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Current State of the Inter-Organizational Information Exchange Strategies of German SME - A Survey

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Abstract

The reliability of well-performing production processes not only depends on internal but also on external factors in the upstream supply chain. Therefore, companies require fast and reliable information exchange with cooperating organizations. We aim to support the industry in improving their communication methods and, therefore, have conducted a survey to capture the current state and needs in this area — addressing inter- instead of the usually surveyed intra-organizational degree of digitalization. In this paper, we outline the main outcomes of our survey. We received 135 evaluable questionnaires from manufacturing companies based in Germany, predominantly from small and medium-sized companies. Based on the responses, we detected that the use of modern methods correlates with the company size. Furthermore, we showed that only a few companies are completely satisfied with their current methods for inter-organizational information exchange. The greatest potential for improvement is seen in standardization and the increase of required resources.

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1. Introduction

The manufacturing industry is subject to current trends and sustained tendencies in the market, such as increasing product variety, custom and individual fabrication, as well as reduction of production and delivery times [5, 15]. Due to these trends and the implied needs for innovation and differentiation, companies have started to review and adapt their internal processes and structures as well as enhance them by implementing Industry 4.0 technologies. This evolution within the companies can be seen in surveys, such as [3].

However, especially in the manufacturing industry, the success of business processes not only depends on company-internal structures. It, furthermore, highly depends on external collaborations with partners along the supply chain. Such supply chain collaborations support companies to guard against risks, obtain complementary resources, reduce logistical costs, and enhance profit performance and gain a competitive advantage over time [14, 16].

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Inter-organizational communication is the basic enabler for a tight supply chain collaboration [14] and it will, most probably, become more important in the near future [15]. Conventionally, inter-organizational communication is done via e-mail, fax, and phone. Since these methods are usually based on high manual effort, they are often slow and error-prone and, therefore, not suitable for fast and comprehensive information exchange. To overcome these problems, companies can focus on the use of tools and systems that enable an automated information exchange between different organizations.

The importance and urgency to improve production-related information exchange are already recognized and discussed in many places. For example, in the past decade, several different concepts have been developed to realize and improve the company internal digital and automated information exchange (e.g. LISA[17], ProSense[16], SmartFactory^{KL}[11]). Some systems that are used for company internal information handling already imply basic approaches to share information with cooperating companies (e.g. via APIs or GUIs), while a few architectural approaches (such as IIRA[9], IMSA[12], IVRA[10], and RAMI4.0[4]) and recent research (such as EPCIS[7], IDS[13], and GAIA-X[6]) already focus on this aspect.

Have companies already implemented modern technologies for the inter-organizational information exchange or is there still high potential of improvement? Whereas recent research, such as [1, 3], surveyed the implementation of digitalization and Industry 4.0 aspects in the industry, we undertook additional research to focus on the communication strategies companies pursue.

In this paper, we present the main outcomes of our survey regarding the current state of digitalization and inter-organizational communication strategies in German SME. In section 2 we provide an overview of our survey's structure. As explained in section 3, we sent out the survey to more than 4500 companies based in Germany. Based on the 180 responses which we received (135 questionnaires from manufacturing companies plus 45 additional questionnaires from companies without manufacturing tasks)¹, we provide the main outcomes of the survey in section 4. After discussing the survey's outcomes in section 5, we finally state our conclusion in section 6.

2. Motivation and Survey Structure

As described in section 1, current research already examined the implementation of Industry 4.0 aspects in companies. However, the current status of inter-organizational information exchange strategies has hardly been researched at the moment. To get more information and a more general overview of the digitalization within companies and their behaviour regarding the inter-organizational information exchange, we decided to survey companies based in Germany on this topic.

In order to reach as many companies as possible from all regions of the country, we decided to conduct an online survey. The survey was designed with a web-interface survey template and contained 18 questions. As displayed in table 1, the questions asked in the survey can be grouped into five parts.

