationships with suppliers regarding whether they were involved in supplier development efforts or not. The authors found that most of the companies involved in supplier development observed their suppliers as partners, and put more effort on top management involvement, on cross-functional teams, and on communication than companies not implementing supplier development. These elements should be considered when planning to implement supplier development. Modi and Mabert (2007) in turn found positive correlation between supplier performance improvement and increased operational knowledge transfer, and between collaborative communication. Research conducted by Wagner and Krause (2009) also revealed that when a company's goal is to improve supplier's performance, especially product and delivery performance and supplier's capabilities, there is positive relationship with buying company's efforts to transfer tacit knowledge.

Humphreys et al. (2004) identified that transaction-specific supplier development (TSSD), trust, supplier strategic objectives, and effective communication are the most critical elements to consider when developing buyer-supplier performance. TSSD includes performance expectations, joint action, and human- and physical-asset specificity. The authors did not find strategic goals, supplier evaluation, top management support, or long-term commitment significantly contributing to supplier performance improvement. However, there were still positive associations found between the mentioned aspects and improvements. Additionally, later, Li et al. (2012) disclosed that, for example, supplier evaluation is critical in TSSD.

Furthermore, TSSD can lead to supplier performance improvement, buyer-supplier relationship improvement, and finally to buyer competitive advantage. Indirectly also top management support and long-term commitment have an impact on the mentioned aspects, which is why those are also important. The results may seem confusing, but the authors have constructed an illustrative model, which helps to internalize the findings. The model can be found from Appendix 1.

Handfield et al. (2000) identified the most common pitfalls in supplier development. The authors recognized that difficulties in supplier side can be tackled, for example, by illustrating benefits to suppliers first-hand, offering personnel support, and by ensuring sufficient commitment. On the buyer side, the researchers state that it is beneficial, for instance, to determine small goals, get executives committed, keep a long-term focus, and make sure that supplier development programmes are not established with too many suppliers. Finally, to succeed, Handfield et al. (2000) recommend both parties to, for example, trust each other, respect confidential information, and align organizational cultures.

Nagati and Rebolledo (2013) studied supplier development from supplier point of view, and the findings are mostly in line with the buyer's perspective. Trust, preferred customer status, and dynamic environment (environmental uncertainty) affect the supplier's decision whether to participate on supplier development activities. The results of the study indicate that supplier development programs do improve supplier performance also from supplier's viewpoint, but only when relationships are long-term.

It can be concluded from this supplier development literature review, that distinct authors and researches highlight different aspects. However, long-term commitment, trust, top management involvement, and communication seem to be the unifying themes that arose multiple times in the reviewed researches. Other aspects were mentioned only ones or twice, and some of them were quite case specific. Therefore, the importance and usefulness of each factor should be evaluated case-by-case.

4 RESEARCH DESIGN AND METHODS

The research design and methods will be introduced, and a brief case description will be done in this chapter. The “Research Onion” (Figure 2.) formulated by Saunders et al. (2016, 164) guided the research designing process, because it combines well the aspect that usually are considered before commencing a research. The aspects are: philosophy, approach to theory development, methodological choice, strategy, time horizon, and techniques and procedures. In this research, the methodology is qualitative, and the strategy is a case study. Rationales for the decisions and more detailed descriptions about the research design will follow.

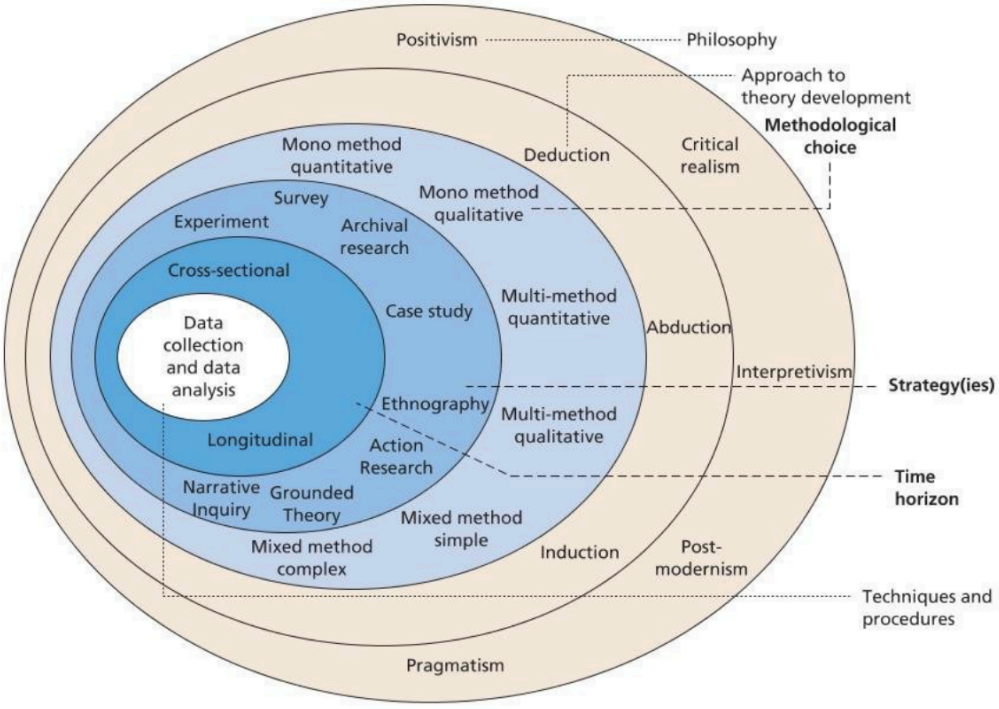

Figure 5.1 The research onion
Source: © 2015 Mark Saunders, Philip Lewis and Adrian Thornhill

Figure 2. The research onion (Saunders et al., 2016, 164).

Usually in a qualitative research, collected data is in a form of text, there are no hypotheses, viewpoint is examinees’, and researcher has a central role. Qualitative research is narrative, and it analyzes experiences. Sample sizes are small, and which scientific criteria is quality not quantity. (Eskola, Suoranta, 1998) The

sampling is purposive, and the aim of data collection is rather to get data and do interpretations that fit a certain situation and are valid, than to be able to generalize results. Qualitative research has an evolving nature, which is why its design should be open to changes during the research process. (Lapan et al., 2012, 263, 3)

Case study is an investigative approach, and it is utilized when the goal is to describe a complex phenomenon in a greater depth (Lapan et al., 2012, 243). The 'case' may refer, for example, to a person, a group, or an organization (Saunders et al., 2016, 184). In this research, the case is an organization, and one organization only, which makes it a single case study. The single case study approach can be selected if a case is, for example, critical or unique (Saunders et al., 2016, 186), and if the target is to do a detailed investigation (Hirsjärvi, Hurme, 2015, 59). The aim in this study is to examine specifically one company's supply chain performance and figure out improvement ideas for them, so the nature of the case calls for the single case study approach. Additionally, since the study is based on experiences of a few employees of the case company, and the wanted data is unique and narrative, the qualitative methodology fits the case. All the other characteristics of qualitative research mentioned above correspond the case as well.

According to Saunders et al. (2016, 174) research can have either exploratory, descriptive, explanatory or evaluative purpose. A research fulfills evaluative purpose, if its aim is to disclose how well something is executed. Commonly, evaluative research assesses the effectiveness, for example, of a business strategy, policy, initiative or a process. In evaluative research, performance can be appraised and compared. (Saunders et al., 2016, 176) This research assesses performance of a certain supply chain, and compares it to theoretical recommendations, which matches to the evaluative purpose. Previous researches about the topic were reviewed before conducting the empirical part. Different findings were combined, so any existing theory was not selected to be tested, which is why the theory building relied on descriptive framework built based on prior experience, expectations, and researches (Figure 1.). The fact that theoretical decisions were made before the qualitative research indicates that the research has a deductive approach. (Saunders et al., 2016, 51)

It was interpreted that none of the philosophies would be directing this study particularly, which is why this aspect is not editorialized. In the middle of the Research Onion is data collection and data analysis section, which will be covered in the chapters 4.2 and 4.3. Next, the case which the study concern is described shortly.

4.1 Case description

The case company operates in energy industry, and this study concern its functions in Finland. The company's biogas supply chain is interesting and roughly new, which makes it an intriguing topic. The focus of the research is on the case company's biogas operations from raw-material sourcing till residue placing, and on three groups of supply chain partners. The actors are logistics partners, raw-material suppliers, and residue handlers, for example, agriculture companies. The raw-material suppliers are simultaneously customers because the case company manages their waste. However, the waste is raw-material for the biogas production, which is why they are considered as suppliers in this study.

The strengths of the case company and its supply chain were examined before analyzing and figuring out improvement areas. It was disclosed in the interviews, that the biogas plant network is essential since it enables good production possibilities and high volumes, certainty and back up. The company manages to handle high volumes well, and their service reliability is good. The case company has a good reputation, right partners, competent employees, and ability to react and change quickly. Additionally, the case company has sustainable products, they can reach emission reduction goals, and top management is committed to safety and environmental issues. Even though there are many positive things, there is still room for development. The industry is in a turning point, and efficient supply chain performance is becoming more and more critical. Additionally, the case company has done multiple acquisitions, and its current form is quite new. Therefore, reviewing the supply chain now in detail is beneficial. Disclosing improvement ideas can support the supply chain of biogas production becoming even stronger.

4.2 Data collection

Data can be collected from multiple sources, for instance, from interviews, observations, documents, videos, and newspapers, and those can be utilized alone or in combination (Corbin, Strauss, 2008, 27). An interview is a common way to collect qualitative data, and its target is simply to figure out what someone has in mind. Interviews are sort of conversations, which are steered by researchers. (Eskola, Suoranta, 1998) Interviewing is a good option, for example, if a research area is unknown, or if there is a need for deepening answers by asking justifications, examples, and follow-up questions. Additionally, an interview is more flexible than, for instance, a survey. (Hirsjärvi, Hurme, 2015, 35-36)

In this research, the main primary data collection technique is interviewing, and more specifically semi-structured interviewing. Semi-structured interviews are non-standardized, and the interviews are based on themes. A researcher may have planned also questions but their order and the questions can vary from interview to interview. (Saunders et al., 2016, 390-391) Hirsjärvi and Hurme (2015, 48) call this type of interviews theme interviews, and they describe that in theme interviews the format of questions is not as strict as in surveys and neither as free as in in-depth interviews. Themes of interviews in this study are: background, supply chain operations, supply chain relationships, and industry trends and future. Example questions were formed, and those can be found from Appendix 2. but as typical for semi-structured interviews, the same questions were not asked from every interview participant. Selection of questions depended on a person's position in the case company, and on the flow of conversation.

Six individual interviews were conducted, and their duration varied from 58 minutes to 1 hour and 19 minutes. All the interviews were held over a short period of time, 28 days, and those concerned a particular subject, which makes the time horizon cross-sectional (Saunders et al., 2016, 200). The selection of interviewees was purposive which indicates that the samples cannot be statistically representative of a target group (Saunders et al. 2016, 301). However, this is typical for qualitative study, since the aim is to understand and get thorough information about a certain

topic rather than generalize results. In qualitative research, sample size is not critical either, and collecting data can be continued, for example, until new information does not occur anymore (saturation) (Eskola, Suoranta, 1998). This saturation principle is controversial, but it was still utilized as a guideline in this research.

