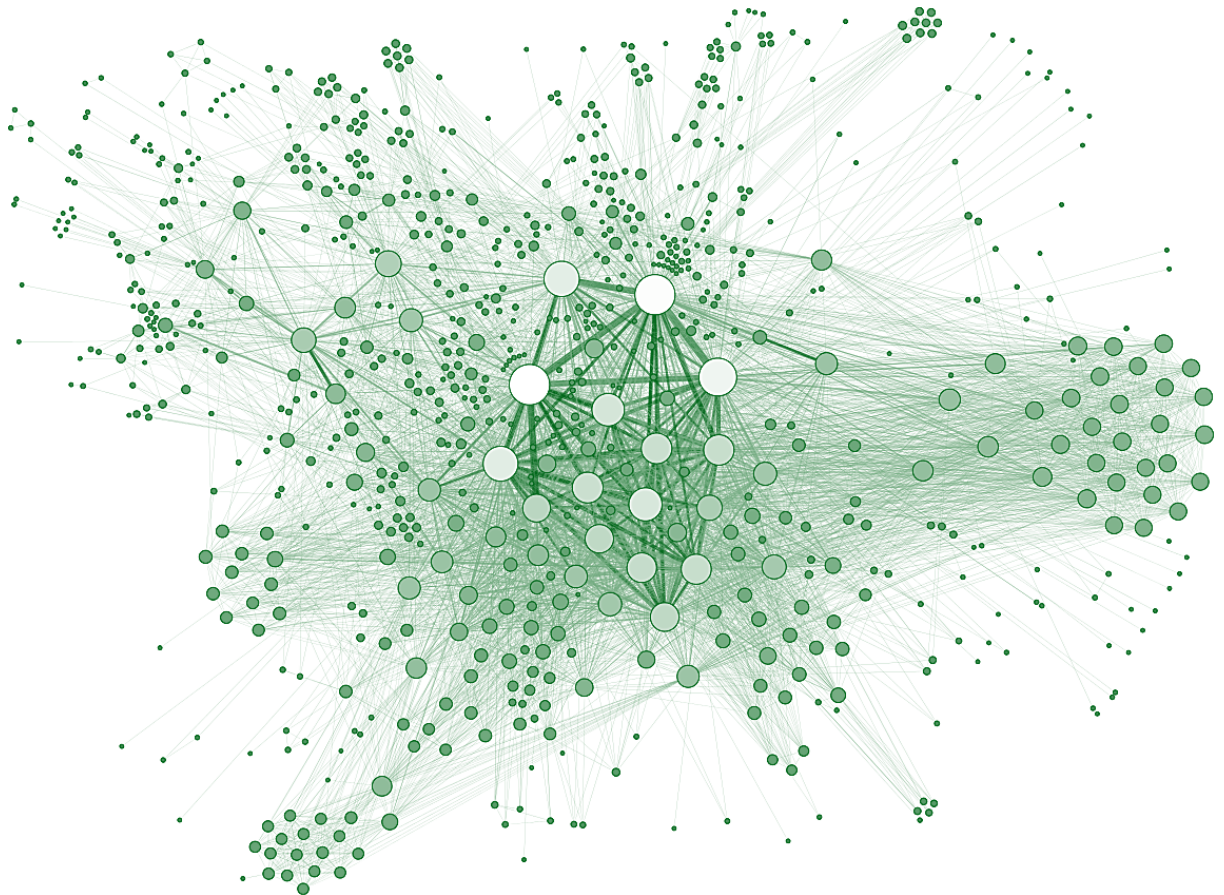


Institute of Technology Management



University of St.Gallen



Benchmarking

Industrie 4.0

From a Management Perspective

General Report

***"From insight
to impact"*** 



Industrie 4.0...

“...refers to the fourth industrial revolution, a phenomenon that marks a quantum leap in organization and management of the *entire value chain throughout product life cycles*. Such life cycles are oriented towards *increasingly individual customer requirements*. They span from the original idea over product order, development and manufacturing up to delivery to the end customer and ultimately recycling. Product life cycles also include all services associated.”

German Platform for Industry 4.0, 2014

Please note: In following report we decided to use the term “Industrie 4.0”. Depending on the country it is also known as “Smart Manufacturing”, “Industry 4.0” or “Industrial Internet”.

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IMPORTANT INFORMATION

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What Makes a Successful Practice?

Executive Summary



DOWN-UP APPROACH

A Down-Up approach is the combination of Top-Down and Bottom-Up. In this case the shop floor initiates projects and implements solutions whilst top-management coordinates the company's activities regarding Industrie 4.0 and defines the right parameters and strategic goals.



BUSINESS MODEL INNOVATION

Industrie 4.0 enables new products and services to offer improved and new solutions for the customers. Additionally, new customers are served – the interaction with customers and partners changes. New business models are crucial success factors for sustainable success.



START EARLY

Successful Practice companies started early with Industrie 4.0 activities. They try out new technologies and solutions to improve their production and check where already proven concepts can be used. Experiencing such things helps them to better understand technological innovations.



FOCUS ON CUSTOMER NEEDS

Profound knowledge of customer needs and a systematic approach for the development of customer-tailored value propositions result in precisely fitting offerings. Furthermore, customer needs often trigger introducing new technologies that later provide a competitive advantage.



COLLABORATE WITH KEY PARTNERS

Interaction and exchange with partners along the value chain, including customers and suppliers, but also with other companies, are crucial for the successful implementation of Industrie 4.0. Most Successful Practice companies engage in (funded) official initiatives and research projects.



PROCESS UNDERSTANDING

Successful practice companies view Industrie 4.0 as a technological tool box to enhance their current business and strategic position. The value of a technology does not originally stem from the technology itself, but rather from the way it is able to improve the business processes.



TOP-MANAGEMENT SUPPORT

Top-management support is a huge enabler, especially when it comes to one of the key factors for success regarding Industrie 4.0: Speed. Projects and investments are easier to pass with top-management support. Also, a holistic character of Industrie 4.0 is facilitated.



CAPTURE MORE THAN MONEY

Successful practice companies gather comprehensive internal and external data. Data driven improvements for both, processes and products are reaching new levels. Also, data might be a source of future competitive advantages, as data driven services already show.



OVERCOME DEPARTMENT SILOS

As Industrie 4.0 is a joined approach that requires a holistic approach across functional borders, departmental boundaries within the successful companies are overcome. An integral approach, crossing all functional borders and working along the process is key for success.



QUALIFIED EMPLOYEES

The successful practice companies employ experts that enhance the companies' digitalization. They think in processes and across functional borders. IT-knowledge is a key factor for implementing Industrie 4.0 and thus is an important qualification of employees. The company's culture should also be ready to embrace changes of what has been achieved so far.

Key Facts

Executive Summary



115 participants

52 Users of Industrie 4.0 solutions

36 Providers of Industrie 4.0 solutions

27 Users & Providers of Industrie 4.0 solutions



10 countries

are represented in the sample



23.0%

of all participants have been working for more than 3 years on Industrie 4.0



100.0%

of the Successful Practice companies chose a Down-Up approach, a combination of Top-Down and Bottom-Up, to deal with Industrie 4.0

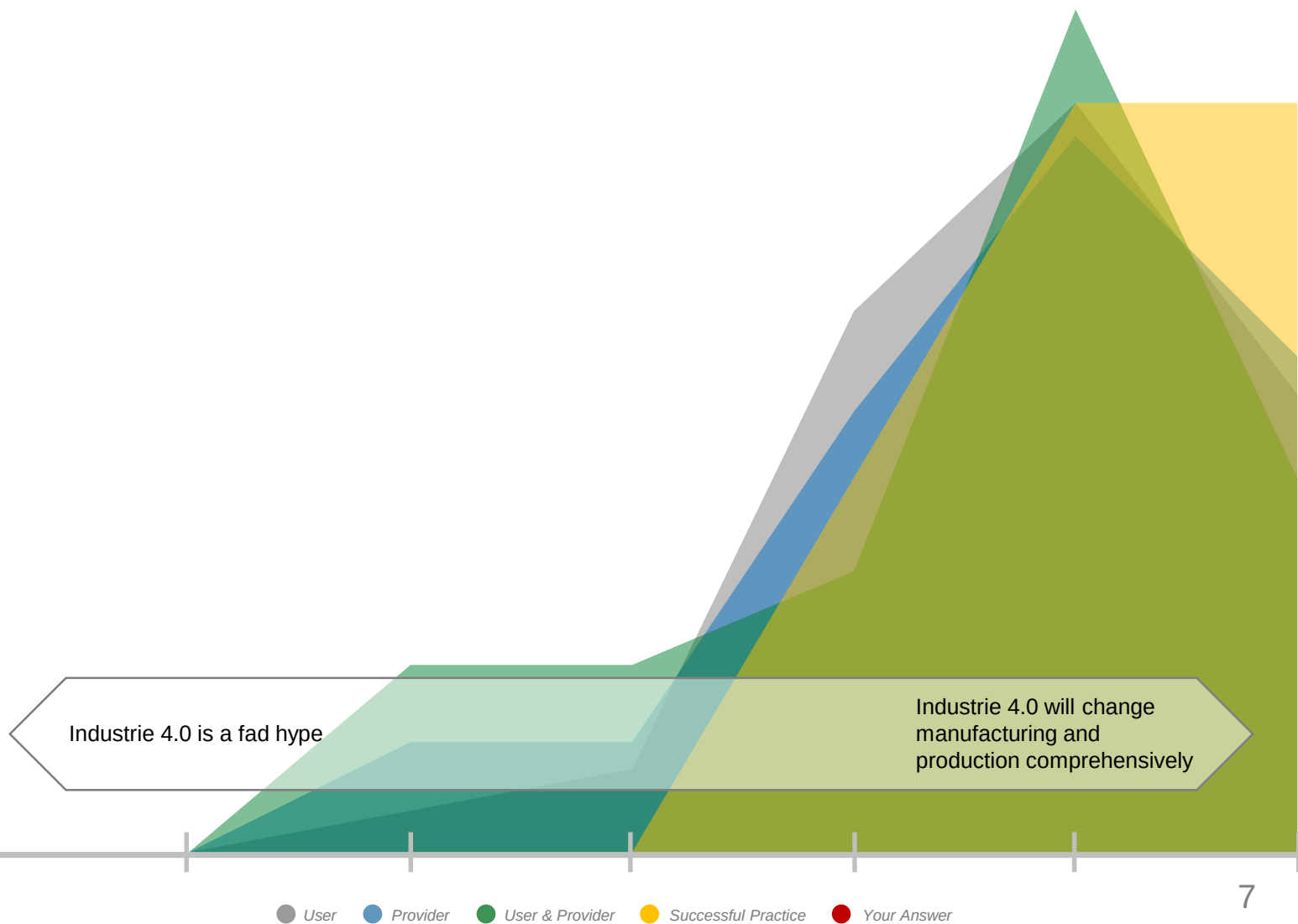


The usage of innovative automation technologies in production is very common. Mobile devices, 3-D printers and RFID are implemented disproportionally often.