Table 1: Structure of the survey

Part	Objectives	Questions
I	general information	1-4
II	digitalization in general and in production	5-7
III	inter-organizational information exchange	8-14
IV	value and risks of digitalization	15-16
V	feedback	17-18

Part I - General Information. In part I, we asked for general information about the participants' company, such as size (number of employees), age of the company, and industrial sector, with the latter being asked as an expandable multiple choice question. The general company information is relevant to group the responses in the analysis phase.

Part II - Digitalization in General and in Production. In part II, we wanted to get an overview of the companies' degree of digitalization. We asked the participants to rate the degree of digitalization in their company and to specify

¹ See also figure A.6 in the appendix.

the use of different methods and tools within the company's production. For these questions we provided Likert scales to represent varying degrees of usage.

Part III - Inter-Organizational Information Exchange. In part III, we asked for information regarding the handling of information exchange with external partners, such as customers or suppliers. Beside the evaluation of the current state of inter-organizational information exchange, we also asked for the satisfaction of the current situation as well as possibilities to support the improvement. Here, the options for answers were also provided in the form of Likert scales.

Part IV - Value and Risks of Digitalization. Part IV includes two open questions where the participants could give us feedback about their opinion regarding the value and the risks of digitalization in general.

Part V - Feedback. In the last part, we offered two open questions to the participants by which they could leave us feedback to the questionnaire or further information regarding the topic of the survey.

3. Method

In this report, we present the statistical evaluation results on a survey (introduced in section 2) that was carried out amongst companies, mainly settled within the manufacturing industry in Germany. The questionnaires were distributed via newsletters of business associations and networks but were also sent directly to the companies by e-mail. The companies contacted were selected based on their size and the probability for executing manufacturing tasks (mainly in the aerospace, optics, electronics, and automotive industries). For the direct messaging we predominantly became aware of the companies through the member lists of associations, networks and clusters as well as through google searches. There are about 220,000 companies in the manufacturing sector in Germany [2]. From more than 4,500 sent out questionnaires, we obtained 180 evaluable responses (response rate < 4%), out of which 135 questionnaires were answered by employees of manufacturing companies. We are aware that the small number of answers may contain biases (also addressed in section 5). Since we want to focus particularly on the development status of small and medium-sized manufacturing companies, and since more than three quarters of the answers were given by companies with less than 250 employees, trends in this target group can be derived from the questionnaires.

4. Results

In this section, we present the results of our survey. Since not every question was answered by every participant, the evaluation of the questions is based on a range of 115 to 180 answers. In section 4.1, we show some general information about the group of participants and the general state of digitalization within their companies. Section 4.2 comprises the outcomes regarding our questions about the inter-organizational information exchange. Finally, we summarize the values and risks of digitalization, which were stated by the participants, in section 4.3.

4.1. General Information and State of Digitalization

As described in section 2, we asked for general information about the participants company in Part I of the questionnaire. Figure 1 displays the distribution of the manufacturing companies by their size. As shown in the figure, 78% of the obtained responses we received from members of medium or smaller sized companies. Participating companies mainly operate in the industry sectors of electronics (52%), Automotive (38%), Space (30%), and Aircraft (26%), but also in other industry sectors, such as manufacturing systems engineering, medical technology, and optics (multiple choice answers were possible).²

Since we wanted to get a general overview about the current state of digitalization in the companies (part II of our survey), we asked the participants to rate their company-internal level of digitalization. As displayed in figure 2, two-thirds of the participants rank the level of digitalization of their company to 60% or higher. Compared to the responses of all participating companies, it can be observed that manufacturing companies consider themselves to be less digitized in comparison to the general level of digitalization in German companies.

² For further information, look at figure A.9 in the appendix of this paper.