Employees of the case company who were assumed to know most about the research topic were selected and interviewed. Interview order, areas of responsibilities, and interview types are presented in the table 1 below. All the conducted interviews were audio-recorded. According to Lapan et al. (2012, 256, 262) interview questions should be neutral, one question should ask about one matter, and questions should be in a form that does not enable yes or no answers. Additionally, the authors emphasized that a researcher should be open, naïve, non-threatening, nonbiased, and watch closely and think deeply. These advices were considered when interviews were planned and held.

Table 1. Employee interviews.

Interview order	Area of responsibility	Type
1.	Logistics	Skype
2.	Business Controlling	Face-to-face
3.	Directing	Face-to-face
4.	Leading	Face-to-face
5.	Planning	Face-to-face
6.	Environment and Energy	Face-to-face

In addition to the interviews, primary data was collected through a biogas plant visit, which was guided by a site manager. Even though the biogas production process is not included in the research, the guided tour was beneficial because the case organization became more familiar, it helped to understand some of the supply chain processes in practice, and gave an opportunity to ask questions related to the research topic. In addition to the tour, observations and interpretations about the environment, occasions, and processes were made. A report about the visit can be found from Appendix 3. This data collection method is not called observation in this research, because it was planned by the case company. However, some typical

characteristics of observation can be found. For example, details about environment were examined, (Lapan et al., 2012, 257) and the researcher was part of the field for a while (Flick, 2014, 42).

Secondary data that was utilized in this study are journal articles, and e-books. The theoretical part, and basic facts about biogas are built based on previous researches. Additionally, the findings of the case study are compared to the collected previous literature.

4.3 Analysis methods

The aim of analysis is to clarify and summarize data, create meaningful information from dispersed data, and through this to develop new information about the research topic (Eskola, Suoranta, 1998). It is a dynamic process of finding out what something is and how it functions. To be able to do this, comprehensive knowledge about the data is needed. (Corbin, Strauss, 2008, 46) Additionally, interpretations, investigation of connections, and context descriptions are crucial in the analysis (Hirsjärvi, Hurme, 2015, 137, 153, 146). Since researcher's style, skills, and judgements are critical in the research process, it is important, for example, to reveal researcher's expectations and reflect possible influencing factors to avoid researcher bias when implementing the analysis (Lapan et al., 2012, 71, 254-255).

When data has been collected, it should be transcribed and organized (Eskola, Suoranta, 1998). Transcribed data can be, for example, coded, classified, and compared (Lapan et al., 2012, 263). Coding means taking data to a conceptual level through codes, which are names of concepts marked, for example, in margins. Coding includes also activities, such as, interacting with, asking questions about, and comparing between data. (Corbin, Strauss, 2008, 66) Even though any literal coding would not be done, some kind of categorization should be generated, and matters that are relevant should be separated from the data. After that, interpretations can be made. (Eskola, Suoranta, 1998)

Analysis in this study was executed by first transcribing interviews, which resulted approximately 16 500 words. Transcriptions can include spoken words, and notes, for example, about pauses and intonations (Eskola, Suoranta, 1998) but data of this research was transcribed without those silent elements. This decision was made because analysis, for instance, about emotions or attitudes are not included into this study. After this, relevant data was highlighted but codes were not used. Similar topics were aggregated based on the previously mentioned themes and asked questions. By this categorization, information was easier to review and process. Information were written down in Microsoft Office Word, but any computer-aided qualitative data analysis software was not used. Gathered information was compared to the collected literature because comparison enables reviewing a topic in distinct ways, and finding out a range of possible meanings (Corbin, Strauss, 2008, 75). Finally, interpretations were made and presented.

4.4 Quality of the research

In qualitative study, the researcher should continuously consider made decisions, evaluate trustworthiness, comprehensiveness, and overall quality of the research process (Eskola, Suoranta, 1998). To be able to conduct a valid research, it is important, for instance, to follow decided research method, decide between the aims of doing description or theory building, and be aware of researcher's biases and assumptions (Corbin, Strauss, 2008, 302-303). In this research, the research method was successfully followed, and in the beginning of the process it was decided that the aim is to do a description. Additionally, when interpretations were made, the impact of possible researcher's assumptions were considered and attempted to avoid. One viewpoint is also that the aim of a research is to convince others (Eskola, Suoranta, 1998), which is why the research process was made as transparent as possible.

Even though the accuracy of utilizing the terms reliability and validity in evaluating qualitative research has been questioned (Corbin, Strauss, 2008, 301; Hirsjärvi, Hurme, 2015, 185), it is decided that the quality of this research is assessed through those traditional terms. Reliability means, for example, that two parallel research

methods will lead to similar results. However, the results can vary depending on time, place, and context, which is why distinct results are not always a weakness. Validity consists of considerations, for example, about concept accuracy, generalizability of results, and about impact of unwanted variables on findings. The mentioned characteristics are more typical for quantitative research, and it is suggested that in qualitative research, validity refer to justifying how alternative solutions are ruled out, and reliability is about the quality of materials, and researcher's actions. (Hirsjärvi, Hurme, 2015, 186-189)

The quality of an interview research may be enhanced, for example, through preparing for interviews well, by making notes about good and difficult questions based on previous interviews, transcribing interviews as soon as possible, and ensuring technical functionality (Hirsjärvi, Hurme, 2015, 184-185). These advices were taken into account in this research. Preparations for the interviews were done carefully, modifications were made during the data collection process if challenges appeared, and the functionality of the used audio-recorder was checked before every interview. The transcriptions were made within a few days but mostly during the day after every interview. The transcriptions were done precisely, and respondents responses were respected and not modified. The mentioned efforts improve the reliability of this research, because those enhance the quality of materials utilized. Additionally, the biogas plant visit improves the quality of materials because it increased the researcher's knowledge about investigated processes, which support correct interpretations.

Corbin and Strauss (2008, 305) state that ultimately the quality of the findings matter the most, so the aim was to gather encompassing information, and based on that, draw conclusions accurately. The target was also to report the findings clearly, in detail, and truthfully, and pay attention to justifications because Eskola and Suoranta (1998) emphasize the importance of argumentations and truthfulness. Additionally, Hirsjärvi and Hurme (2015, 189) express that it should be clarified how decisions and interpretations have been made, which is why one goal was to implement this type of reasoning continuously to improve validity of the research. It

is perceived that these mentioned aims were successfully implemented. Additionally, the researcher's actions were as honest as possible.

Some weaknesses can also be found. Previous literature utilized in this research does not concern specifically biogas, which might have impact on the suitability of the findings. The specification was not made because the aim was to focus on successful supply chain performance in general level. A person from the case company's sales unit was not able take part into the research, and it might affect the reliability slightly (Hirsjärvi, Hurme, 2015, 185). Any computer-aided qualitative data analysis software was not utilized, which should not be a significant weakness because those are not a solution for achieving reliability (Eskola, Suoranta, 1998). The results of this research are not generalizable. However, that is not the aim of qualitative research either, and the findings can still be beneficial for other companies on top of the case company as well, even though direct assumptions based on this research cannot be made.

5 ANALYSIS AND FINDINGS

This chapter includes analysis about the case study, and presentation of findings. The interviews are construed, and discoveries are expressed. First, background of the case is disclosed, including basic facts about biogas, introduction to the supply chain of biogas production, and to sustainability, because the case concerns renewable energy. Additionally, measurement procedures are assessed. Then, supply chain operations are reviewed by examining integration level, material flow, and cost efficiency. The analysis also includes supply chain relationships, which covers collaborations, information flow, and partner development. Finally, industry trends and future are discussed, and all the results are concluded and demonstrated in table 3.

5.1 Background of the case

Reasons why interest towards biogas is increasing are, for instance, its ability to reduce greenhouse gas emission, and to support a sustainable development of energy supply (Weiland, 2010). Altogether, biogas is attractive because it is a part of circular economy. Biogas is mostly methane, which is produced, for example, from biodegradable waste-materials by anaerobic digestion (Awudu, Zhang, 2012). Any biomass could be utilized for its production if it contains carbohydrates, proteins, fats, cellulose, and hemicelluloses as main components. However, wood cannot be used. (Weiland, 2010) This renewable energy source can be used as a substitute for fossil fuels, for example, for heat and electricity production, as fuel in vehicles and in gas stoves. A solid byproduct, residue, which will remain after the biogas is assorted, can be used, for instance, as a fertilizer (Awudu, Zhang, 2012).

5.1.1 Supply chain of biogas production

The supply chain of biogas production is illustrated in the figure 3. below, and it is analyzed from the raw-material and residue perspectives. The figure is build based on information received during the biogas plant visit. Raw-materials that are transported to biogas plants are, for example, bio-wastes and sewage sludge. After

biogas is produced from the wastes, there remain residues, which can be utilized, for example, as nutrients and fertilizers. The residues can be in liquid or in solid forms, and when the liquid residue is further processed, for instance, reject water is generated, which can be released to sewers after it is treated with nitrogen separation equipment. Both liquid and solid residues can be transported, for example, to farms and fields. Biogas as a material and its processing are mentioned and included in the figure 3. to illustrate the big picture, but those are not examined any further in this research.

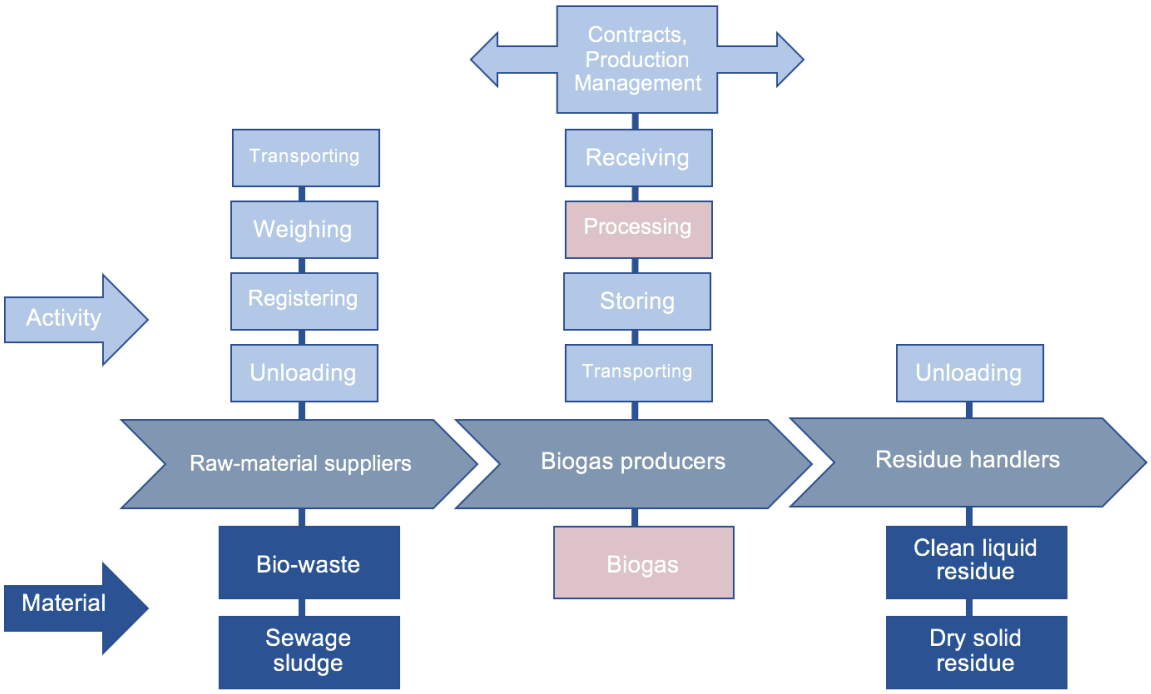

Figure 3. Supply chain of biogas production materials.