“Don’t do Industrie 4.0 because of Industrie 4.0 – use it as a tool for achieving your strategic goals.”

Dr. Uwe Kaltenborn
Product-Portfolio-Management
Maschinenfabrik Reinhausen GmbH

FIGURE 0.1
FUTURE
IMPORTANCE
OF INDUSTRIE 4.0
n=115



Introduction

This personalized report provides you with the results of the benchmarking “Industrie 4.0 – From a Management Perspective” that has been running since October 2015 and is still going on for interested participants. The study is being conducted by the Institute of Technology Management at the University of St.Gallen, Switzerland. Over 115 participants from different industries and with origins mainly in Europe and North America provide solid data for the descriptive findings presented in this report.

The opportunities for and ways of manufacturing are changing worldwide. Companies may chose different strategies and methods, but they all lead to the same goal: improving the production, products and services by connecting the physical with the cyber world.

Digital transformation has already begun and will keep going with an extensive impact on the manufacturing industry. Since its advent as a conceptual idea in 2011, Industrie 4.0 is nowadays a huge phenomenon which affects almost all markets and manufacturing companies. But what is the real impact? Are companies ready for such a fundamental transformation? When is the right time for investing in Industrie 4.0? What are possible improvements regarding products and services? And, most important: how does the new way of manufacturing influence the company's competitiveness?

This benchmarking project focuses on those topics, and aims at improving their understanding. While the technological side of Industrie 4.0 is well focused in many cases, companies often struggle to economically take advantage of the implementation of Industrie 4.0. Hence, in contrast to other studies, which mainly focus on technologies like sensors, robots, IT infrastructure, etc. we decided to take a look at it from the management perspective.

This benchmarking provides an overview on the state of the art regarding Industrie 4.0 implementation, enabling you to compare yourself with the most successful companies and thus leveraging the hidden potential of your business.

In this study, five companies were selected to be Successful Practice companies. This selection was based on anonymized case studies. The cases used the companies' answers in the questionnaire and an interview with the responsible manager for Industrie 4.0 activities as data sources.

Benchmarking Process

The benchmarking follows an established and proven model. First, the topics of major emphasis that will be investigated during the benchmarking process are defined. Next, a benchmarking questionnaire to collect data on those topics is developed. The results of the questionnaire and further secondary research are processed and transformed into anonymized case studies. Based on those cases, five Successful Practice companies are chosen.

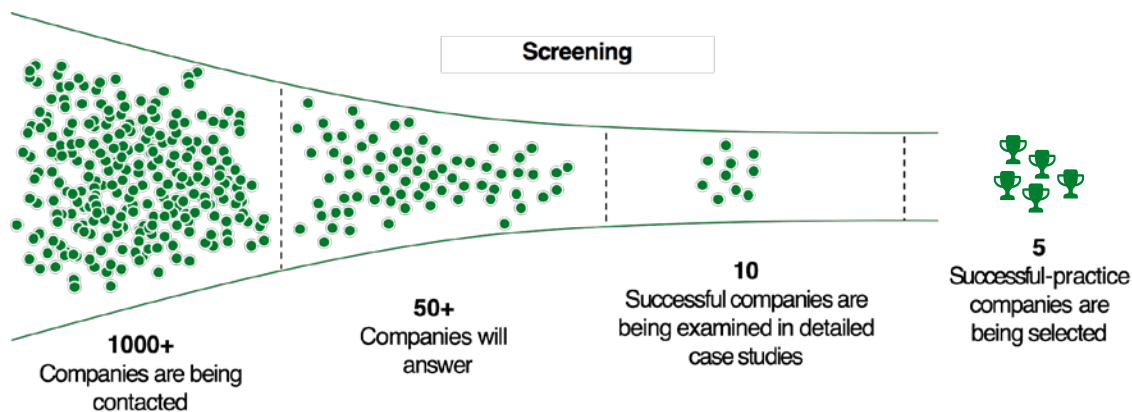


FIGURE 0.2
UNDERLYING
BENCHMARKING
PROCESS

This final report contains all results from the benchmarking: general information about the relevant Industrie 4.0 user or provider, i.e. your company, information about Industrie 4.0, strategy, technology as well as stakeholders. The report closes with some additional information about the performance of the participating companies in the sample.

Methodology

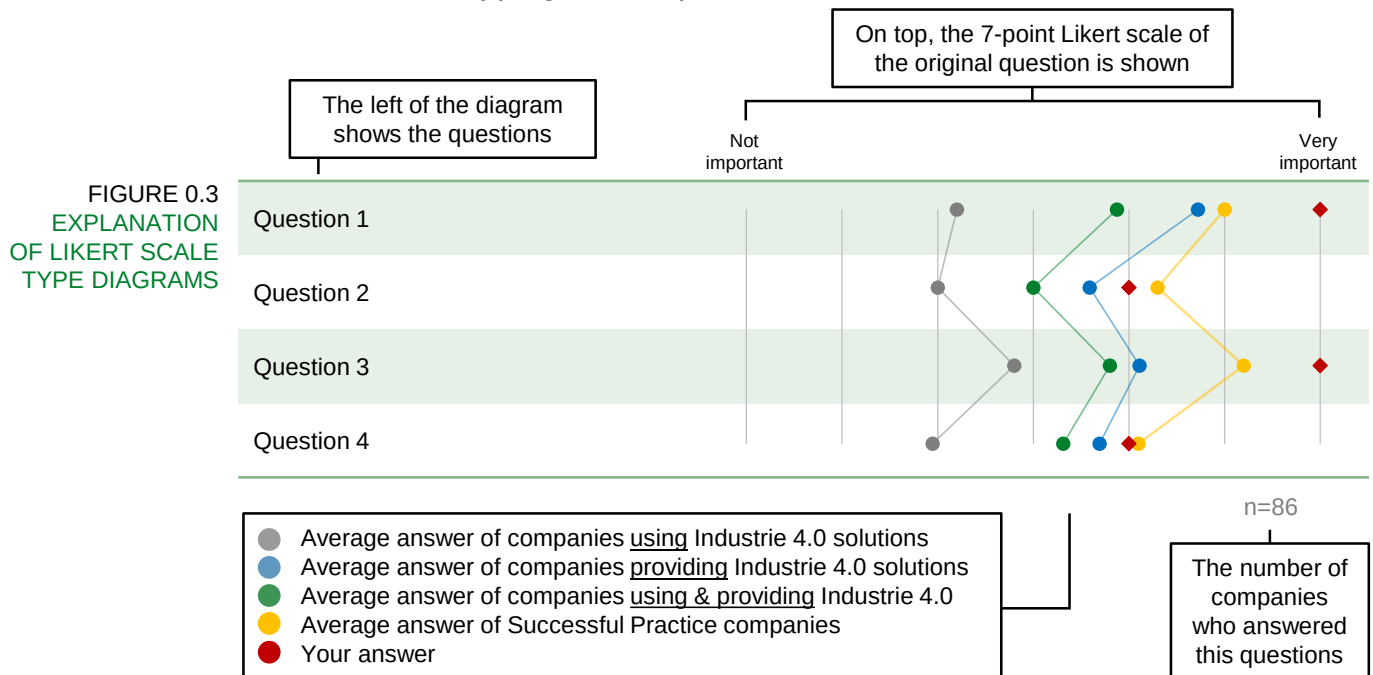
The graphs and conclusions in this report are all based on the survey results and additional insights gathered from 12 interviews with the Successful Practice companies as well as potential Successful Practice candidates.

A group of high performance companies was defined and serves as a reference sample to analyse the activities of a high performance group. This group of Successful Practice companies mainly consists of companies that are user and provider of Industrie 4.0 solutions at the same time. In addition, answers of all participating companies that are exclusively using or providing, or are both using & providing solutions, is presented.