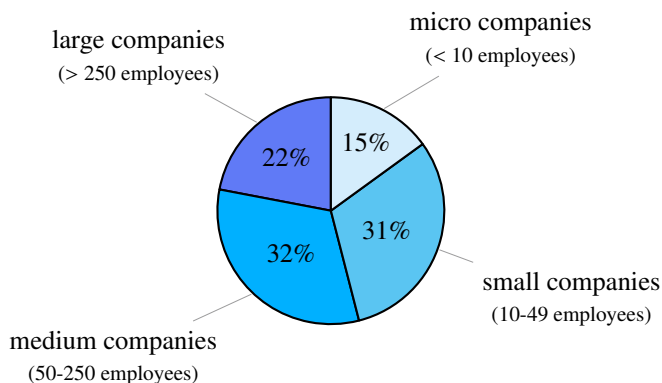


Fig. 1: Distribution by company size (135 manufacturing companies)

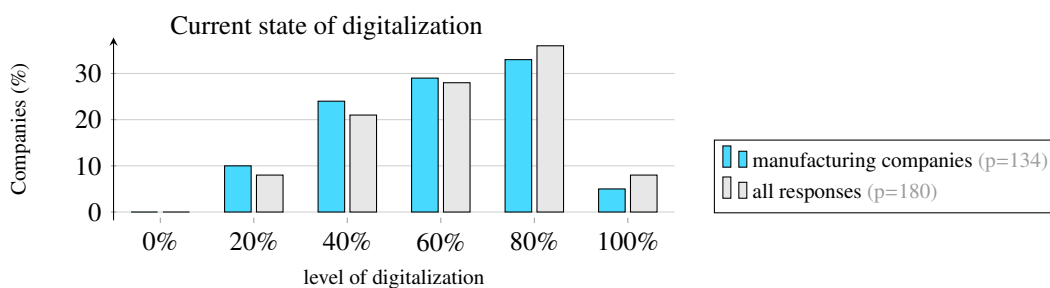


Fig. 2: Results for "How would you grade the level of digitalization in your company?" (Likert scaling, 180 companies)

As we asked for modern methods within the manufacturing area, we could recognize that methods to physically support production such as autonomous driving systems, drones, and exoskeletons, as well as methods of augmented reality (AR) and virtual reality (VR) are used rarely.³ In contrast, manufacturing management supporting systems, such as enterprise resource planning (ERP) and manufacturing execution systems (MES), as well as the record and usage of manufacturing data is already implemented in many companies.⁴ It can be seen that the progress on implementing the aforementioned systems and methods correlates with the company size. Less plans on such integration can be found amongst small- and micro-sized companies.⁵

4.2. Inter-Organizational Information Exchange

In part III of your survey (see section 2), we asked for information exchange methods with external partners. The results of our survey show that the majority of the companies (>70%) only rarely make use of the old methods, like fax and letters.

As displayed in figure 3, the results furthermore show that the main methods for inter-organizational information exchange are still the common methods, phone and e-mail. Besides that, several companies apply additional methods. 66 % of the companies stated to, at least sometimes, use FTP/FTPS-Servers for the information exchange with external partners. Furthermore, the information exchange via APIs, GUIs and digital platforms is used from time to time, but regularly only used by less than 30% of the companies.⁶

³ More details on the use of modern technologies in the manufacturing plant can be found in the figure A.10 in the appendix of this paper.

⁴ For further information regarding the implementation of modern methods in the manufacturing plant see figure A.11 in the appendix.

⁵ As an example, see the current state of integration of manufacturing management supporting systems, such as ERP and MES, in the companies in figure A.12 in the appendix.

⁶ For more details regarding the inter-organizational information exchange see figures A.13 and A.14 in the appendix.

Information is mostly exchanged as human readable documents, followed by tabular data and (de-facto) standardized data formats. Proprietary and non-standardized data formats are less in use.⁷