Activities in the supply chain are performed by multiple actors, and here raw-material suppliers, biogas producers, and residue handlers are considered. Sometimes suppliers' suppliers are the source, but those second-tier suppliers are excluded from this study. Activities that consist the supply chain in question are raw-material transporting, weighing, registering, unloading, receiving, processing, storing, and residue transporting. Wastes are weighed and registered before unloading, and based on that charged (gate fee). Suppliers are the ones who pay, so they are also customers. Usually waste is not stored before production, and therefore it is unloaded straight to plants. However, residues are stored before their placement.

Either a producer company or a raw-material supplier can be responsible of raw-material transport execution and costs. Transportation distances in bio-wastes and in residues are approximately 50 km, and in sewage sludge 70-80 km in average. In the case company, transportations are mostly outsourced but the case company has also three own trucks. According to one interviewee, it is beneficial to have own transportation equipment as well because it improves efficiency, and it could be good to have even more own vehicles. Another interviewee stated that it is not optimal to have own trucks but it was explained that it is still essential because the company's logistics partners' availability, reliability, and quality are not desirable. Therefore, they must have own backup transportation equipment to mitigate risks. Those logistics service providers are also considered as suppliers in this research.

In the figure, the two-headed arrow demonstrates activities that biogas producers execute with other supply chain actors. The contracts part means agreements that are made about quantities, quality, indexed prices, and other policies before cooperation. The business depends on contracts which require, for instance, adequate market knowledge, and interaction skills. The aim is to settle long-term, approximately 5-10 years, contracts. In the residue sector, there are also written contracts but in addition, customers place orders occasionally and those serve as informal agreements. There are also oral agreements in that sector but those are not reliable, since often things do not happen as agreed. Overall, low price and minimal cost contracts are optimal. The production management implies that producers supervise the processes, for example, decides in which biogas plant raw-materials are transported. This optimization is especially done after the biogas is produced and when only residues remain, then decision about its placement and storing need to be done.

Material, cash, and information flows are demonstrated in the figure 4. Suppliers deliver materials to biogas producers, and they deliver residues to residue handlers, so the flow moves from left to right. Cash flow goes in multiple directions. Raw-material suppliers pay to biogas producers for being allowed to bring waste to their plants. Sometimes residue handlers pay from the residue, and in some cases biogas producers pay to residue handlers for being able to get rid of their residues. The

residue placement is getting more difficult because of a market change. Residues has significantly less demand, for example, because agriculture companies do not want to utilize sewage sludge based products in their business. However, the target in the residue sector is that at least transportation costs are paid by residue handlers. Finally, information should flow constantly and extensively within a supply chain, and therefore the arrow is two-headed in the figure 4.

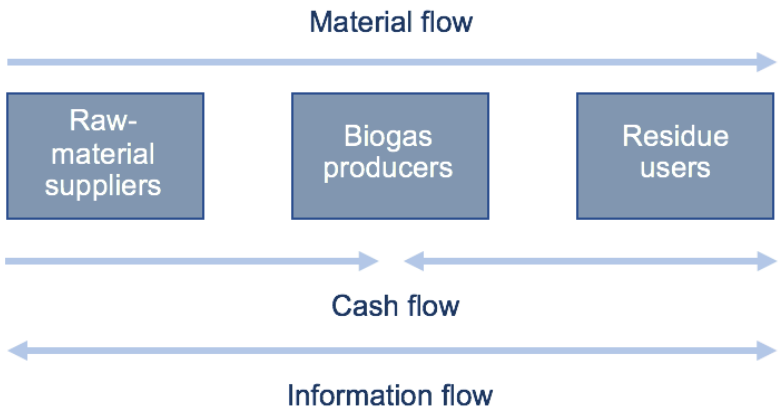

Figure 4. Material, cash, and information flows in the supply chain of biogas production.

5.1.2 Sustainability

EU regulations determine that renewable fuels need to have a certain emission reduction percentage, which is calculated by comparing emissions to fossil reference values. The reduction calculation includes the whole biogas supply chain, for example, transportations, used electricity and water, chemicals, and methane emissions. The results need to be 50 % in old and 60 % in new plants. The factors that affect the emission reduction percentage the most are; the use of electricity and fossil fuels, and methane emissions. Transportation logistics cause about 15 % of the emissions.

Therefore, it is optimal that, for instance, raw-materials are local so that transportation distances are as short as possible. Additionally, in the case company transportation equipment is selected so that the emission reductions are considered, and the logistics partners take care of route optimization. EU is

constantly making regulations stricter. For example, emissions caused by heavy duty vehicles need to be reduced by 15 % by the year of 2025. Therefore, the biogas industry has a huge potential in the future. The case company's aim is to get their partners to operate with, for example, liquid biogas trucks eventually.

The case company's sustainability efforts include, for instance, sustainability system, environmental management standard ISO 14001, energy analysis, life-cycle analysis, carbon footprint and handprint calculations, and responsibility reporting. Currently data used for reporting is shattered, and it would ease the reporting process if it would be more easily accessible. The company is focusing on safety, which is why they do, for instance, risk evaluations, safety meetings, safety and environment observations, inspections, and highlights safety by organizing campaigns to communicate safety issues. Additionally, the case company implements internal and external audits to ensure that plants fulfill criteria of their sustainability system.

5.1.3 Performance measuring

The aim was to review the current performance of the case company's supply chain by examining supply chain performance metrics, and to reveal some improvement needs through the results. However, it turned out to be more complicated to get information about performance measurement systems and key performance indicators (KPIs) than expected. First, mixed information about the systems were brought up in the interviews, but later the person leading the biogas unit explained that: "First comes processes, then information systems, and then when we have the data then based on that we can build business intelligence". Now the company is in the situation that they can start to build metrics, for example, for measuring waiting times. Currently the best measure is that all the volumes can be handled. The respondents agreed that there are no exact supply chain performance related KPIs but these metrics were still mentioned during the interviews; EBITDA, revenue, average gate fee per ton, cash flow, capacity utilization, production volume, safety aspects, supplier audits, customer feedback, sustainability criteria fulfillment, energy efficiency, and the quality of the fertilizers.

When adequate data is available, it is essential to start to measure supply chain performance, and build metrics that are related to supply chain (Gunasekaran et al., 2001) and strategic goals (Beamon, 1999) because the most important thing is to know what is currently happening to be able to proceed forward. The mentioned metrics above include both financial and nonfinancial measures, which is optimal (Brewer, Speh, 2000). It is important that the amount of metrics is sufficient, and that everyone knows what is being measured and why. Metrics in the case company could be created and modified by following, for example, the Beamon's (1999) measurement groups: resource, output, and flexibility. The interviewees already brought up metrics related to each group but organizing the current metrics, and determining KPIs related to supply chain performance would be necessary.

The interviewees were asked to disclose results that current measures have indicated. It was disclosed that the target is always to be better than before but currently the business is growing, significant investments are done, and distinct things are emphasized during different years, which causes challenges for financial results. In one interview, it was mentioned that there are quite a lot odor harms but otherwise the measurement results, for example, the quality of the fertilizers has been good. Additionally, currently it is not possible to get measurements, for example, from fugitive methane emissions, which is a weakness.

5.2 Supply chain operations of the case company

After reviewing the background of the case company, analyzing the supply chain operations of the case company can be commenced. The analysis will include both strategic and operational aspects. However, first the critical goals and flexibility of the case supply chain are examined. The most critical targets are operational reliability and cost-efficiency. Additionally, overall efficiency, full utilization of capacity, minor emissions, fulfillment of environmental, safety, and legal targets, trustworthy partners, and transparency of cost impacts are aspects that were also disclosed in distinct interviews. Furthermore, it was highlighted that it is important that production management and logistics are transparent, and that the supply chain can be visualized. It was explained that it would be important to track where does a

raw-material come from, what is the material, in which plant does it end up, and finally where are residues from it placed after the biogas production.

In the reviewed theory, for example, responsiveness to changes and flexibility are aspects that were identified to occur in excellent supply chains (Agrawal, Shankar, 2002; Steward, 1995). Occurrence of these aspects in the case were investigated by asking a question about change management abilities in daily basis and long-term in five of the six interviews. All the respondents agreed that change management is in a good shape, and two respondents brought up the market change and the wet year of 2017, which complicated the residue business. The interviewees were pleased about the company's ability to be flexible, and respond to these significant changes by keeping up the production, receiving loads, and dealing with all their obligations. However, one respondent stated that development is needed in reacting to unexpected situations in the biogas plant network. For example, it would be important to react and make decisions quickly, in some cases take risks, and be productive.

5.2.1 Integration level

Supply chain integration can comprise only suppliers and customers (Frohlich, Westbrook, 2001) or along with those also internal aspects (Flynn et al., 2010; Chen et al., 2009). Respondents mostly considered internal aspects. One interviewee approached the question from management point of view, and stated that every plant is a separate cost center but the production management is centralized. Three respondents explained that since the biogas company is rather young and still growing, parts of plant operating manners might vary within the network but all of them did not assess this as a critical problem. However, it was stated that the aim is to standardize processes and productize services but, for example, public procurements sets constrains. Additionally, permissions vary between plants according to raw-materials, fertilizers, and use of biogas.

Two interviewees considered both internal and external aspects, and explained that there has been significant progress in the integration, and further improvements are

possible through a new, soon released, ERP system which reduces manual work and helps in process optimization. The system is partly in use and partly in a trial phase. The enhancements concern, for example, better internal communication, and development of a raw-material delivery schedule. The aim is to create an online scheduling system that both the case company and its suppliers could utilize for planning production, accurate process capacity, delivery schedules, and for tracking, for instance, waiting times. This could enable more accurate short-term predictability, and enhance the biogas production process through stable flow of raw-materials. There are also improvements needed externally, and the aim is, for example, to implement supplier audits. Currently, the performance and objectives of critical logistics partners are monitored to maintain and develop the relationships.

Simatupang et al. (2002) and Prajogo and Olhager (2012) brought up multiple perspectives, which they found to have an effect on supply chain integration in their studies. In the two researches, logistics and information flow/sharing were unifying themes. In this case, the respondents' enhancement ideas concerned similar aspects. The mentioned delivery schedule is both related to information sharing and logistics, internal communication is directly related to information sharing, and logistics partners' performance reviewing to synchronized logistics. Additionally, the last one concern long-term relationships, which was also mentioned to be critical in achieving integrated supply chain (Prajogo, Olahger 2012).

Process integration can involve process simplification, which is the other essential element of integration in the study conducted by Chen et al. (2009). It is apparent that process simplification is not done frequently nor determinedly in the case company. It is recognized that it would be necessary but proper actions are not done yet, partly because processes need to be formed in a wider scale first. However, some aspects had been considered. It was emphasized that everyone's responsibilities need to be clear to avoid, for example, double work. This is in line with the article written by Brewer and Speh (2000), where the authors recognize that if there is a lack of integration, tasks might be done multiple times. Additionally, Chen et al. (2009) claim that simplification can be enhanced through decreasing complexity, and eliminating unnecessary activities.

The considered integration level of the supply chain varied quite a lot in the interview answers. There might be variations because of different viewpoints and positions that respondents have in the organization. Additionally, it turned out to be slightly difficult to explain what was meant by the question about integration, and its aim, for example, to minimize non-value-add activities (Steward, 1995). However, it can be interpreted from the interviews that there have been efforts to improve the connectivity of the biogas plant network and supply chain. The supply chain could still be more integrated, and a holistic view for process optimization would be necessary.