Diagram Types and Colours

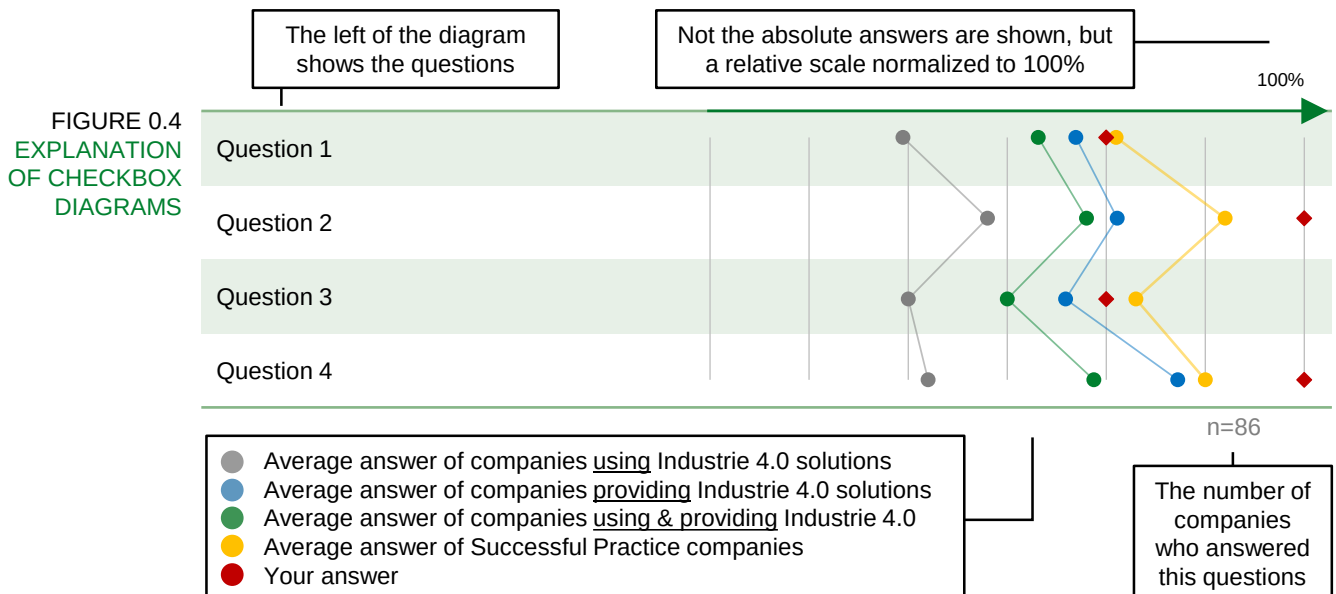
Questions using a 7-point Likert Scale

Answers to questions with a 7-point Likert scale are usually displayed using a line chart. Overlapping answer points can be deduced from the used lines.



Checkbox Questions

Answers to checkbox questions are also usually shown using a line chart. As multiple answers are possible in many cases the scale is adjusted to 100% showing the percentage of all answers within a category.



Trade-off Questions

Trade-off question visualizations show the distribution of all answers. This means that the vertical axis displays the percentage of answers of each group, not the total number of answers.

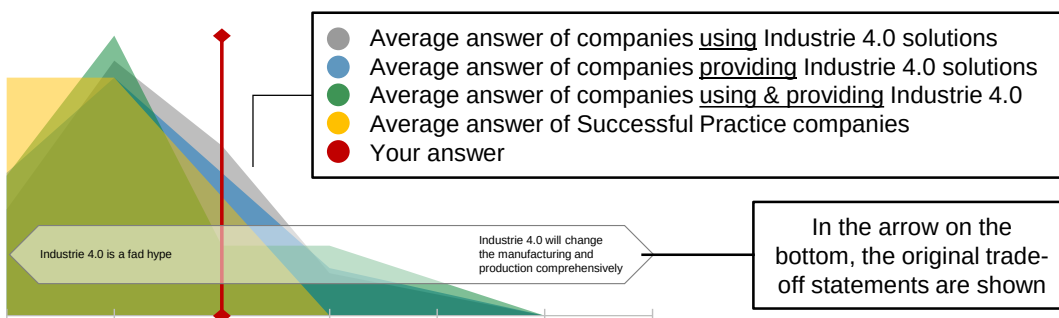


FIGURE 0.5
EXPLANATION
OF DIAGRAMS
FOR TRADE-OFF
QUESTIONS

Competitive Priorities

To display ranking of competitive priorities, a radar chart (*also called spider chart*) is used to plot the values of each category along a separate axis that starts in the centre of the chart and ends on the outer ring. A point close to the centre on any axis indicates a low value. A point near the outer ring is a high value. When you're interpreting a radar chart, check each axis as well as the overall shape.

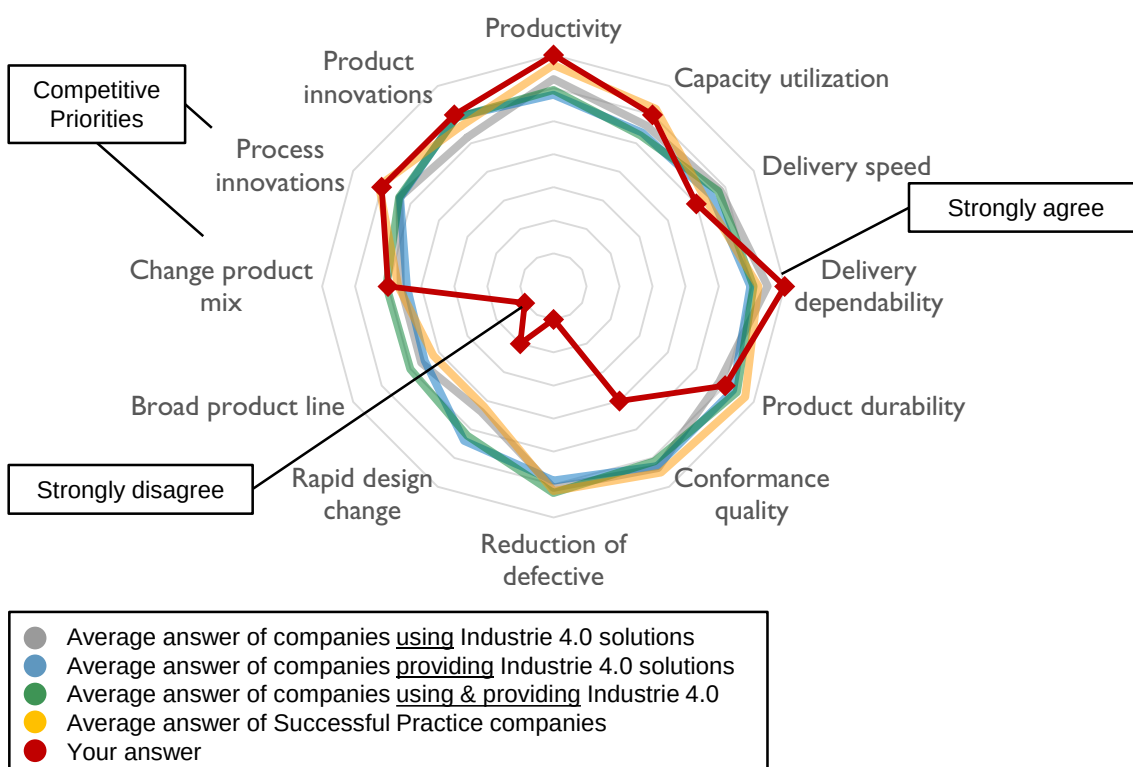


FIGURE 0.6
EXPLANATION
OF DIAGRAMS
SHOWING
COMPETITIVE
PRIORITIES

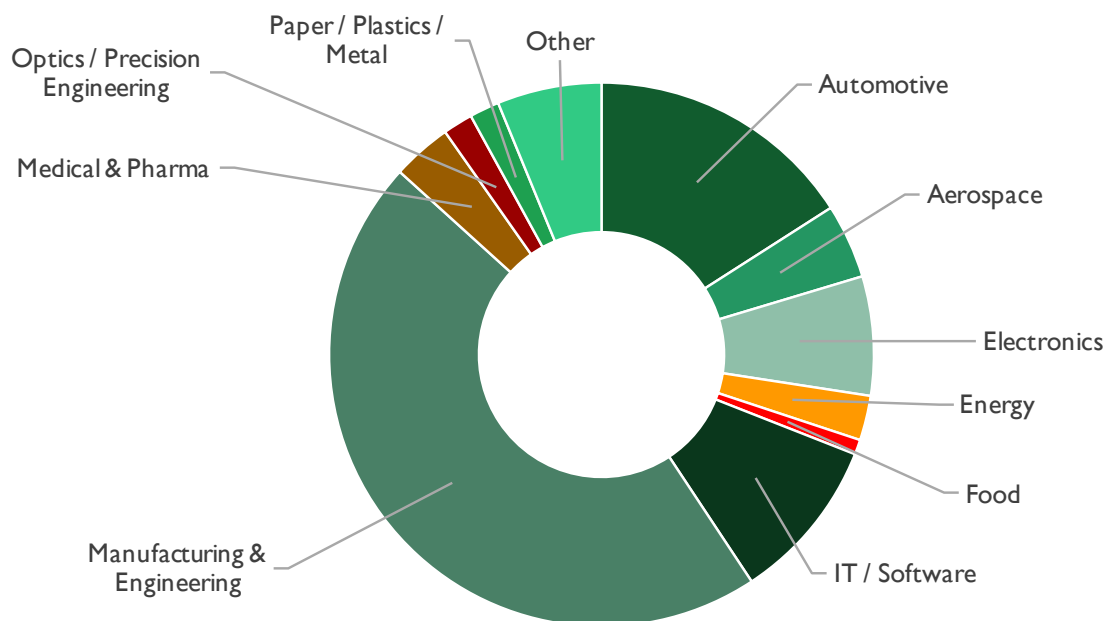
I General Information

In the first section of the benchmarking questionnaire characterizing elements of the participating companies were requested. The following pages give insights into the composition of the benchmarking sample regarding product type, size, industry and competitive positioning.

Participating companies originate from a wide range of industries, with most companies from manufacturing & engineering, automotive and IT/Software industries. There are only a few industries which are missing in the sample: defence, clothes & textiles as well as transport & logistics are not represented.