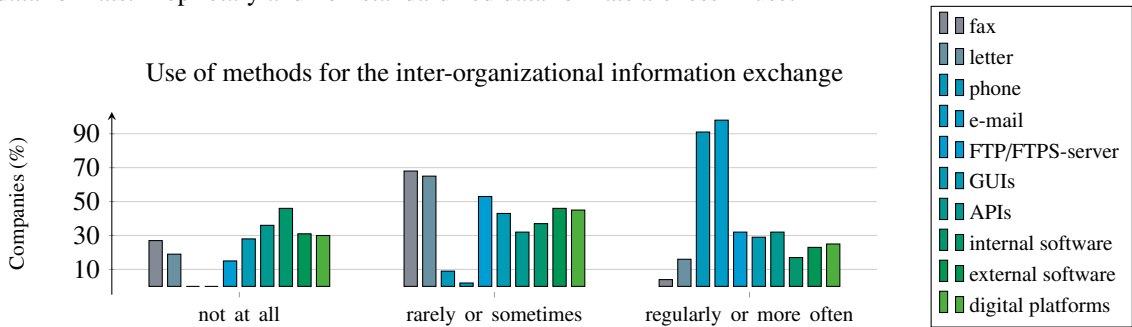


Fig. 3: Results for "Which methods do you use to exchange information with external partners?" (Likert scaling, answers clustered, 135 manufacturing companies)

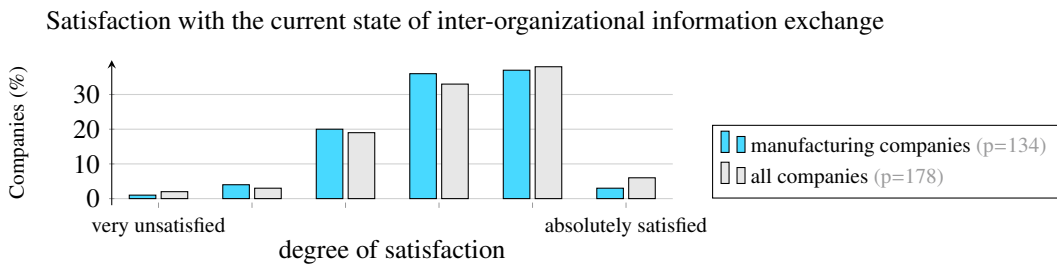


Fig. 4: Results for "How satisfied are you with the current information exchange with external partners?" (Likert scaling, 178 companies)

As displayed in figure 4, three quarters of the companies are in general more satisfied than unsatisfied about the current situation of information exchange. But there is still space for improvement. Only 3% of the participating manufacturing companies stated to be absolutely satisfied with the current exchange of information. Compared to the responses of all participating companies, it can be observed that manufacturing companies seem to be less satisfied with the exchange of information than German companies in general.

As displayed in figure 5, companies indicated that more standardization, more resources, and a higher degree of company-internal digitalization would provide best support for the development and improvement of the inter-organizational information exchange.

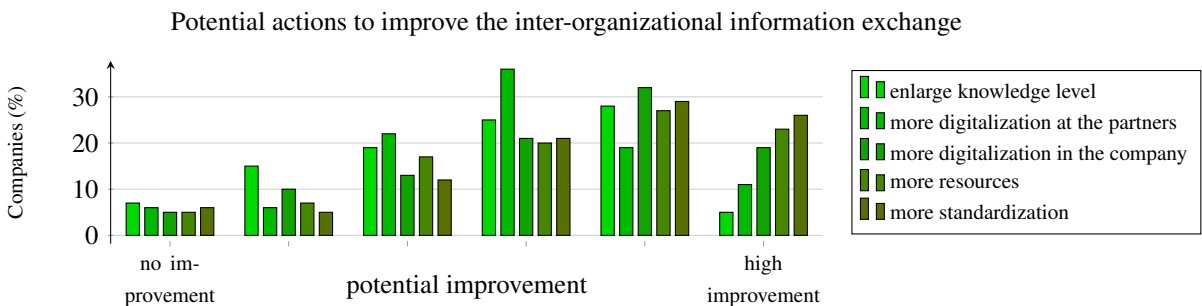


Fig. 5: Results for "Which measures would help to improve the information exchange with external partners?" (Likert scaling, 115 manufacturing companies)

⁷ For more information regarding the use of data formats see figure A.15 in the appendix.