5.2.2 Material flow

The case company is aiming to have smooth and cost efficient material flows but recently the most important thing has been securing the production. There have been complications in efficiency because of the market change. Additionally, the material flow is not always the smoothest because of, for instance, load reversals to other plants, and inefficient old contracts within the supply chain. Currently, there is a lot manual planning work in the logistics sector which also reduces efficiency. Along with optimal material flows, also the earlier mentioned better material flow traceability would be important. All in all, logistical solutions are crucial because materials are cheap, and therefore logistics costs have an important role in the overall profitability.

Transportations in the case company are mostly outsourced, and suppliers do, for example, route optimizations. Wilson (2007) suggests that risks in transportations can be minimized by planning alternative routes and modes but since those are suppliers' tasks originally, the case company does not mitigate risks in that way. They have a few own trucks, which can be used if disruptions occur. The case company plans and forecasts transportation needs, and coordinates the suppliers. During the interviews, it was strongly highlighted that it is important, that the coordinating is done by the case company, even though the operational actions are implemented by the suppliers. This was clear in the top management level, but not that evident in the operational level, and therefore emphasis on this is needed.

In practice, a part of the coordination is that every biogas plant has their own contract base, which includes information about raw-material suppliers; how much materials each supplier supplies, which logistics supplier is used, and what is their weekly schedule. Based on the information, free capacity and utilization rates are analyzed, and decisions with salespersons about raw-material receiving possibilities and prices are made. This type of management is done weekly. The organizing work will be less manual with the new ERP system, which will include information also about overall capacities. Capability to coordinate material flow in a way, which would improve gas production will be improved as well.

The case company's suppliers deliver raw-materials principally as agreed in contracts but in several interviews, it was disclosed that sometimes waiting times to unload charges are long, and those cause costs for the case company. Since vehicle scheduling and information exchange affect delivery performance significantly, and controlling capacity utilization can have an impact on supply chain performance (Gunasekaran et al., 2001), the delivery scheduling system would be essential to deploy. Additionally, the earlier mentioned transportation management and coordination are critical for delivery performance. For example, Da Silveira and Arkader (2007) found that supplier coordination has positive impact on delivery performance. Currently, the case company is not tracking delivery performance but when the scheduling system is put into effect, for instance, on-time deliveries can be measured, which is a valuable metric (Forslund, Jonsson, 2010). With the system, it could also be monitored whether the waiting times originate from suppliers' or the case company's performance, which affects costs.

Storing possibilities were examined, and it was disclosed that there are only small storing facilities for raw-materials, and the aim is to put everything to the process straight away. This reduces the possibility to balance deviations between demand and supply, and to protect availability (Gudehus, Kotzab, 2009, 271). In the case company, raw-material availability is a plant-specific issue. The aim is to balance arriving loads in the network so that the production is not too hard, or that plants would not lack raw-materials. However, if the distances between raw-materials and plants are long, or commercial utilization of biogas is not desirable, balancing is not

done. Currently the plant utilization rates are good but in the plants where the rates are too high, raw-material prioritization could be an alternative option. However, prioritization possibilities also depend on biology, process suitability, and on contract obligations. Additionally, environmental permits restrict and determine what materials can be utilized in the production process.

Since there is hardly any inventory, possibilities and needs to expand storing facilities for raw-materials were investigated. It was explained that raw-material storing is strictly regulated, and therefore expanding might not be possible. However, it has been discussed in the case company that it would be beneficial to have a storage bin for strongly responsive raw-materials. Contrary to raw-materials, residues require a lot of storing capacity because those can be used only twice a year. The company is all the time expanding residue storing facilities, and evidently, there is still a constant need for more space. The fact that, for example, fertilizers can be spread to fields only during autumn and spring time causes, for instance, storage costs, and possibly disposal costs retroactively. Additionally, if the spreading does not pull off during the seasons, it causes even more costs, and apparently, there are always troubles during the spreading times.

Inventory scheduling mentioned by Gudehus and Kozab (2009, 272) is not practiced in the residue business because storing cannot be affected by scheduling, since residues could be reduced only by decreasing the whole biogas production, or by innovating new ways of treatment. However, raw-material demand anticipation is done to be able to coordinate capacity utilization in the biogas plant network. In addition, delivery anticipation possibilities could be enhanced through gathering information about how full raw-material providers' trash storages are. Currently this type of data comes from a few big providers, but maybe in the future more gauges could be installed to trash storages. Additionally, the case company rarely orders raw-materials, and those are mostly delivered according to agreements, and to waste management necessities of the providers. In the future, if feeds are changing, it could be possible that the company would also order raw-materials, and then it would require different type of planning.

5.2.3 Cost-efficiency

It is essential to separate, which costs origin from inbound and which from outbound logistics. It should be also noticed that ideal and actual costs can be different. Logistics costs and handling costs need to be considered in contracts and in sales prices but inefficient processes cannot be included in prices. Therefore, efficiency in the case company could be enhanced through investigating every contract, and identifying whether the problem is the process or the price. Plants' locations also affect efficiency and costs substantially. To examine and make improvements, overall transparency of logistics costs in customer and contract level should be better.

Logistics costs were not commented more precisely in any interview, which is why total logistics costs in the case company cannot be determined in this study. This is unfortunate because, for example, Rentizelas, Tolis and Tatsiopoulos (2009) argue that significant portion of costs in biomass energy generation results from logistics operations. However, it was disclosed that transportation costs are significant in the case company, which correspond to the argument of Thomas and Griffin (1996) about transportation costs covering a big part of total logistics costs.

Cost-efficiency was defined to be one of the most critical goals of the supply chain in the interviews, and similarly Fiedler et al. (2007) state that "cost-efficient supply logistics are a prerequisite for a competitive production of bio-energy." Therefore, overall cost reduction possibilities were examined. Multiple ways how costs could be decreased were exposes, for example, procurement of utility goods could be optimized, strategic partners for residue operations added, value for residues created, and capacity of pretreatment could be improved by adding shifts for plant operatives. Additionally, suitable plant utilization rates, plant maintenance are important, and overall optimization of transportation costs are important factors. To gain cost-efficient material flow, also contracts need to be made or modified so that those enable raw-material transporting to plants where costs are the lowest.

In addition, other improvement needs related to contracts arose multiple times during the interviews, and the mutual goal seemed to be reduced costs. It is suggested that contracts need to be centralized to achieve better prices through the higher volumes. However, the company cannot be dependent on a one partner either, which is why they need back up. Contracts could be tendered more often as well. Prices must be competitive but it is not always the best option to select the cheapest agreements. Benefits, such as, reliability should be considered as well. Contracts have been reviewed also from sustainability viewpoint to ensure that those correspond to the case company's sustainability system and to Nordic Swan Ecolabel.

5.3 Supply chain relationships

Supply chains consist of multiple companies, and relationships between the actors are closely involved when assessing and enhancing supply chain performance. In this section, the aim is to figure out what type of relationship does the case company have with its supply chain partners, how and what type of information do they exchange, and to examine development possibilities for supply chain partners' performance. It was challenging to get comprehensive data about the subjects, because all the respondents told only few words about the co-operations. Explanations for this could be that the asked questions were not explicit enough, the relationships are self-evident and therefore difficult to describe, or that the company's focus is not on the supply chain relationships, which affects the ability to analyze the relations. Nevertheless, specifying questions were inquired constantly, and finally, a sufficient amount of information was successfully gathered.

The case company has both transaction oriented relationships and more strategic collaborations with its supply chain partners. An estimation is that a third of the overall relationships could be described as collaborations. There are a few strategic raw-material suppliers and logistics partners, who help to balance and adjust capacities and optimal processing in the plants. These suppliers are long-term partners, and a strong trust exists between the actors, which is desirable since trustworthy partners is one of the critical aims of the case supply chain. There are

operation improvement projects with some large and crucial raw-material suppliers, and in those relationships both parties are dependent on each other. The mentioned relationships characteristics correspond to collaborative relationships well. For example, long-term cooperation (Boddy et al., 2000), common development projects (Agarwal, Shankar, 2002), mutual dependence, and trust (Ploetner, Ehret, 2006) are characteristics, which are equal in previous researches.

In addition to the mentioned co-operations, for example, public authority relationships are also essential in the case company. The company has built convenient relationship whit them through open co-operation, and by acting as agreed. On the other hand, there are also transaction-oriented relationships, for example, with suppliers who just deliver raw-materials every now and then. Conflicting with other respondents' opinions, one interviewee described that all the inbound logistics partners are transaction oriented, and that there is no need for developing those relationships towards collaborations because those involve only bulk products.

In the residue part of the supply chain, the cooperation is tight and the market is being created with the supply chain actors. There is also common research and development work with the partners. Even though the actors are described as strategic partners, some weaknesses also arose in the interviews. The business cultures and policies are different in agriculture companies than in the case company. Similarly, Boddy et al. (2000) recognize that cultural differences between partners can cause problems. Additionally, the case company should align the strategy better; whether to focus only on the main energy business, or to other business sectors, for example, to residues as well. Currently, the case company do not have the fertilizer market know-how nor the resources to focus on that. However, they have not outsourced the function either, and therefore changes and make-or-buy decisions are needed.

It is construed that the relationships are important in the supply chain of biogas production, for instance, because partners are essential in transportations and in the residue markets. Based on the interviews, it could be argued that the focus has

not been enough in the relations, since there are still strategical issues and contrary opinions about the relationships. It would be beneficial to scrutinize the big picture and constitute frames, and then put emphasis on selected strategic relationships. This seems to be considerable option also because opportunistic behavior has not occurred in relationships between the case company and their partners, and it is not considered as a significant risk in the future either. However, opportunism is one principal risk of collaboration (Handley, Benton, 2012), which is why loyal partners are crucial.

If collaborations would be enhanced, especially in the residue business field, it could help to tackle, for example, difficulties caused by the market change. The nature of collaboration is inimitable, which improves competitive advantage (Jap, 1999). Additionally, since there are strategical questions, collaborations also enable participating companies focus on their core competencies (Ploetner, Ehret, 2006), which in this case is energy business. The plant network and relationships in it should be examined as an entity but one interviewee stated that it is a plant-specific decision whether to develop more collaborative relationships or not, which is why case by case assessing and adapting is also needed. Additionally, it should be considered that collaborative relationships are not recommended for every partner (Moeller et al., 2006).

5.3.1 Information flow

Currently, information sharing within the case supply chain is not transparent enough, and information is not shared continuously. There are communication weaknesses especially in the agriculture sector, which is related to the residue business. The new ERP system will support both external and internal communication and anticipation possibilities in some areas in the future. IT systems help, for instance, to share real-time information, and to increase the amount and complexity of the shared information (Prajogo, Olhager, 2012). The case company is already providing real-time information to a few partners about their deliveries, and the aim is to expand this to other partners as well. One part of information sharing is also that the case company gives data to raw-material suppliers about

the materials they have provided. Currently the data is scarce, and therefore the case company is aiming to do their supply chain more transparent to be able to share information, for example, about how much gas has been produced from a certain supplier's waste. The suppliers could utilize this type of information, for instance, in their sustainability reporting.

The frequency of communicating and exchanging information with supply chain partners seem to depend on one's position in the case company. Some interviewees stated that they are in contact with partners daily, and some are aiming to communicate with strategic partners monthly. It is explained that the communication happens in three different levels; managers meet yearly, salespersons do proactive customer management, and operational level, for example, reacts to changes. However, there is no formal way to communicate. It can be interpreted that there is frequent information sharing between the supply chain actors in the case company, which is crucial. Prajogo and Olhager (2012) state that the frequency along with quantity and quality are the most important things in information exchange.