FIGURE I.1
INDUSTRIES OF
BENCHMARKING
PARTICIPANTS

n=115



The following chart shows the product type of the participants. It is obvious that companies producing for the B2B (business-to-business) segment dominate the sample compared to B2C (business-to-customer) or B2G (business-to-government). Multiple answers were possible.

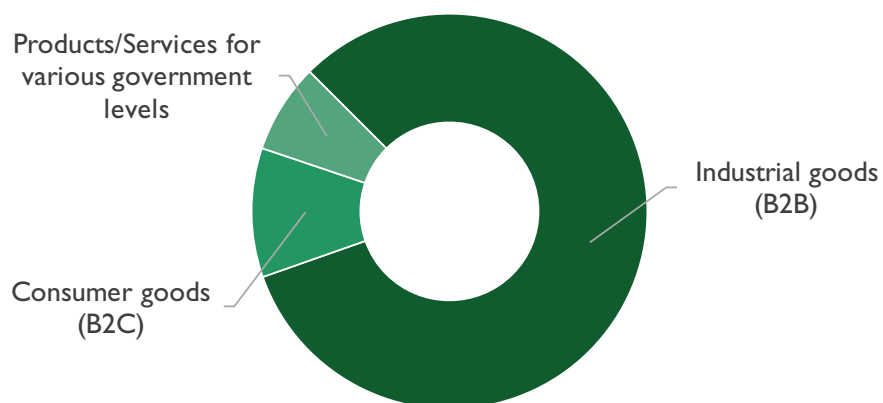


FIGURE I.2
PRODUCT TYPE
multiple answers

Participants are predominantly located in European countries, with non-European companies from Argentina, Canada, China, and the United States. In particular companies from German-speaking countries participated in the benchmarking.

Switzerland	63
Germany	36
Austria	4
USA	4
Liechtenstein	3
China	1
Canada	1
Argentina	1
Italy	1
Sweden	1
Other	0



FIGURE I.3
COUNTRIES OF
BENCHMARKING
PARTICIPANTS
n=115

More than 110 companies participated in the benchmarking. While most of them are exclusively using Industrie 4.0 solutions, some are actively providing such solutions to their customers. More than one third of all participants do both, using and providing such solutions. The selected Successful Practice companies belong to the two groups of using and using & providing companies.

FIGURE I.4
STATUS OF
PARTICIPANTS

n=115

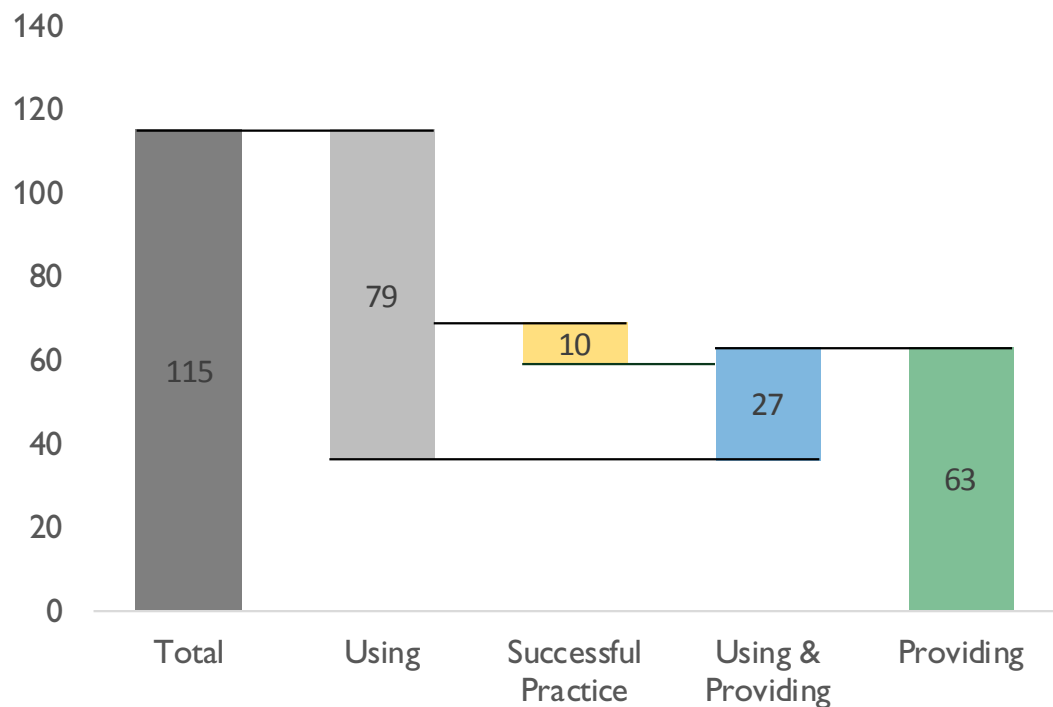


FIGURE I.5
EMPLOYEES

n=115

Participating companies range in size from multinational corporations with around 375,000 employees to relatively small companies completely focused on developing and providing solutions whose work force number just tens of people. The graph to the left of the text displays the number of people in the companies (in thousands).

On average, around 15,000 employees work at the companies or business units in the benchmarking sample.

With regard to the different categories, Successful Practice companies are the largest companies with an average of 46,980 employees. This large number arises especially from one multinational corporation in this category. Excluding this company from the average calculation, average size of Successful Practice companies is 10,533 employees. Using & providing companies are more or less the same size.

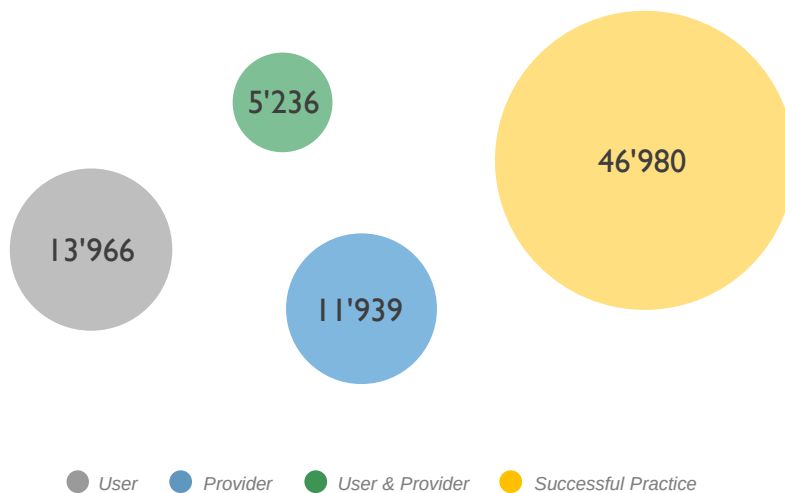


FIGURE I.6
EMPLOYEES BY
CATEGORIES

n=115

The implementation of order fulfilment strategies is evenly distributed. As multiple answers are possible, several companies selected more than one strategy. However, most of the participants have one single order fulfilment strategy. Less than one of four companies applies more than two strategies at the same time. 7 out of the 10 Successful Practice companies follow the order fulfilment strategy "Make-to-order".

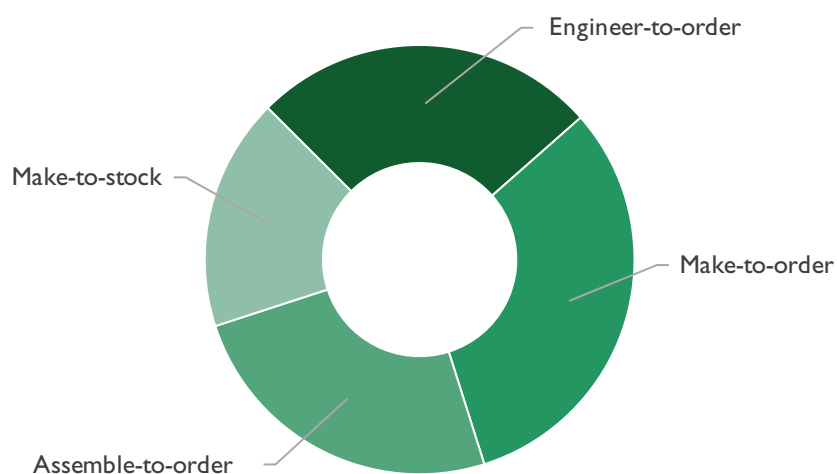


FIGURE I.7
STATUS OF
PARTICIPANTS

multiple answers

Explanation

- Engineer-to-order (e.g. a machine specifically designed for one customer)
- Make-to-order (e.g. a standard machine of given product line produced for an individual customer)
- Assemble-to-order (e.g. a car - individualized, but being only one variety of a mass product)
- Make-to-stock (e.g. a soap produced for retailing)

An analysis of the competitive priorities of the sample shows that Successful Practice companies tend to compete in their respective industries with a focus on cost and quality, then innovativeness. Flexibility is considered to be of medium importance. Compared to the other categories, Successful Practice companies consider process innovation as an especially important priority.