Currently, only a few companies (<10%) directly work on improvements of the inter-organizational information exchange. Most of the companies focus on the improvements of company-internal digitalization strategies.⁸

4.3. Benefits and Risks of Digitalization

In Part IV of our survey, we asked the participants to tell us what benefits and risks they generally see in digitalization. Among the 113 responses, the benefit of digitalization was mostly seen in the increase in efficiency (e.g. time reduction, quality improvement, and cost reduction). Security concerns, undesired dependencies, and dehumanization of the corporate culture were identified as the main risks of digitalization. In general, we could observe that the opinions on digitalization's benefits and risks vary strongly among the participants.⁹

5. Discussion

As stated in section 3, we received an adequate number of responses to obtain results with statistical relevance. Due to the high number of participating SME (more than 60% of all participants), we could detect the status and needs of this relevant group of companies of the German economy system.

As written in section 4.1, two-thirds of the companies rank the current level of digitalization in their company to 60% or higher. This outcome conforms with results from other studies, such as [3]. However, the number still needs to be regarded critically since there could be a bias in such case that members of companies, which are not interested in digitalization, would probably rather not participate at a survey that is concerned to this topic. Since we distributed our survey digitally via e-mails and newsletters, it is also possible that we did not reach less digitized companies, or that they did not dare to take part in our survey. Nevertheless, there are still a lot of companies which see a lot of potential to further improve their level of digitalization.

In part II of our questionnaire (see section 2), we could observe that the progress of the implementation of modern methods and technologies in the manufacturing plant is further developed the larger a company is. This could be caused by the restricted resources of smaller companies. In addition, the expected benefit of implementing a new method rises the more executed orders will be effected and improved by this change. This could be also a reason why larger companies rather tended to invest in such methods than smaller companies with a smaller amount of orders.

Due to the responds we got in part III of our survey (see section 4.2), we were able to show that old methods for inter-organizational information exchange, such as fax and letter, are almost completely replaced by the information exchange via phone and e-mail. It is furthermore observable that newer methods, which would support automated or pull-based information exchange, are not very popular to use. Nevertheless, as figure 4 shows, there is still potential for the improvement of inter-organisational information exchange. However, this does currently not seem to be the focus for most of the companies. As we could recognise when we asked the participants for their current developments, it becomes obvious, that company-internal improvements regarding the digitalization and the improvement of information exchange, seem to be more urgent. This fact leads to the assumption that many companies did not already reach an internal level of digitalization that is required to build an automated inter-organizational information exchange upon it.

As displayed in this paper, our survey could show some tendencies of the current state of digitalization and the inter-organizational communication strategies of german companies. However, as explained above, the research is limited due to the group of participating companies. Furthermore, our survey did not capture respondents' position within their organization, meaning it was not possible to map variations in responses that may be related to an individual's position within their organization. Including the respondents' profile details, such as position in the company, in the survey might be an approach for future work.

⁸ This information was collected via an open question in our survey. We asked the participants which developments and improvements are currently aspired in their company. The answers were evaluated but will not be published verbatim.

⁹ As described in section 2 these questions were asked as an open question format. The answers were evaluated but will not be published verbatim.

6. Conclusion

Since small and medium-sized companies play a significant role in most supply chains [8], it is particularly important to consider their needs in the implementation of methods and systems for inter-organisational information exchange. Compared to large enterprises, SME face even bigger obstacles by the development and implementation of new technologies, due to their limited resources in personnel, funds, and knowledge [18]. As our survey shows, there is still a high potential for improvement in most German SME. Information exchange that require a lot of manual work, such as e-mail and phone, are often slow and error prone. Hence, they should be replaced by automated solutions which help to improve the information exchange between cooperating companies and help to react faster on occurring events that come up in the supply chain. In order to support SME in improving their communication strategies, it is necessary to develop and provide solutions for the inter-organizational information exchange that can be easily implemented and connected to existing systems of the companies.

Acknowledgment

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Appendix A. Additional information to the results of our survey

Our survey was developed to get more information about the current state and practices of manufacturing companies in Germany. However, as explained in section 3, we also got some responses from companies, that do not have manufacturing tasks in their companies. Figure A.6 shows the distribution of manufacturing companies to companies without manufacturing tasks.