It was expressed that relationship maintenance is not sufficient, and frequent cooperation cannot be done. A statement arose that after sales the relationship maintenance cannot be production's responsibility, because there are no resources for that. It was wished that post marketing responsibilities would be more clearly designated. This post marketing issue, and proactive customer management were discussed because in the case company suppliers are also customers as mentioned before. In this part, the lack of one interview has an impact, because sales point of view about the topic above could not be examined. Nevertheless, it is important to try to fix the information sharing shortages because lack of information cause uncertainties (Yu et al., 2001) and effective communication affect significantly on supply chain performance (Cheng, Huang, 2007).

5.3.2 Supply chain partner development

In the chapter 3.3, previous researches are concentrating on supplier development but in the interviews the aim was to find out performance development actions and

possibilities with any actor in the case company's supply chain. The exploration started by examining whether the performance of supply chain actors fulfill expectations. If shortages were identified, then development possibilities were asked because, for example, supplier performance is essential in maintaining competitive advantage (Humphreys et al., 2004). Additionally, since the interviews were semi-structured, in some cases, conversation about performance development needs evoked naturally.

It was disclosed that the performance of the supply chain actors does not fulfill expectations entirely, for example, partners who are not fulfilling contract obligations cause a lot of additional work. Problems concern, for instance, quality of services, regularity, and cost levels. Issues arise mostly with small-sized companies whose operational reliability is insufficient. Even though the case company would not be satisfied with the service that they are receiving, they do not always have a possibility to change partners because of, for example, a lack of operators with suitable equipment. With logistics partners, problems arise occasionally in the raw-material unloading process. Drivers who deliver raw-materials, do not always obey rules, which may cause process disruptions. Uncertainties also appear in the agriculture interface, and it is, for example, claimed that sometimes the case company questions if they get what they pay for. To avoid this, agriculture companies' procedures could be more transparent so that doubts would not arise.

The case is optimal for considering performance development initiatives because the case company is not fully content with their supply chain actors' performance, and they do not always have the option to change partners. The necessity for partner development has been recognized in the case company, and some actions towards enhancements have occurred. Krause and Ellram (1997a) mentioned that supplier development can include supplier evaluation and performance improvement requests and these the case company has implemented. The main partners' safety related issues and operation procedures in the biogas plants are audited regularly. Novel supplier audits will also be started in Autumn 2018, and the target is to ensure that suppliers' operations correspond agreements. Currently, suppliers fulfill a foreknowledge document before co-operation, and based on

information in those suppliers for audits are selected. If shortages are found, the aim is to develop performance together, and the last option is to end the co-operation. This is desirable because switching costs are usually high (Krause, Ellram, 1997a).

Since the agriculture sector is challenging for the case company, they have also decided to develop closer cooperation with partners who could act as intermediaries between the case company and agriculture companies. The case company does not have the know-how about the fertilizer and nutrient markets, and that is not the company's core business either, which is why it needs reliable partners. This is not directly residue partner development but it affects them indirectly. Currently there is a successful cooperation with one company whose services can be used in one biogas plant's residue placement operations. The person responsible of directing explained that clear strategic policies, long-term commitment, trust, top management involvement, aim to create a win-win situation, and proof of functionality have been behind the success of developments. Narasimhan et al. (2008) state also that steady relationships and trust are needed to be able to succeed, and Routroy and Pradhan (2013) agree with strategic goal, and top management commitment aspects.

There have been also aims to develop the raw-material unloading operation in the plants, and partly the initiatives have been successful. This has included information and knowledge sharing, which Wagner and Krause (2009) define to be a part of supplier development, and Modi and Mabert (2007) identified to correlate with supplier performance improvement. Currently the performance of permanent drivers is in adequate level, and troubles are usually caused by drivers who are not used to work at biogas plants. Therefore, development ideas for unexperienced drivers who unload raw-materials to the biogas production process could be created in the company. Additionally, Krause and Ellram (1997a) recognize that supplier's personnel training can be involved in supplier development, and that could be also beneficial to implement. The current development initiatives have been moderate so in the future it is important to be determined and set goals, and define how to achieve the goals (Wagner, Krause, 2009). Additionally, putting effort and active communication are important (Krause, Ellram, 1997b).

The respondents were quite open-minded, and felt that there would be possibilities for developing their partners' performance more but also some barriers were identified. The earlier mentioned problems with the quality of small logistics partners' services were brought forth. The current partners cannot commit, for example, to equipment investments, and the case company cannot make long-term contracts in this sector, which the small-sized partners would need, because the industry is in a turning point. A question about who would carry financial risks also arose. It was claimed that suppliers' performance cannot be assessed ultra-critically, and that currently the aim is to manage risks and costs in the changing environment. Nevertheless, these barriers do not rule out the possibility to develop the raw-material unloading process, supplier performance based on audits, neither to develop cooperation with intermediary partners between the case company and agriculture companies. In the mentioned fields, enhancements are started but more work needs to be done. Supply chain partner performance improvements could, for example, improve quality of services and reduce costs (Humphreys et al., 2004).

When the case company continues to implement development programs, attention should be paid to the success factors; clear strategic policies, long-term commitment, trust, top management involvement, aim to create win-win situations, and proof of functionality. Additionally, illustrating benefits and offering personnel support to suppliers, and focusing on controllable amount of initiatives is helpful (Handfield et al., 2000). The table 2. below conclude the supply chain partner development findings. In the table, the improvement idea is partner development, and the areas where partner development could be done are presented below that. The partners which the development areas concern are also disclosed, and specifying notes added.

Table 2. Supply chain partners' performance development possibilities.

Improvement idea:	Partner which the development concern:			Notes:
Partner development:	Raw-material suppliers	Logistics service suppliers	Residue placement partners	
Identify, and then improve shortcomings	x	x		Audits coming
Co-operation with intermediaries			x	Indirect, to get market know-how
Quality		x		Investment and commitment barriers
Raw-material unloading process		x		Personnel training for unexperienced drivers
Tackle uncertainties			x	More transparent procedures for partners

5.4 Biogas industry trends and future

Biogas industry is growing but also changing rapidly, for example, the mentioned market change affects the fertilizer business. There is no longer enough demand for sewage sludge based fertilizers in agriculture. The case company, and other companies in the industry as well, need to develop different residue handling options and technologies in the future. Additionally, new ways to create value for fertilizer and nutrient markets should be sought. These require significant investments, which is why competition is decreasing. Additionally, price levels are in a turning point. Raw-materials that are hard to process are getting more expensive, and prices of raw-materials which are easy to handle are decreasing. Residue placement costs will be also considered in the processing prices in the future. There is also a new plan for waste in Finland, and an EU recycling directive, which both increase the need for biogas plants.

Investments, for example, in novel treatment manners are needed because of the market change. But investments are also necessary since the aim is to grow the business. Those investments concern, for instance, new plants and feeds. If the

feeds are changing, the supply chain will become longer and storing costs will increase, which demand efficiency considerations and emphasized SCM. However, capacity needs to be pushed up to get more biogas, either by producing or buying more biogas. Currently, the case company's business is dependent on gate fees, and biogas utilization rates need enhancement, which is why market development and new feeds are needed. Two interviewees agreed that one of the main targets should be enhancing the utilization of the produced biogas. The case company's ideas about new feeds and ways of treatment correspond to Brewer and Spehs' (2000) process innovation – improvement idea. However, these changes require careful preparations, and, for example, sustainability need to be ensured.

New plants are also an option, but it was noted that there must be a significant raw-material supplier in a certain area that it would be profitable to invest to a new plant. Additionally, strong market knowledge and flexibility are needed, and risks need to be mitigated by not relying either on a one supplier or a feed, and by making long contracts. However, biogas is always a regional solution, since the optimal way is to produce biogas in the vicinity to feed sources, which is why biogas plant network could be expanded.

5.5 Results

The case study findings offer extended awareness and details about the investigated theme for the case company and for others interested in the subject (Lapan et al., 2012, 244). The presentation of results will include both text and graphics. During the interviews and the analyzing process multiple improvement ideas were identified. The ideas varied considerably, and the differences occurred especially between strategic and operational point of views. However, it was excellent that there were distinct perspectives because it makes the study more comprehensive, which was the aim.

Next, the key findings are revised, and results clarified in a written form. When the case company's background and the current state of the supply chain was examined it was identified that proper supply chain performance metrics did not exist.

Therefore, the case company should create a clear measuring system, and define KPIs to assess and track their supply chain performance. Currently, there are some metrics in use but those are not organized nor managed sufficiently, and therefore enhancements are necessary. Advices to build the metrics combination can be found from the performance measuring chapter 2.2.

Since the biogas plant network is not integrated enough, a holistic biogas plant network view is needed. The lack of integration became apparent, for instance, because communication shortages, and non-optimized processes were identified. The case company should also align their strategy better, and decide where to focus. The case company is an energy company, and they need to specify whether to concentrate on residue business as well. Furthermore, the company is also a waste management company but in the future, it could focus more on biogas utilization. This require strategical decisions, and careful partner assessing. After deciding the common goals (through aligning the strategy, and creating supply chain performance measures) also the integration level can be improved (Chen et al., 2009).

Material flows should be examined and traced in more detail to get product life-cycle information, for instance, about a certain loads origin and biogas yield. Additionally, delivery schedules are needed to enhance the biogas production process, reduce waiting times, improve predictability, and to track costs. Gauges could be installed to suppliers' trash storages as well, for example, to predict raw-material deliveries. Multiple cost reduction possibilities were identified, and those concerned mostly enhancing efficiency and contracts, optimizing transportation costs, and improving the transparency of logistics costs. Contracts should be examined and modified to enable transporting to plants where costs are the lowest, and identify whether the lack of cost-efficiency originate from the process or from the prices. Additionally, contracts need to be centralized and tendered more often.

Logistics suppliers' coordination could be emphasized, because even though, for example, route optimization is suppliers' responsibility, the case company still needs to control the operations, and provide beneficial information to their suppliers, for

example, concerning capacity and production. Guidance can concern also optimizing, for example, trying to avoid trucks to drive without loads. This coordination can also enhance integration (Chen et al., 2009).

The case company should focus on clear responsibilities, for example, it should be clarified how and who handles post-marketing actions. Currently, the relationship maintenance is not in the wanted level, and there are no resources to do it frequently, and therefore changes are needed. In addition, the case company should concentrate on their core competences, which means that since the company do not have the fertilizer market know-how, they should not focus on that but rather build strategic partnerships with companies who have expertise on that business field. However, it should be noted that implementing this type of collaboration is time-consuming, and might be hard. Therefore, it must be carefully decided with whom to collaborate, and build trust first.

In the interviews, the respondents perceived their relationship types differently, which indicates that the case company could clarify their relationship aims better. The division between strategic partners and transaction-oriented suppliers should be evident. External and internal communication and information sharing is partly good but improvement possibilities were still identified. The development possibilities concern transparency and continuity, real-time material flow information, and the agriculture sector. Generally, information sharing is recommended but confidential information should be shared only with strategic partners. Additionally, in the residue business all contracts should be in a written form, to ensure that contract obligations will be covered. Supply chain partner development is also one way to enhance supply chain performance, and the development areas were presented above in the table 2.

The company has recognized that in the near future they, and other biogas companies as well, need to do changes in their business since the biogas industry is in a turning point. For example, biogas market could be developed, and utilization of biogas increased. Because of the market change, also new treatment ways need to be developed, and value for residues created again. Additionally, new feeds could

be utilized. All the identified improvement ideas are gathered into the table 3. The ideas can be seen vertically in the second column from the left.