FIGURE I.8
IMPORTANCE OF
COMPETITIVE
PRIORITIES
n=108

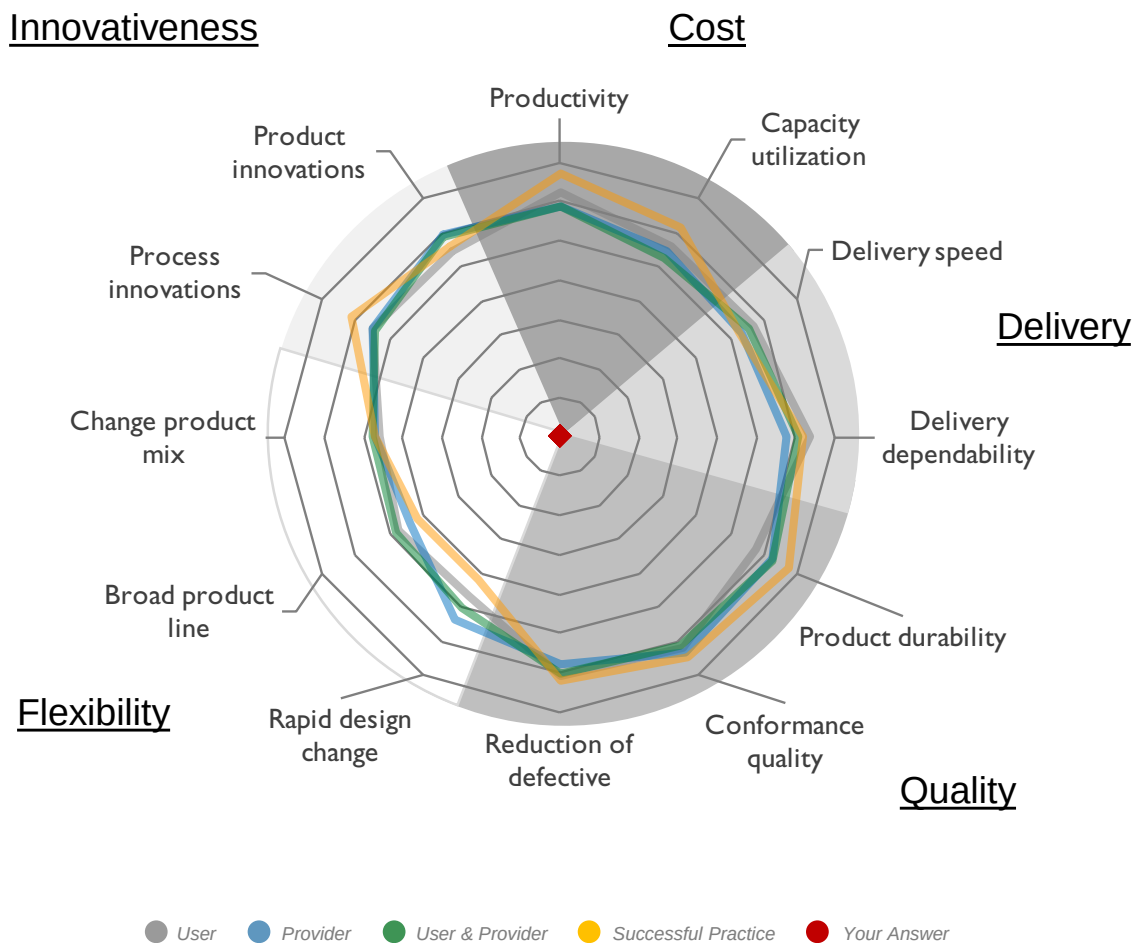


FIGURE I.9
NUMBER OF
PRODUCT
LINES
n=101

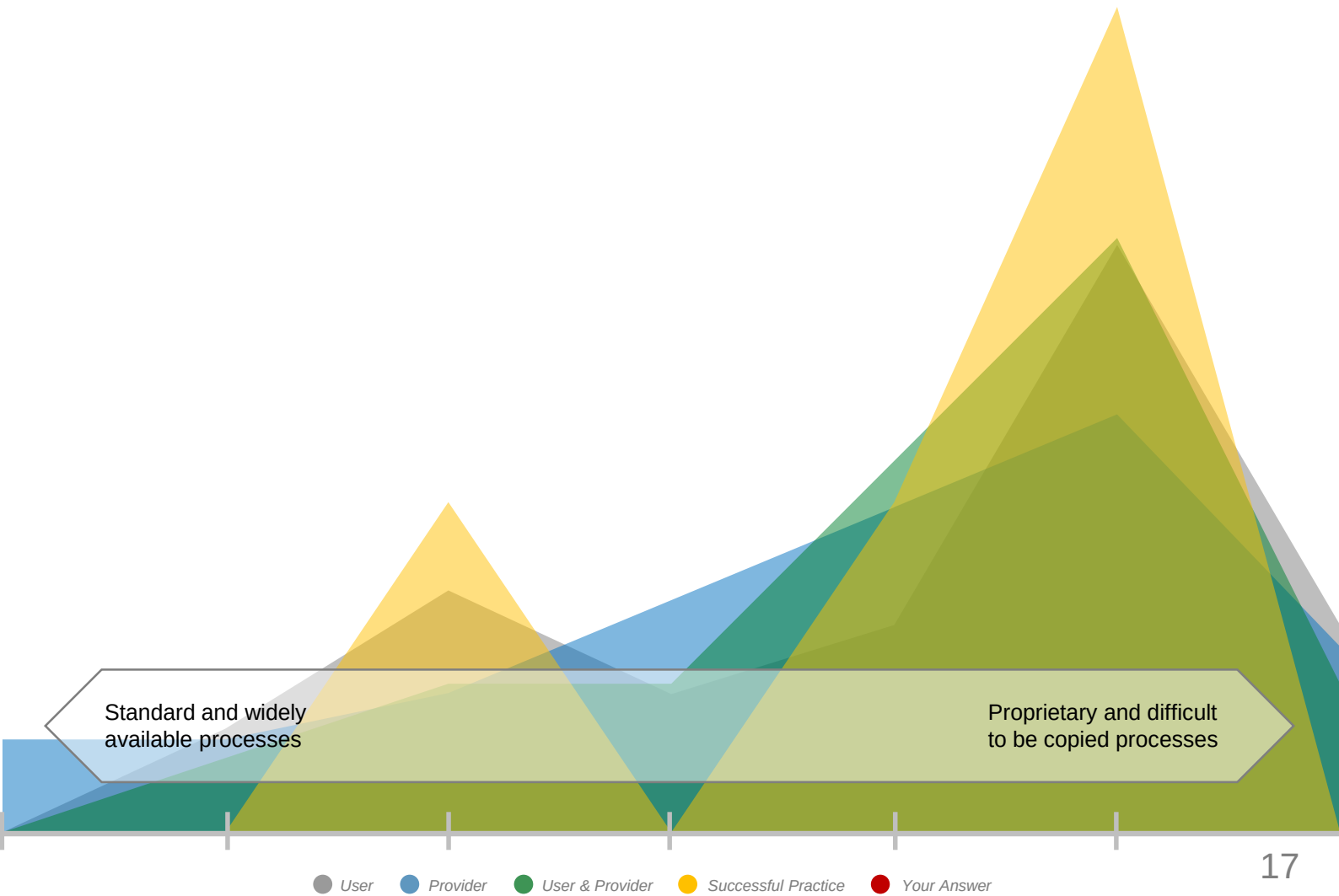
► An analysis of how these factors are affected by Industrie 4.0 will be shown in chapter II ("Introduction to Industrie 4.0")

A product line is a group of products that are closely related to each other by function, customer group, market, or price range. The average amount of product lines in the sample is 49.9 while two companies have 1,000 product lines. The analysis shows, that the number of product lines does not automatically depend on the firm size.

Companies which are using & providing Industrie 4.0 solutions have an average of 94 product lines; Successful Practice companies have about 100 product lines.

Particularly the users and most of the Successful Practice companies tend to rate their production processes as unique. Also companies using & providing Industrie 4.0 solutions at the same time stated that their processes are proprietary and difficult to copy, while provider companies do not evaluate their processes as being that unique and more widely available.

FIGURE I.10
PRODUCTION
PROCESS
UNIQUENESS
n=104



II Introduction to Industrie 4.0

The second chapter will focus on the status and current activities regarding Industrie 4.0. The sample is quite mixed. On the one hand, most companies are evaluating, researching on and developing Industrie 4.0 solutions. On the other hand, companies are already implementing or selling products produced with Industrie 4.0 technologies. No company is dismantling their activities and only a few say the topic is decreasing in importance in their company.

Our data shows that user companies tend to do less regarding Industrie 4.0 in comparison with the other categories. It is important to mention, that many companies do not use the term Industrie 4.0 in their wording and that they use some technologies and solutions which they do not consider to be part of Industrie 4.0. RFID and Remote Services are just two examples which are frequently used, but not mentioned in the context of Industrie 4.0 by many companies. Providers are usually more active in these fields. Of course, they are researching and developing, but also implementing and selling products produced with the help of Industrie 4.0. This also applies to companies which do both. Those companies use their own products to make the production more efficient and to increase productivity.

Most Successful Practices are already a step further. Their status of implementation is outstanding. In addition, the percentage of Successful Practice companies selling products produced with Industrie 4.0 is very high – already 70% of the Successful Practices do so.