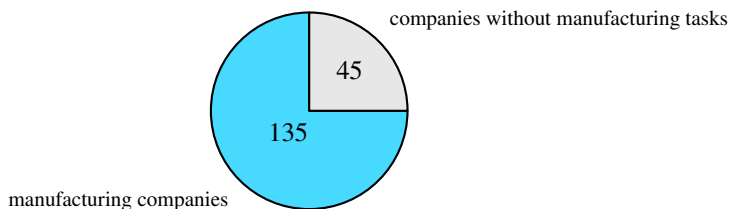


Fig. A.6: Ratio of manufacturing and non manufacturing companies (180 companies)

Figure A.7 displays the distribution by size of the companies. The pie chart on the left side displays the distribution of the manufacturing companies, the pie chart on the right side displays the distribution by size of all participating companies. In addition, figure A.8 displays the distribution by age of all participating companies.

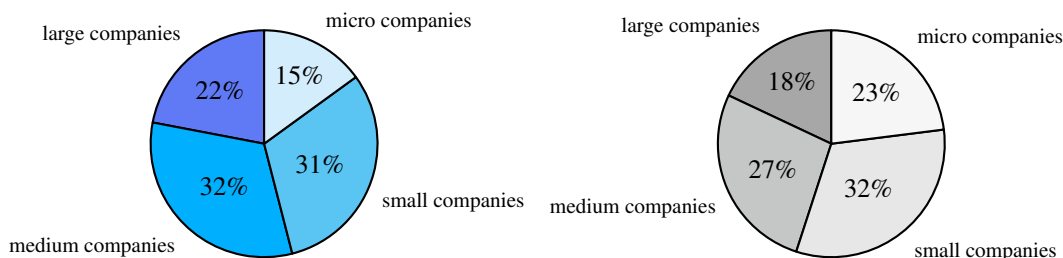


Fig. A.7: Distribution by company size (left: manufacturing companies (135 companies); right: answers of all participants (180 companies))

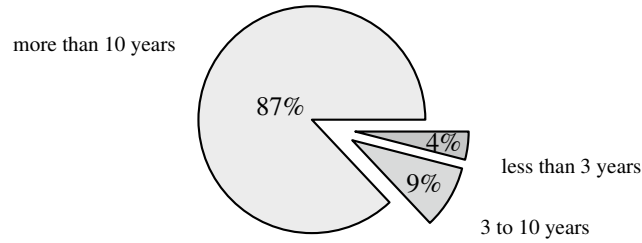


Fig. A.8: Age of the companies (180 companies)

In the first part of our survey, we, furthermore, asked which industry sectors belong to the business area of the participating companies. Figure A.9 displays how many of the participating companies operate in each industry sector.

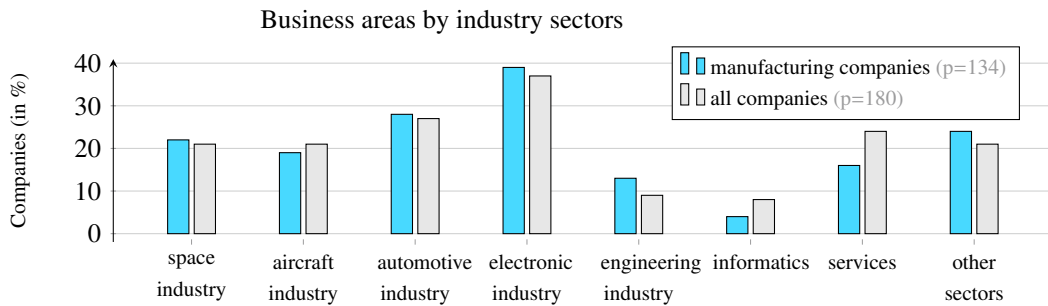


Fig. A.9: Results for "Which industry sectors belong to your company's business area?" (multiple choice, 180 companies)

To get more information about the current situation within the manufacturing, we asked the manufacturing companies which methods for digitalization and which modern technologies are used in the manufacturing plant and in which intensity it is used. The answers are displayed in figures A.10 and A.11. As an example, figure A.12 displays the answers how planning software is used in the companies in more detail. In comparison to figure A.11 the answers are distributed by company size. As mentioned in section 4.1, it can be observed that larger companies already have implemented such methods more extensively than smaller companies.