Table 3. Improvement ideas for supply chain performance in biogas production.

Performance improvement idea:		**Ideas concern:**		
		Logistics Services	**Raw-material Supply**	**Residue Placement**
Create supply chain performance metrics		x	x	x
Supply chain operations	Holistic biogas plant network view	x	x	x
	Align strategy		x	x
	Deploy delivery schedules	x	x	
	Track material flows	x	x	x
	Gauges for trash storages		x	
	Reduce costs	x	x	x
	Review contracts	x	x	x
	Emphasize logistics suppliers' coordination	x		
Supply chain relationships	Clear responsibilities	x	x	x
	Focus on core competences			x
	Relationship maintenance	x	x	x
	Clarify relationship aims	x	x	x
	Improve communication & information sharing	x	x	x
	Partner development	x	x	x
	Written contracts			x
Industry trends & future	Biogas market development	x	x	x
	Increase utilization of biogas	x	x	x
	New residue treatment ways			x
	Create value for residues			x
	New feeds		x	

The research structure was divided, and the semi-structured interviews included the themes, which are presented in the first column from the left in the table 3. The themes are supply chain operations, supply chain relationships, and industry trends and future. However, the “create supply chain performance metrics” idea is presented separately because it concerns all the mentioned themes. The division of improvement ideas based on the themes is illustrated in the figure 5 below.

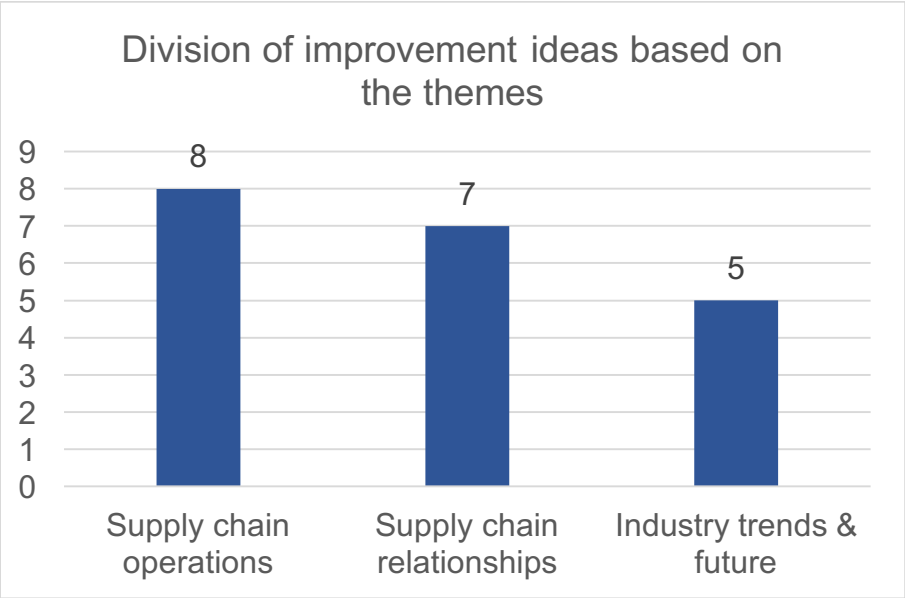

Figure 5. Division of improvement ideas based on the themes.

The “x” marks in the table 3. illustrate the supply chain phase, which the performance improvement idea concern. It can be seen in the figure 6. that the ideas concern almost evenly all the supply chain sectors. 34 per cent of the ideas are related to raw-material supply, and almost the same amount, 36 per cent to residue placement. A little bit less, 30 per cent, concern logistics services.

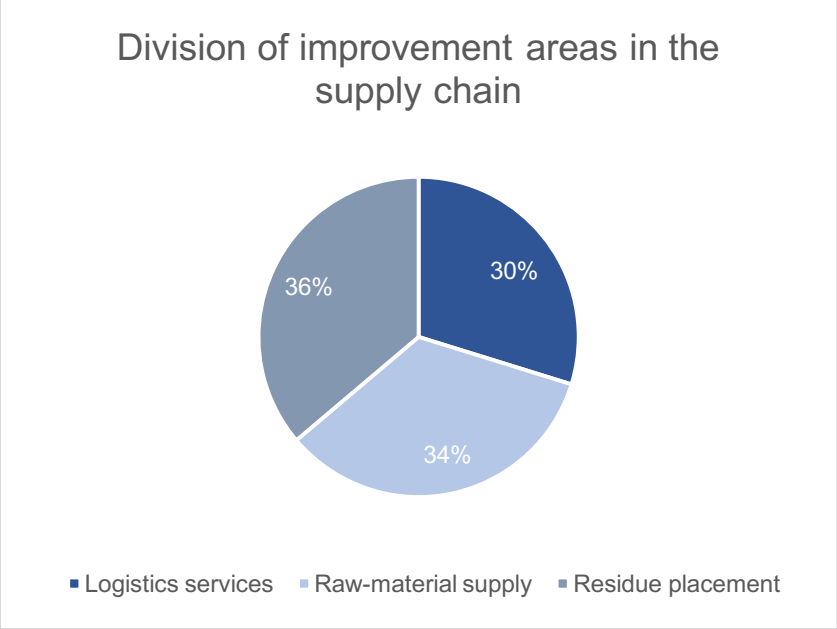

Figure 6. Division of improvement areas in the supply chain.

There are multiple areas where development efforts are already started in the case company. The company is, for example, enhancing their ability to be more proactive in production planning, and creating the raw-material delivery schedules. Customer-specific profitability and efficiency are being evaluated, and plant utilization rates, biological processes and logistics costs are being enhanced through production management. Additionally, the new ERP system will be deployed soon, and it can partly improve, for instance, information sharing, and capability to coordinate material flow, and it can also reduce manual work. However, the improvement efforts need to be continued as found in this study.

6 CONCLUSION

This research extends knowledge about efficient supply chain performance in biogas production. The study combines multiple aspects related to the topic aiming to identify comprehensive improvement ideas based on previous literature and empirical findings. The aims were achieved, and the results are summarized in this chapter. The summary is conducted on grounds of the research questions. Additionally, this chapter includes points about theoretical and managerial implications, limitations, and suggestions for future researches.

6.1 Summary

The main research question was how to improve supply chain performance in biogas production. Weaknesses were searched from logistics, raw-material sourcing and residue placement activities. Multiple (21) performance improvement ideas were identified, and those were related to supply chain performance measuring, supply chain operations, supply chain relationships, and to industry trends and future. The findings are concluded more closely by examining the three sub-questions.

The first sub-question was related to the current state and future orientation of the case company. Basic facts about biogas, supply chain of biogas production, and about sustainability aspects were examined and presented. It was found out that there have been development efforts constantly to improve the supply chain in question because the supply chain in its current form is roughly new. The exact current state was challenging to analyze because the case company do not have proper supply chain performance metrics in use. This resulted the first improvement idea: to create supply chain performance metrics. Otherwise, the current state examining extended to the whole research because all the improvement ideas were constructed based on the case company's current state. The future orientation was investigated by identifying trends. It was find out that the biogas industry is in a turning point and that significant changes are needed. The shifts concern biogas market development, utilization of biogas, residue treatment and value, and feeds.

The second sub-question concerned possibilities to improve supply chain operations. It was identified that the network is not yet holistic, and the strategy is not focused enough. It was recognized that it would be crucial to have delivery schedules, and the case company is aiming to deploy those as soon as possible. To gain extended knowledge, material flows could be tracked which could benefit both internal and external stakeholders. To support predictability, gauges for suppliers' trash storages could be installed. Multiple areas where cost reductions could be made were identified, and it was emphasized that contracts could be reviewed to identify weaknesses, and to make modifications. Additionally, logistics suppliers' coordination could be emphasized.

Supply chain relationships were also reviewed because the third and final sub-question concerned relationship development possibilities. It was figured out that relationships maintenance could be better, and that responsibilities who implements that clearer. Overall, clear responsibilities are important because through that, for example, double work can be avoided. The aim of each cooperation should be clarified, and after that strategic supply chain relationships could be enhanced, and utilized even more to enable the case company to focus on their core competences. All contracts should be written, and even though information sharing is partly good there were still some shortages identified as well in that field. In addition, partner development could be utilized because it could enhance the overall performance of the supply chain, and support the partners' ability to fulfill expectations.

6.2 Theoretical implications

The theoretical part of the research was conducted based on previous journal articles and e-books, and it was not aiming to extend theory but rather to utilize it to investigate the selected case. However, material was built to support future theories, and some interview responses included aspects that were in line with previous literature.

For example, characteristics of collaborations were similar as in previous researches. It was identified that with strategic partners the case company's

relationships are long-term, trust exists, there are common operation improvement projects, and both parties are dependent on each other. Boddy et al., (2000) also recognized the long-term view, Agarwal and Shankar (2000) the common development projects, and Ploetner and Ehret (2006) the mutual dependence and trust. In addition, supply chain partner success factors disclosed in this study: clear strategic policies, long-term commitment, trust, top management involvement, aim to create a win-win situation, and proof of functionality corresponded to earlier studies as well. Narasimhan et al. (2008) state also that steady relationships and trust are needed to be able to succeed, and Routroy and Pradhan (2013) agree with strategic goal, and top management commitment aspects.

6.3 Managerial implications

The managerial implications concern the identified supply chain performance improvement areas of the case company, and argued benefits are constructed based on the previous researches, and the findings presented earlier. It is assumed that this study will provide beneficial information for the case company, and possibly to their stakeholders, and other companies in the same business field as well. Even though the improvement areas are gathered through interviewing the case company's employees, the results are valuable because shattered ideas, experiences and knowledge were combined which can support future improvement initiatives. Additionally, by asking questions, interpreting and combining data, new information can be revealed.

It is essential to create supply chain performance metrics because those can reveal efficiency and quality improvement needs (Chan, 2003), and results from metrics provide information about a current state which can enable a company to proceed forward. Process integration is important as well, for example, because of increasing competition, and increased significance of supply chains (Horvath, 2001; Fawcett, Magnan, 2002; Prajogo, Olhager, 2012). Processes can be optimized, and double work can be avoided if integration is enhanced. Additionally, if the strategy is aligned better, it releases resources, for instance, to focus on core competences.

The delivery schedules are crucial, because those enable waiting time tracking, more accurate short-term predictability, reserving an accurate process capacity, and stable flow of raw-materials. Those can also enhance operational reliability, which is a critical target of the case company. To gain extended knowledge, transparency, and traceability, material flows could be tracked. This was also identified to be one of the main goals of the case supply chain, and the tracking results could benefit both internal and external stakeholders. If gauges for suppliers' trash storages are installed, it could support delivery predictability.

There are multiple areas where cost reductions could be done to enhance cost-efficiency. For example, it was emphasized that contracts could be reviewed to identify, for example, are prices and efficiency in correct level, and is a utilized biogas plant the lowest-cost option. Highlighting logistics suppliers' coordination is necessary, because delivery performance, for example, speed and reliability can be enhanced (Da Silveira, Arkader, 2007), and optimal operations and accurate decisions can be ensured through that.