FIGURE II.1
INDUSTRIE 4.0
STATUS

n=112

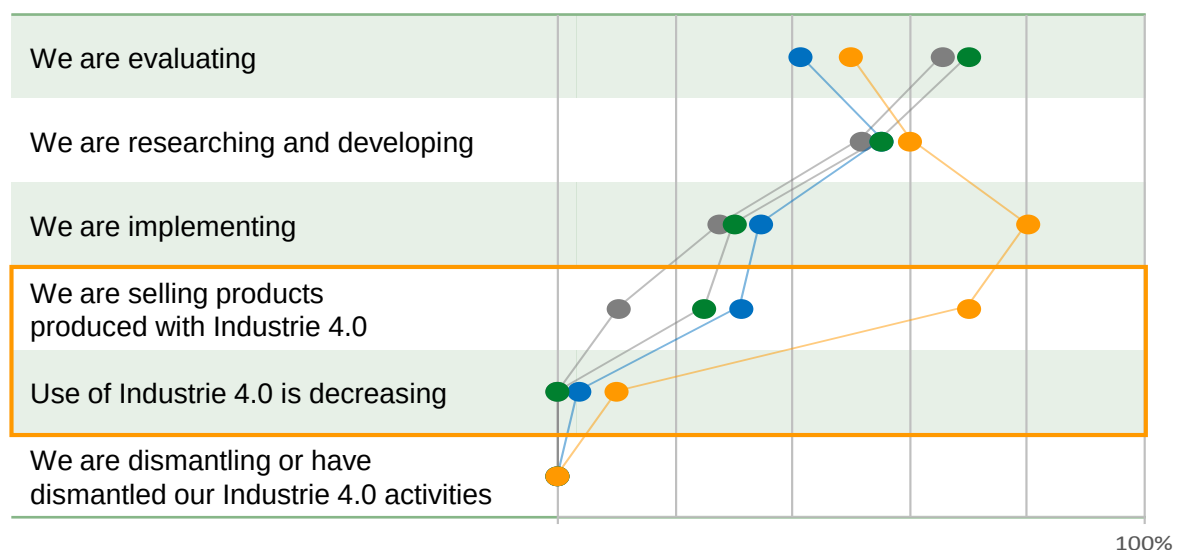


FIGURE II.2
INDUSTRIE 4.0
EMPLOYEES

Companies allocate a remarkable percentage of their work force on activities related to Industrie 4.0. On average, 138 employees work on the topic or are directly involved. The number of employees working on Industrie 4.0 related activities ranges from 0 to 5,000. However, for many companies it is difficult to determine how many employees are actually working on the topic since most projects are interdisciplinary and different departments are involved. Therefore, several companies couldn't distinguish between the categories of directly working on Industrie 4.0 and being directly affected by it.

It appears that especially the larger companies of the sample created special Industrie 4.0 job positions such as "Lead Architect Industrie 4.0" or "Head of Industrie 4.0".

Moreover, several companies explicitly hired people to work on the topic Industrie 4.0. One company of the sample hired 450 employees, but this is a real exception. Most of the companies hired between two and 25 people to work in this field. Again, it is difficult for the companies to tell how many people are exclusively working on Industrie 4.0.

The graph to the left of this text shows how many employees are working on the digitalization, connection of systems and new IT solutions in the companies.

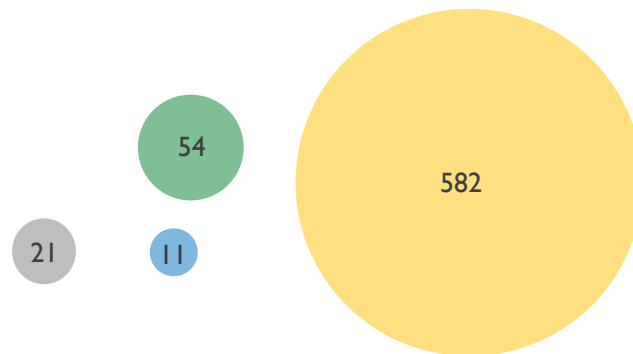
FIGURE II.3
INDUSTRIE 4.0
EMPLOYEES
EXPLICITLY
HIRED

n=115

With regards to different company categories, Successful Practice companies employ an average of 582 employees directly working on Industrie 4.0. The user & provider companies also have many employees in the context of Industrie 4.0. This is not a coincidence as research and development activities in the field of Industrie 4.0 are very important for them in order to sell products and stay in the market.

FIGURE II.4
INDUSTRIE 4.0
EMPLOYEES
BY CATEGORY

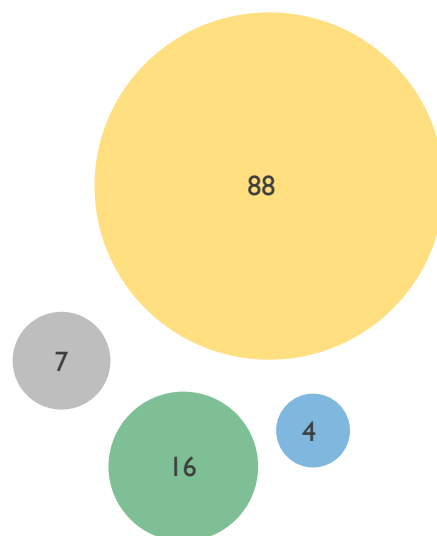
n=115



It can be extracted from the illustration below that Successful Practice companies hire more people to execute and further advance their Industrie 4.0 activities. These people mainly work in production or in the IT department. They work on improving productivity and the connection between machines, people and systems.

FIGURE II.5
INDUSTRIE 4.0
EMPLOYEES
HIRED BY
CATEGORY

n=115



Strikingly, companies claim they experience a severe shortage of manpower regarding the successful execution of Industrie 4.0. We conclude that the numbers presented here might increase when the topic becomes more relevant for the different companies (see "Barriers regarding Industrie 4.0")

Industrie 4.0 – Since when?

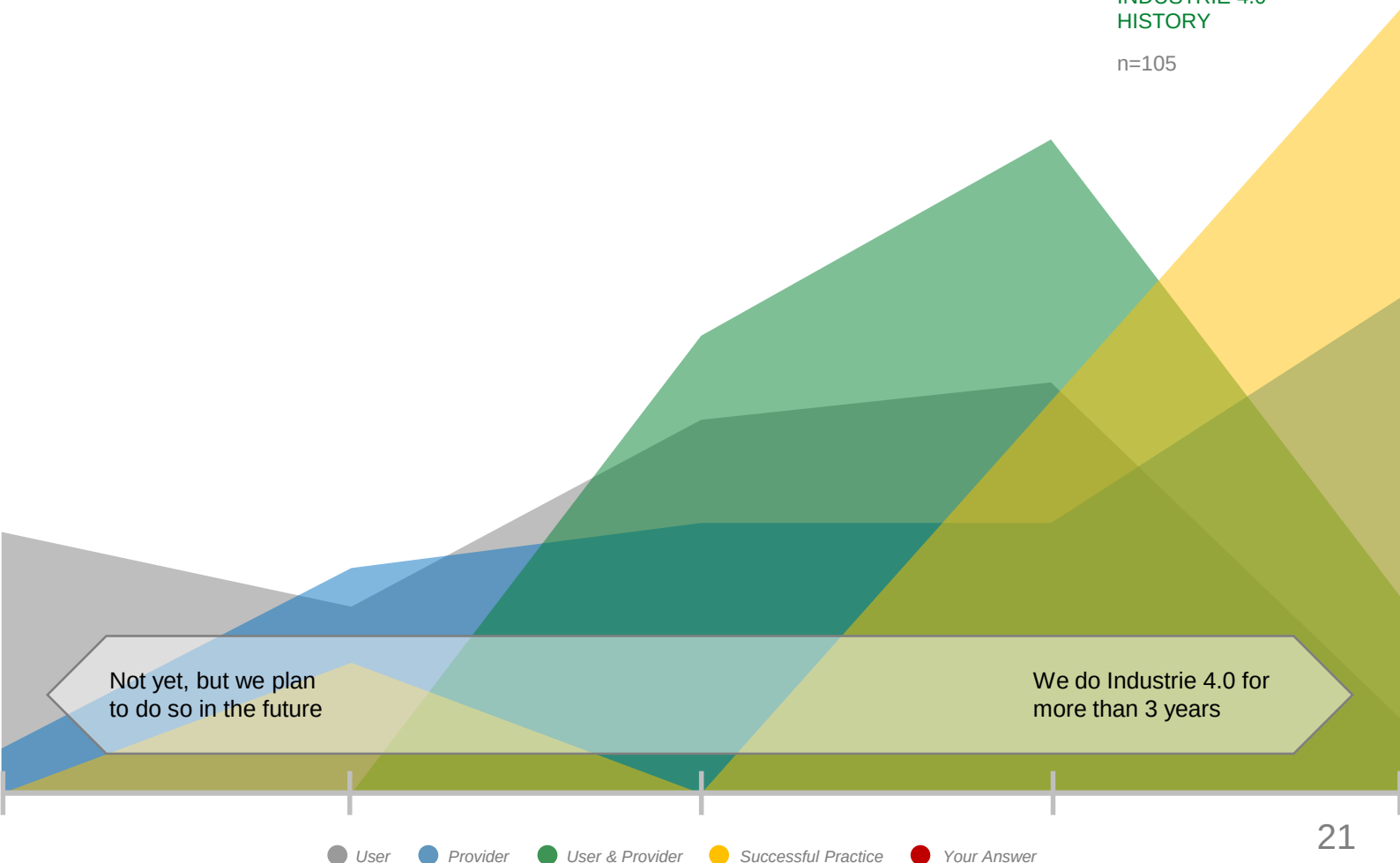
Around 20% of all participating companies have been working on Industrie 4.0 and related topics for more than three years now. Another 25% have been working on it for at least one to three years. On average, provider companies started earlier to implement Industrie 4.0 compared to the using companies. The same applies to the Successful Practice companies since 60% of them have been working on the topic for more than three years.

Nonetheless, some of the respondents are at a very early stage as presented in the diagram or can be concluded from some quotes we gathered:

- “Too early stage to understand the potential.”
- “We don't know enough yet, so we have a lack of knowledge about all the possibilities.”
- “In the production field this is more and more a topic we will have to address.”
- “There are no products or product categories, because we haven't started with Industrie 4.0 yet.”