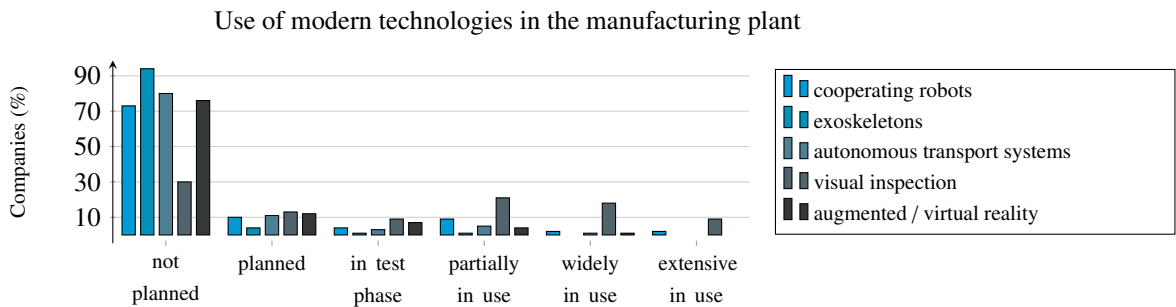


Fig. A.10: Results for "Which of these technologies are used in your company?" (Likert scaling, 133 manufacturing companies)

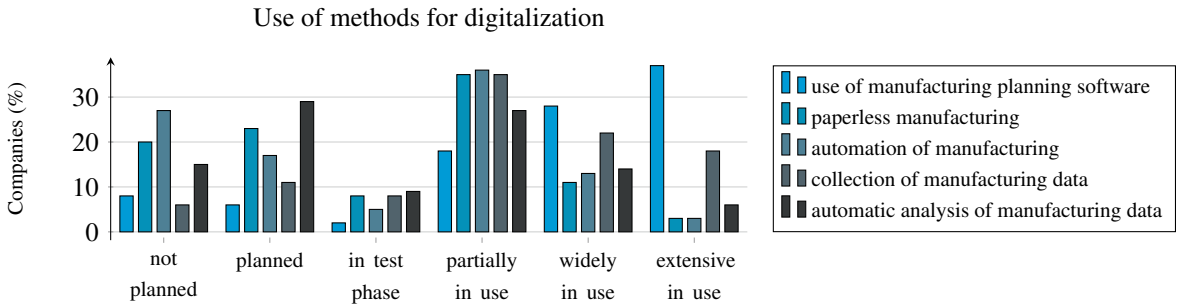


Fig. A.11: Results for "Which of the methods for digitalization are used in your company?" (Likert scaling, 134 manufacturing companies)

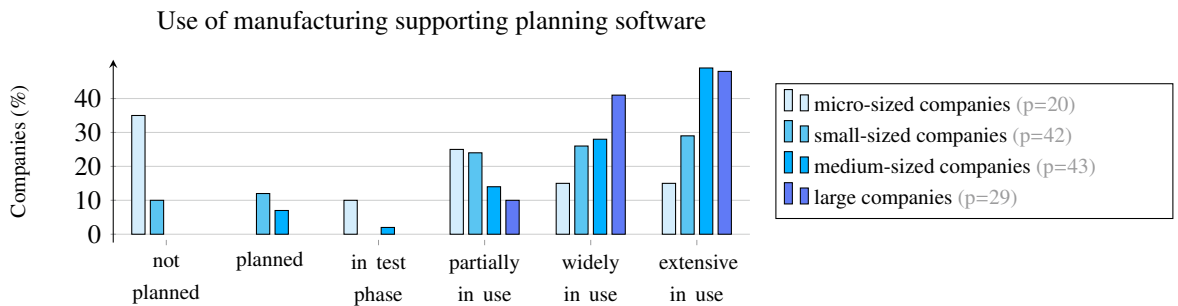


Fig. A.12: Results for "To what extent is planning software (e.g. ERP and MES) used in your company?" (Likert scaling, 134 manufacturing companies)

As also described in section 2, in part III of our survey, we put focus on the inter-organizational information exchange. Supplementary to figure A.13 in section 4.2, figure A.14 displays the current use of further methods for the inter-organizational information exchange. In figure 3 the answers are grouped in three clusters of usage. This shows more obvious which methods are used regularly by manufacturing companies for the exchange of information with partners. Supplementary to the methods for information exchange, we asked for the data formats that are used for the exchange. As one can see in figure A.15, human-readable documents are the main format to exchange information, followed by tabular data and (de-facto) standardized data formats.