If relationships maintenance would be better, and responsibilities who implements that clearer, it would be beneficial because it could reduce the risks that actions are not efficient, partner practices opportunism, and that no one takes care of relationships. In addition, the aim of each cooperation should be clarified to know where to focus and put effort. After that, strategic supply chain relationships could be enhanced and utilized even more to enable the case company to focus on their core competences, which deeper specialization (Ploetner, Ehret, 2006). Collaborations are important because those can enhance supply chain efficiency (Gunasekaran et al., 2001) competitive performance (Prajogo, Olhager, 2012), flexibility (Chao, Zhang, 2011), productivity (Liu et al., 2010), and process integration (Agarwal, Shankar, 2002).

All contracts should be written to know, for instance, what payments concern, and to improve reliability. Communication and information sharing has positive affect on supply chain performance (Chen, Huang, 2007; Zhou, Benton, 2007), and those can reduce uncertainties, such as, delayed deliveries and machine breakdowns (Yu et

al., 2001). Partner development could be utilized as well because partner switching costs are high (Krause, Ellram, 1997a) and supplier performance has critical impact in competitive advantage. Through supplier development quality, cost, delivery, inventory, and/or lead time can be improved. (Humphreys et al., 2004) Additionally, in the case company's situation, supply chain partner's reliability, knowledge about processes, and agreement obeying can be increased.

The industry is in a turning point and significant changes are needed also in ways how to implement biogas business. The shifts concern biogas market development, utilization of biogas, residue treatment and value, and feeds. Reasons behind the change are that there is no longer enough demand for sewage sludge based fertilizers, the aim is to get more biogas, and that biogas utilization rates need development. If modifications are not made, it is claimed that biogas companies might face problems in the future.

6.4 Research limitations

The delivery of the ready biogas to end-customers and the biogas production procedures were left out from the study, and therefore the results concerned only functions from raw-material sourcing till residue placement. The limitation was made to avoid too wide research topic, and to focus on business perspective but if those operations would have been included to the study, the case supply chain entity could have been perceived better. Before the interviews respondents' working tasks were not know, only their titles were advised. Therefore, for example, preliminary interviews via e-mails could have supported the data collection process, because the most accurate questions could have been selected beforehand. Possible benefits that could be gained after implementing the suggested improvement areas are relying on findings from previous researches because any case specific calculations or testing was not implemented. Additionally, since only one case company was analyzed and sampling was purposive, the results cannot be universalized.

6.5 Future research suggestions

During the research process, it was noticed that many researches about material flows are based on complex mathematical equations. A future research could concern, for example, material flow success factors identified through a multiple case study method. Additionally, reviewed studies about supplier development included mostly supplier perspective (e.g. Handfield et al., 2000; Humphreys et al., 2004; Krause, Ellram, 1997; Li et al., 2012; Modi, Mabert, 2007; Nagati, Rebolledo, 2013; Routroy, Pradhan, 2013; Wagner, Krause, 2009). During the interviews, it was noticed that development efforts can occur similarly between any actor within a supply chain, which could be visible likewise in theoretical world. In this research, the term supply chain partner development was utilized, which could be applied in the future as well.

The supply chain of biogas production from raw-material sourcing till residue placement was successfully perceived as entity, and improvement ideas were comprehensive, which was the aim of this research but, in the future, one or a few found ideas could be selected and studied in more detail. Another idea is also to conduct a study that concern the excluded perspectives of the case supply chain, which are biogas distribution to end-customers, and biogas production procedures. Finally, it could be investigated whether the improvement ideas constructed based on the descriptive framework presented in the figure 1. will actually lead to enhanced supply chain performance. In this research, it was assumed that enhancements can be achieved because there is evidence that each of the included aspects have had positive impact on supply chain performance in previous researches. The effects could be examined within the same biogas context, or within any other manufacturing industry. If the context is changed, the supply chain phases have to be modified. However, no other study concerning supply chain performance in biogas production could be found which is one reason why this context is intriguing.

7 REFERENCES

Agarwal, A., & Shankar, R. 2002. Analyzing alternatives for improvement in supply chain performance. *Work study*, *51*(1), pp. 32-37.

Awudu, I., & Zhang, J. 2012. Uncertainties and sustainability concepts in biofuel supply chain management: A review. *Renewable and Sustainable Energy Reviews*, *16*(2), pp. 1359-1368.

Balfaqih, H., Nopiah, Z.M., Saibani, N. & Al-Nory, M.T. 2016. Review of supply chain performance measurement systems: 1998-2015. *Computers in Industry, 82,* pp. 135-150.

Barratt, M. 2004. Understanding the meaning of collaboration in the supply chain. *Supply Chain Management: An International Journal*, *9*(1), pp. 30-42.

Bartlett, P.A., Julien, D.M. & Baines, T.S. 2007. Improving supply chain performance through improved visibility. *The International Journal of Logistics Management, 18*(2), pp. 294-313.

Beamon, B.M. 1999. Measuring supply chain performance. *International Journal of Operations & Production Management, 19*(3), pp. 275-292.

Boddy, D., Macbeth, D. & Wagner, B. 2000. Implementing collaboration between organizations: an empirical study of supply chain partnering. *Journal of Management Studies, 37*(7), pp. 1003–1017.

Brewer, P. & Speh, T. 2000. Using the balanced scorecard to measure supply chain performance. *Journal of Business Logistics, 21*(1), pp. 75-93.

Cachon, G.P. & Fisher, M. 2000. Supply chain inventory management and the value of shared information. *Management Science*, *46*(8), pp. 1032-1048.

Cao, M. & Zhang, Q. 2011. Supply chain collaboration: Impact on collaborative advantage and firm performance. *Journal of Operations Management, 29*(3), pp. 163-180.

Chan, F.T.S. 2003. Performance measurement in a supply chain. *The International Journal of Advanced Manufacturing Technology, 21*(7), pp. 534-548.

Chen, H., Daugherty, P. & Roath, A. 2009. Defining and operationalizing supply chain process integration. *Journal of Business Logistics*, *30*(1), pp. 63-84.

Chen, S.J. & Huang, E. 2007. A systematic approach for supply chain improvement using design structure matrix. *Journal of Intelligent Manufacturing*, *18*(2), pp. 285-299.

Corbin, J.M. & Strauss, A.L. 2008. Basics of qualitative research: techniques and procedures for developing grounded theory. 3rd ed. Los Angeles: Sage Publications.

Da Silveira, G.J.C. & Arkader, R. 2007. The direct and mediated relationships between supply chain coordination investments and delivery performance. *International Journal of Operations & Production Management*, *27*(2), pp. 140-158.

Dyer, J.H., Cho, D.S. & Chu, W. 1998. Strategic supplier segmentation: The next "best practice" in supply chain management. *California Management Review, 40*(2), pp. 57-77.

Eskola, J. & Suoranta, J. 1998. Johdatus Laadulliseen Tutkimukseen. Tampere: Vastapaino.

Fang, S.R., Chang Y.S. & Peng, Y.C. 2011. Dark side of relationships: A tensions-based view. *Industrial Marketing Management, 40*(5), pp. 774-784.

Fawcett, S.E. & Magnan, G.M. 2002. The rhetoric and reality of supply chain integration. *International Journal of Physical Distribution & Logistics Management*, *32*(5), pp. 339-361.

Fiedler, P., Lange, M. & Schultze, M. 2007. Supply logistics for the industrialized use of biomass—principles and planning approach. *International Symposium on Logistics and Industrial Informatics*, September 13 - 15, Wildau, Germany.

Flick, U. 2014. An Introduction to qualitative research, 5th ed. London: Sage Publications.

Flynn, B.B., Huo, B. & Zhao, X. 2010. The impact of supply chain integration on performance: A contingency and configuration approach. *Journal of Operations Management*, *28*(1), pp. 58-71.

Forslund, H. & Jonsson, P. 2010. Integrating the performance management process of on-time delivery with suppliers. *International Journal of Logistics Research and Applications, 13*(3), pp. 225-241.

Frohlich, M. & Westbrook, R. 2001. Arcs of integration: an international study of supply chain strategies. *Journal of Operations Management*, *19*(2), pp. 185-200.

Gudehus, T. & Kotzab, H. 2009. Comprehensive Logistics. 1st ed. Berlin Heidelberg: Springer.

Gunasekaran, A., Patel, C. & Tirtiroglu, E. 2001. Performance measures and metrics in a supply chain environment. *International Journal of Operations & Production Management, 21*(1-2), pp. 71-87.

Handfield, R.B., Krause, D.R., Scannell, T.V. & Monczka, R.M. 2000. Avoid the pitfalls in supplier development. *Sloan Management Review, 41*(2), pp. 37-49.

Handley, S.M. & Angst, C.M. 2015. The Impact of culture on the relationship

between governance and opportunism in outsourcing relationships. *Strategic Management Journal, 36*(9), pp. 1412-1434.

Handley, S.M. & Benton W.C. 2012. The influence of exchange hazards and power on opportunism in outsourcing relationships. *Journal of Operations Management, 30*(1-2), pp. 55-68.

Hirsjärvi, S. & Hurme, H. 2015. Tutkimushaastattelu: Teemahaastattelun teoria ja käytäntö. Helsinki: Gaudeamus Helsinki University Press.

Horvath, L. 2001. Collaboration: the key to value creation in supply chain management. *Supply Chain Management: An International Journal*, *6*(5), pp. 205-207

Hoyt, J. & Huq, F. 2000. From arms-length to collaborative relationships in the supply chain. *International Journal of Physical Distribution & Logistics Management, 30*(9), pp. 750-764.

Hult, G.T.M., Ketchen, D.J. & Slater, S.F. 2004. Information processing, knowledge development, and strategic supply chain performance. *The Academy of Management Journal*, *47*(2), pp. 241-253.

Humphreys, P.K., Li, W.L. & Chan, L.Y. 2004. The impact of supplier development on buyer–supplier performance. *Omega, 32*(2), pp. 131-143.

Jap, S.D. 1999. Pie-Expansion Efforts: Collaboration Processes in Buyer-Supplier Relationships, *Journal of Marketing Research, 36*(4), pp. 461-75.

Krause, D.R. & Ellram, L.M. 1997a. Critical elements of supplier development The buying-firm perspective. *European Journal of Purchasing & Supply Management, 3*(1), pp. 21-31.

Krause, D.R. & Ellram, L.M. 1997b. Success factors in supplier development. *International Journal of Physical Distribution & Logistics Management*, *27*(1), pp. 39-52.

Lapan, S.D., Quartaroli, M.T. & Riemer, F.J. 2012. Qualitative research: An introduction to methods and designs. 1st ed. San Francisco: John Wiley and Sons.

Li, W., Humphreys, P.K., Yeung, A.C.L. & Cheng, T.C.E. 2012. The impact of supplier development on buyer competitive advantage: A path analytic model. *International Journal of Production Economics*, *135*(1), pp. 353-366.

Liu, Y., Li, Y. & Zhang, L. 2010. Control mechanisms across a buyer–supplier relationship quality matrix. *Journal of Business Research, 63*(1), pp. 3-12.

Logistiikan maailma 2018. Hankintasopimus. [online document]. [Accessed 28 April 2018]. Available at http://www.logistiikanmaailma.fi/osto-ja-myynti/hankintaprosessi/hankintasopimus/

Macbeth, D.K. 1994. The role of purchasing in a partnering relationship*. European Journal of Purchasing and Supply Management, 1*(1), pp. 19-25.

Modi, S.B. & Mabert, V.A. 2007. Supplier development: Improving supplier performance through knowledge transfer. *Journal of Operations Management*, *25*(1), pp. 42-64.

Moeller, S., Fassnacht, M. & Klose, S. 2006. A Framework for Supplier Relationship Management. *Journal of Business-to-Business Marketing,* 13(4), pp. 69-94.