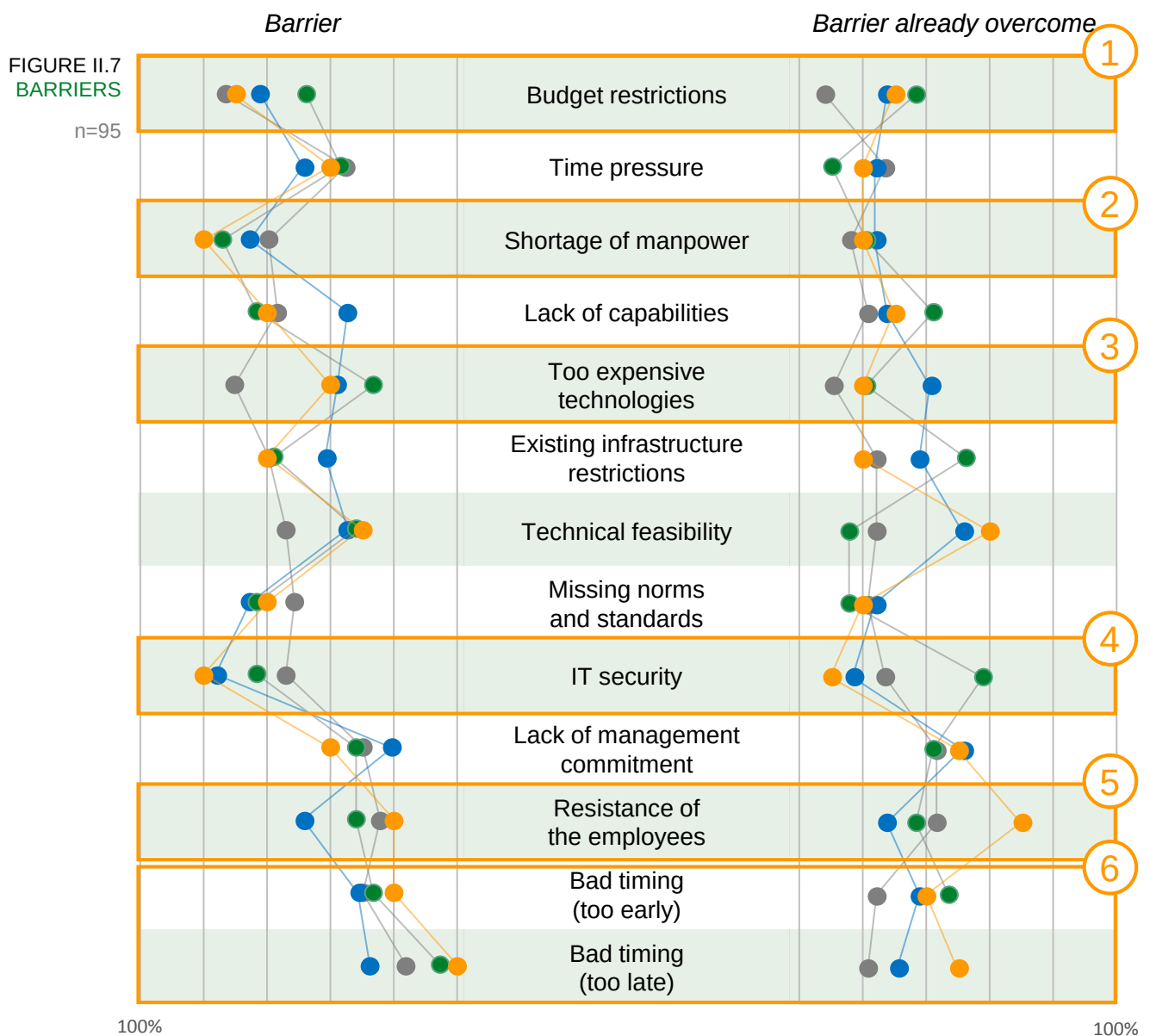
As other studies from BITKOM, VDMA & ZVEI show, most companies are gathering information about Industrie 4.0 today. Only a small group are actually developing or implementing it.

FIGURE II.6
INDUSTRIE 4.0
HISTORY
n=105



Barriers regarding Industrie 4.0

There are several barriers to the successful execution of Industrie 4.0. Since its advent as a conceptual idea in 2011 in Germany, Industrie 4.0 has become very popular and today affects almost all markets and manufacturing companies to a certain degree. However, some barriers limit companies in exploiting the full potential of Industrie 4.0. The following chart shows certain barriers and whether it was already possible to overcome them.



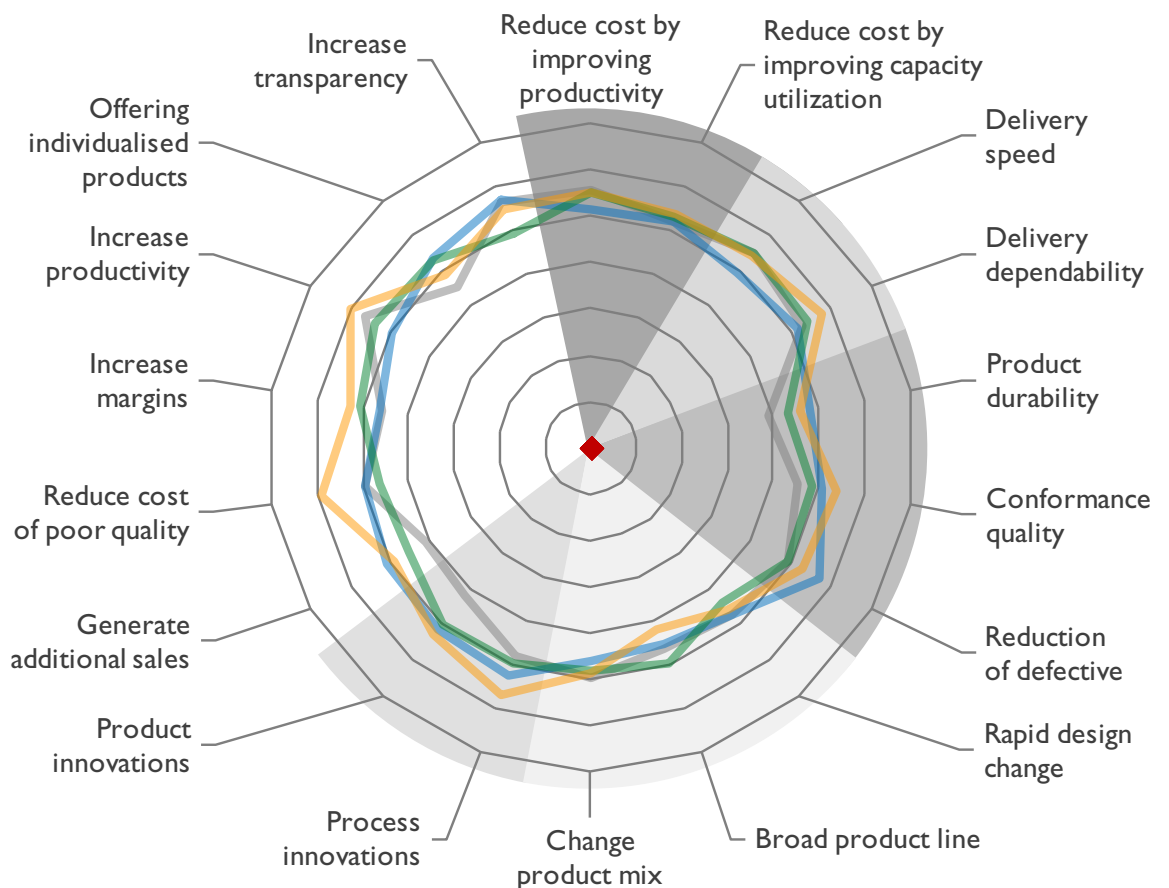
- ① One of the most challenging barriers are **budget restrictions**. Regardless of company size, region, industry, or category – this barrier exists for almost all companies. So far, respondents have not been able to overcome this barrier. Even Successful Practice companies are having struggles with budget restrictions. However, our research shows that top-management commitment can positively influence this barrier.
- ② **Shortage of manpower** is a barrier that limits many companies. Especially smaller firms are greatly affected by this. Again, industry or company category is not the depending factor. Even Successful Practice companies stated that they would like to do more regarding Industrie 4.0. Yet, it is not feasible to increase their activities due to a shortage of manpower, specifically experts. As of today, this barrier is still in place.
- ③ As another barrier, respondents named the fact that **technology is too expensive**. Furthermore, they state that technologies are not very sophisticated or are incompatible with their current equipment. Especially the companies using Industrie 4.0 see this barrier and it has not been overcome at all.
- ④ **IT security** is another major barrier companies are struggling with. Protection of data is a critical issue and will increase in importance with the progressing implementation of Industrie 4.0. Both will increase, the number of data generating devices within a factory as well as the geographic dispersion of Industrie 4.0 implementation in factories abroad. All company categories evaluated this barrier as an important one with using companies being the least sceptical ones.
Our research shows that many using companies expect integrated Industrie 4.0 solutions, that include protected and secured IT systems. Most using & providing companies view this barrier as already overcome.
- ⑤ The **resistance of employees** is another barrier with some importance. Most companies expect the direct working environment to alter due to the implementation of Industrie 4.0. Employees' acceptance of those changes is viewed as limited. However, most Successful Practice companies do not consider employee resistance to be a barrier. On the contrary, some mentioned that their employees' satisfaction has been significantly improved over time with the implementation of Industrie 4.0 solutions in production and assembly.
- ⑥ The **timing** for starting with Industrie 4.0 implementation seems not to be a very strong barrier. Companies are not sure whether it is too early to start with Industrie 4.0 or already too late. However, the Successful Practice companies in particular consider it not too late to start now.

Impact of Industrie 4.0

The influence of Industrie 4.0 on the manufacturing competencies was captured using the already introduced five categories: cost, delivery, quality, flexibility, and innovativeness. Additionally, some goals were added that are often discussed in the context of Industrie 4.0. Those are: generation of additional sales, reduction of costs of poor quality, increase of margins, increase of productivity, offering of individualized products and increase of transparency.

FIGURE II.8
IMPACT OF
INDUSTRIE 4.0

n=107



“Industrie 4.0 is part of our strategy and will be part of many innovations in the future.”

Andreas Conzelmann

Managing Director
TRUMPF Laser Marking Systems AG

Agreement on the positive impact Industrie 4.0 has on their manufacturing competencies is quite similar among all company categories, as the illustration on the previous page shows. On average, using companies (4.87) were less positive than providing & using companies (5.00), provider companies (5.07) and Successful Practice companies (5.26).