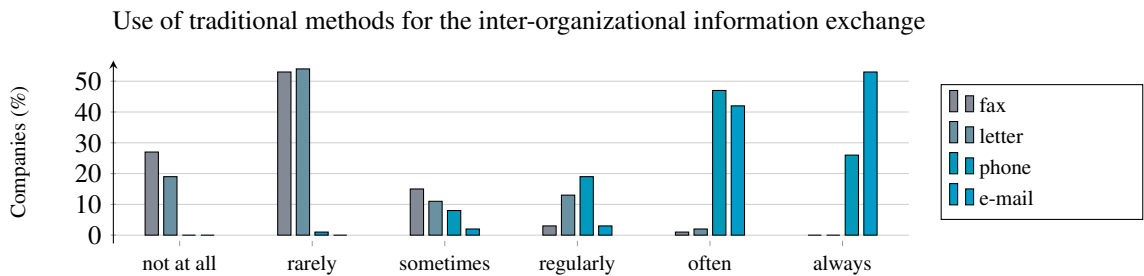


Fig. A.13: Results for "Which methods do you use to exchange information with external partners?" (1/2) (Likert scaling, 135 manufacturing companies)

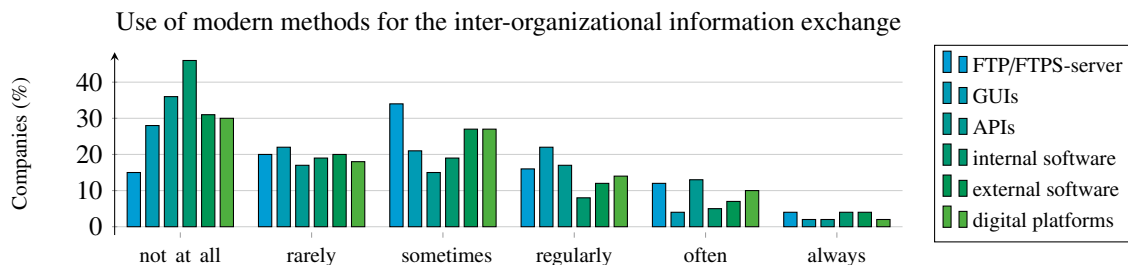


Fig. A.14: Results for "Which methods do you use to exchange information with external partners?" (2/2)
(Likert scaling, 135 manufacturing companies)

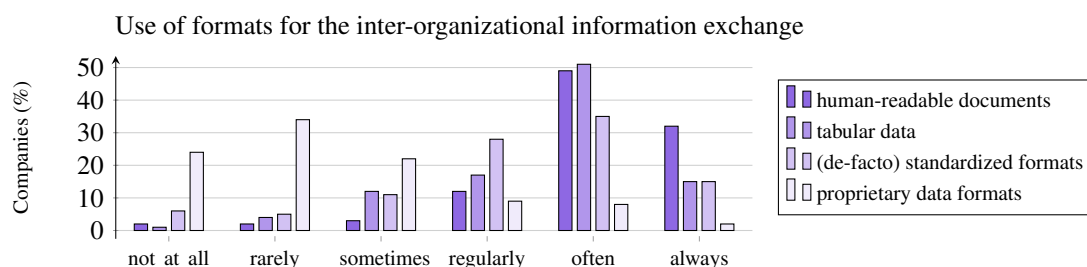


Fig. A.15: Results for "Which data formats do you use for the exchange of information with external partners?"
(Likert scaling, 135 manufacturing companies)

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