Nagati, H. & Rebolledo, C. 2013. Supplier development efforts: The suppliers' point of view. *Industrial Marketing Management*, *42*(2), pp. 180-188.

Narasimhan, R., Mahapatra, S. & Arlbjørn, J. 2008. Impact of relational norms, supplier development and trust on supplier performance. *Operations Management Research*, *1*(1), pp. 24-30.

Ploetner, O. & Ehret, M. 2006. From relationships to partnerships—new forms of cooperation between buyer and seller. *Industrial Marketing Management, 35*(1), pp. 4-9.

Prajogo, D. & Olhager, J. (2012). Supply chain integration and performance: The effects of long-term relationships, information technology and sharing, and logistics integration. *International Journal of Production Economics*, *135*(1), pp. 514-522.

Rentizelas, A.A., Tolis, A.J. & Tatsiopoulos, I.P. 2009. Logistics issues of biomass: the storage problem and the multi-biomass supply chain. *Renewable and Sustainable Energy Reviews*, *13*(4), pp. 887-894.

Routroy, S. & Pradhan, S.K. 2013. Evaluating the critical success factors of supplier development: A case study. *Benchmarking: An International Journal*, *20*(3), pp. 322-341.

Sahin, B., Yilmaz, H., Ust, Y., Guneri, A.F. & Gulsun, B. 2009. An approach for analysing transportation costs and a case study. *European Journal of Operational Research*, *193*(1), pp. 1-11.

Saunders, M., Lewis, P. & Thornhill, A. 2016. Research methods for business students. 7th ed. Harlow: Pearson Education.

Simatupang, T.M., Wright, A.C. & Sridharan, R. 2002. The knowledge of coordination for supply chain integration. *Business Process Management Journal*, *8*(3), pp. 289-308.

Stewart, G. (1995). Supply chain performance benchmarking study reveals keys to supply chain excellence. *Logistics Information Management*, *8*(2), pp. 38-44.

Thomas, D.J. & Griffin, P.M. 1996. Co-ordinated supply chain management. *European Journal of Operational Research, 94*(3), pp. 1-15.

Vereecke, A. & Muylle, S. 2006. Performance improvement through supply chain collaboration in Europe. *International Journal of Operations & Production Management*, *26*(11), pp. 1176-1198.

Wagner, S.M. & Krause, D.R. 2009. Supplier development: communication approaches, activities and goals. *International Journal of Production Research*, *47*(12), pp. 3161-3177.

Weiland, P. 2010. Biogas production: current state and perspectives. *Applied Microbiology and Biotechnology*, *85*(4), pp. 849-860.

Wilson, M.C. 2007. The impact of transportation disruptions on supply chain performance. *Transportation Research Part E: Logistics and Transportation Review*, *43*(4), pp. 295-320.

Yu, Z., Yan, H. & Edwin Cheng, T.C. 2001. Benefits of information sharing with supply chain partnerships. *Industrial Management & Data Systems*, *101*(3), pp. 114-121.

Zhao, X., Xie, J. & Zhang, W.J. (2002). The impact of information sharing and ordering co-ordination on supply chain performance. *Supply Chain Management: An International Journal*, *7*(1), pp. 24-40.

Zhou, H. & Benton, W.C. (2007). Supply chain practice and information sharing. *Journal of Operations management*, *25*(6), pp. 1348-1365.

APPENDIX 1. A Path Analytic Model

Humphreys et al. (2004) did not find strategic goals, supplier evaluation, top management support, or long-term commitment significantly contributing to supplier performance improvement. However, Li et al. (2012) disclosed that, for example, supplier evaluation is critical in transaction-specific supplier development, and it can lead to supplier performance improvement, buyer-supplier relationship improvement, and finally to buyer competitive advantage. Indirectly also top management support and long-term commitment have an impact on the mentioned aspects, which is why those are also important.

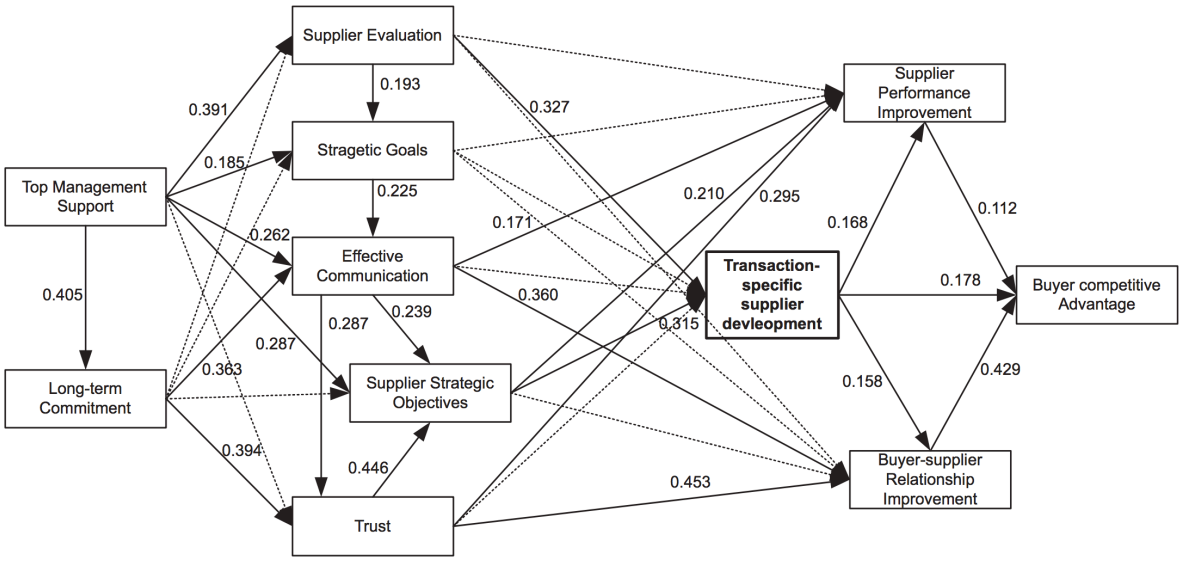

Fig. 2. Revised model of the relationships between supplier development and buyer–supplier performance improvement.

A path analytic model (Li et al. 2012).

APPENDIX 2. Interview Questions

Background

What are the critical goals of the supply chain?

Transportations are mostly outsourced; is this an optimal option?

What kind of contracts are done with supply chain partners?

What kind of performance measurement systems are used? What about key performance indicators?

Have the measurement results been satisfying or poor? In which areas?

What are the strengths of the supply chain?

Is sustainability present in daily operations and decision?

Supply Chain Operations

How integrated is the supply chain of biogas production? Internally and externally.

Is the target to have standardized processes and centralized decision making in the biogas plant network?

Are processes streamlined frequently and, for example, simplified to reduce double work?

How does the company manage changes in the supply chain? In daily basis and long-term.

Are material flows currently smooth and cost efficient?

Are certain raw-material types prioritized?

How well, for example, arriving loads can be forecasted and planned beforehand?

How is logistics coordinated and optimized?

How is production management done in practice?

How are raw-materials stored?

Are there availability problems or excess inventory problems?

How is the financial performance of biogas production?

Where could cost reductions be done?

Supply Chain Relationships

What type of relationships does the company have with its supply chain partners?

(continued on the next page)

What are optimal agreements?

What type of information is shared and how frequently?

Are there information shortages in some areas?

Is opportunistic behavior a risk?

Does the performance of supply chain actors fulfill expectations?

Could supply chain partner development programs be utilized? Or have programs been used?

Industry Trends and Future

Would it be necessary to invest to a new plant or to storing facilities?

What industry trends there currently are?

How much seasonal fluctuations affect the business?

Is the Finnish or Swedish biogas model better, or should the models be combined?

As a conclusion, what should be improved in the supply chain of biogas production?

APPENDIX 3. Biogas Plant Visit

4.5.2018

I visited a biogas plant with five other visitors on Friday the 4th of May 2018. The visit was guided by a site manager. The site manager introduced the plant area, told us about the biogas plant processes, and answered to our questions. In addition to the tour, I observed and did my own interpretations about the environment, occasions, and processes. The visit lasted 2,5 hours, and it deepened my understanding and knowledge about biogas plant operations significantly. In the following text, all information is told by the site manager except my own observations.

In my opinion, the plant seemed surprisingly small, and the site manager also said that the yard is too small when there are multiple trucks at the same time. I would say that the area was quite clean knowing the fact that the factory processes waste. Outside I did not notice almost any smell, but in an office the smell was bad. I think that the smell came from workers' clothes and other things, since the office was not attached to the plant. Inside the plant the smell was shocking. However, the residue that was stored in the yard did not smell anymore. The residue looked like compost, and it covered approximately 15 times 15 meters' area. In the plant, I noticed three plant operatives, but the site manager corrected that there are four. The operatives work in the plant and in the office. In the office I spotted multiple computers, and there were, for example, surveillance videos, process-maps, and metrics in the screens. According to the site manager, the plant is active 24/7, and someone is always on call. However, during the weekends there are no raw-material deliveries.

During the visit, I saw multiple trucks driving to the plant. I noticed that trucks drove to a bridge, and typed something on a machine next to the bridge, and drove to an unloading area. After this observation, the site manager told more about the raw-material receiving process. According to him, the bridge is a scale where loads are weighed, and the machine is for delivery registration. The registration is easy, since information about most of the delivering companies and license plates are saved in

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the machine's software. Based on the registration information, also invoicing is done.

Theoretically, it would be possible that someone would deliver waste to the plant, without registration and would not have to pay for it. However, the site manager does not consider that as a significant risk, and he could not remember that it would have ever happened. Sometimes suppliers are delivering their suppliers waste, and they need to register the delivery to be able to invoice their customers. Additionally, suppliers that deliver raw-materials which contain fats need a plant operative to verify the delivery by signature. Therefore, also suppliers are motivated to act correctly. Nevertheless, the plan is to build a gate, which would prevent unnecessary driving to the plant during nights.

My expectation was that many of the raw-material deliveries would be delivered to the plants without accurate information in advance. However, the site manager stated that there are only few "surprise deliveries". Some suppliers deliver waste weekly and even daily, and therefore those can be anticipated well. Monthly deliveries may occur in short notice, but in those cases suppliers do inform the plant operatives at some point before arrival. Problems arise when a delivery truck just emerges to the scale without any heads up, but this is not happening often.

There were two unloading places; bio-waste and sludge. The unloading is done straight to the plant, because raw-materials are not stored at this point. However, there is one backup store, which can be used only occasionally (regulated by the city). The waste that has been delivered to the plant, will remain in the process approximately one month until biogas is assorted from it. Organic waste can be fully utilized, but sometimes there are plastic and other materials blended in the bio-waste, which are sorted out. At the visiting time, the plant was almost full of raw-materials (4 meters at unloading area). Apparently, the plant is in central location, and volumes are always high. Currently, the plant has capacity to receive about 55 000 tons of waste in a year. Additionally, there will be an extension build on a

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hygiene process, which will bring more capacity for the plant.

Multiple legislations affect the biogas production process. For example, if the ready biogas contains over 2 per cent hydrogen it cannot be utilized, and it must be burned in the plant. The hydrogen is composed especially from organic waste which contain sugars. Additionally, residue placement is problematic. When the liquid residue is further processed, for instance, reject water is generated, which can be released to sewers after it is treated with nitrogen separation equipment. In the biogas plant in question, only 25 kilos of nitrogen can be released to sewers during one day. Both liquid and solid residues can be transported, for example, to farms and fields. The market change affects the residue placement, for example, to fields, which astonishes the site manager.