The largest difference in the sample can be observed for product innovations: Successful Practice companies (5.30) are by far more convinced of a positive impact of Industrie 4.0 than user companies are (4.21). In fact, the latter view Industrie 4.0 as providing the least strong effect on this specific capability. Successful Practice companies are also more positive regarding the effect on process innovation. This might be due to the fact that Successful Practice companies already use machine and product data to inform engineers about customer needs and product weaknesses. Successful Practice companies also leverage this data to reduce the cost of poor quality: they often use process data with the goal of quality improvement, may it be through statistical process control (SPC) or Big Data.

Offering individualized products is a manifold quoted goal of Industrie 4.0. However, our results show rather low levels of positive impact on product customization (5.01 on average). While user companies report the least positive impact (4.53), provider companies are the most positive ones (5.33). Similar to product innovations, promised benefits of Industrie 4.0 have not yet arrived at the appliers of Industrie 4.0 technologies.

Another capability that is evaluated fairly differently is product durability. Again, provider companies (4.83) see a rather positive effect of Industrie 4.0, user companies are less positive (3.90).

Delivery dependability (also: *reliability* or *delivering on time*) is viewed by all company categories as being very positively affected by Industrie 4.0 (5.42 on average). The same is true for increasing transparency (5.46), cost reduction (5.42) and increasing productivity (5.51).

User companies reported the highest impact of Industrie 4.0 regarding increase of transparency (5.64), reduction of cost by improving productivity (5.56), and improving delivery speed (5.49). Successful Practice companies saw the highest impact on productivity gains (6.00), reduction of costs of poor quality (5.90), increase of delivery dependability (5.80), and process innovations (5.70).

III Strategy

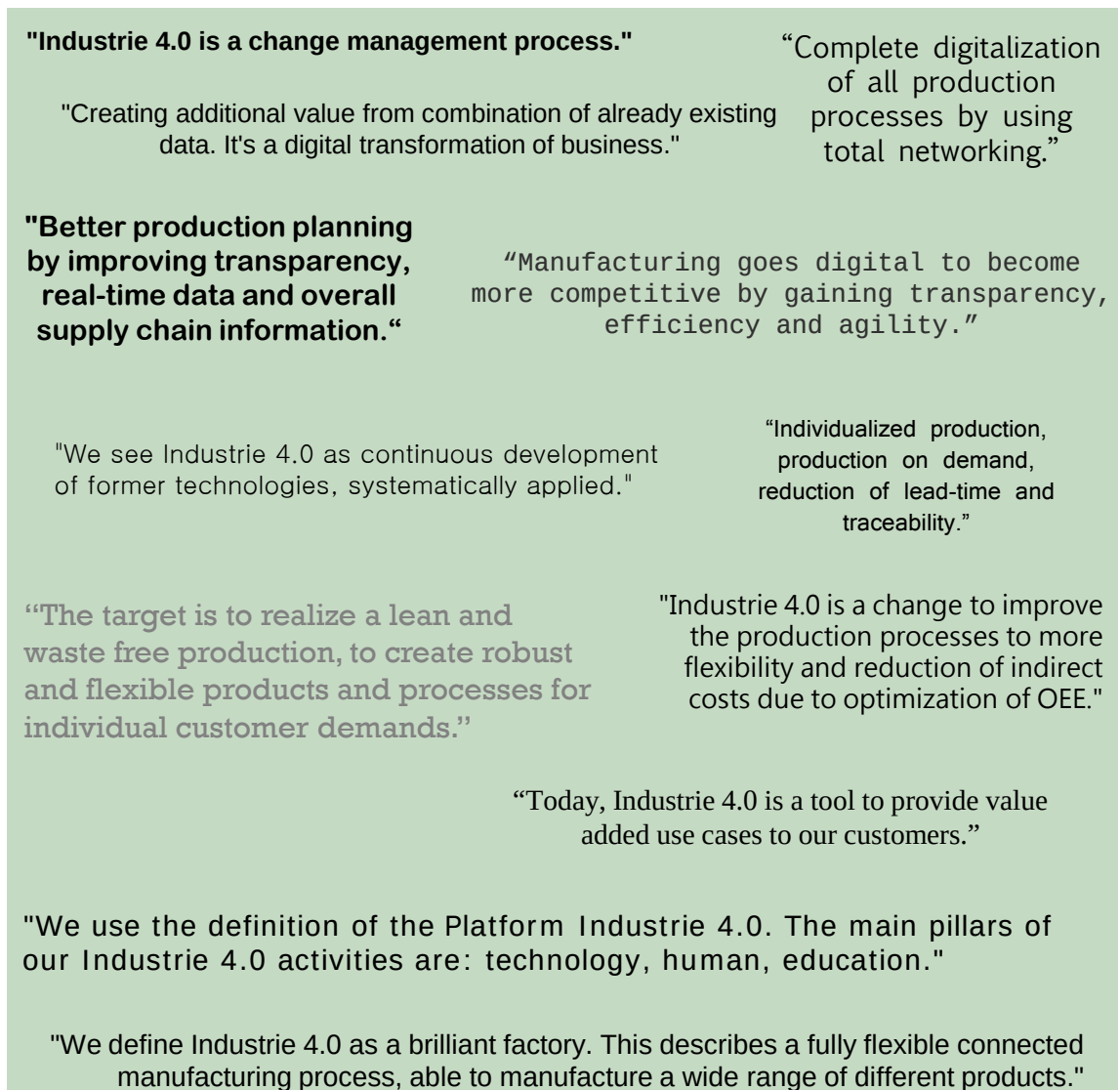
This chapter will present the company's strategies regarding Industrie 4.0. Very often the companies do not have a defined so called "Industrie 4.0 strategy", but it is mostly a way to successfully achieve defined goals like increasing productivity, increase margin or reduce defects.

Users usually deploy Industrie 4.0 to make their production more efficient, flexible, cost efficient, etc., while providers want to make their products and services more competitive.

In the German-speaking area, more than 200 definitions for the term "Industrie 4.0" exist! They are created by politics, research institutes, consultancies, manufacturing companies and associations.

This multitude is mirrored in the answers of the respondents when being asked about their definition of Industrie 4.0.

FIGURE III.1
INDUSTRIE 4.0
DEFINITIONS
(SELECTION)
n=105



“Industrie 4.0 is innovative change management.”

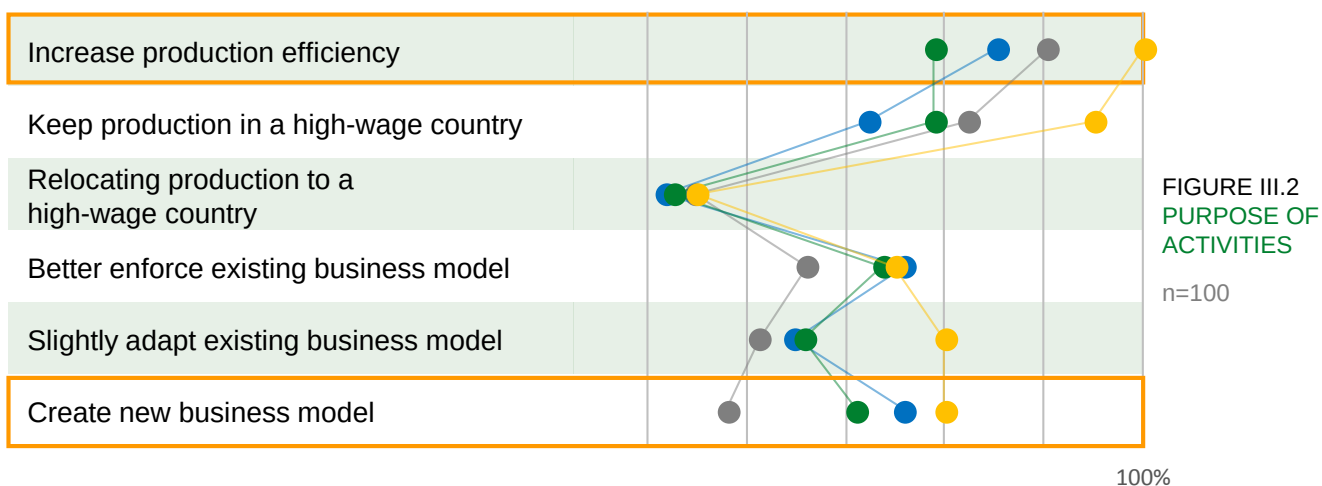
Herbert Dirnberger

Cyber Security Austria

Purpose of Industrie 4.0 Activities

Each company has to decide on their main purpose for implementing Industrie 4.0. In public discussions the two options “increase efficiency” and “create new business models” are dominating. While the first option aims at saving money in the production process, the second option aims at generating more revenue for the company. Some former manufacturing-only companies have already created new business models that enable them to make approximately 14% more revenue (results from the ITEM-HSG benchmarking study: “Success in the Future of Smart Services”).

Our benchmarking reveals the increase in production efficiency being the most important effect of Industrie 4.0, followed by the goal of keeping production in a high-wage country. However, Industrie 4.0 does not seem to be a driver of relocating production. Surprisingly, most respondents do not view enforcing and creating business models as a purpose of Industrie 4.0. User companies do not consider business model innovation as much as a purpose of Industrie 4.0 as provider companies do. Instead they rather aim at increasing production efficiency a lot. Provider companies also strive for this purpose, but also want to better enforce their existing business model or want to create new ones. Successful Practice companies are above average in all categories. With the help of Industrie 4.0, most of them want to improve their production efficiency, keep production in high-wage countries, want to better enforce and slightly adapt their existing business models as well as creating new business models.

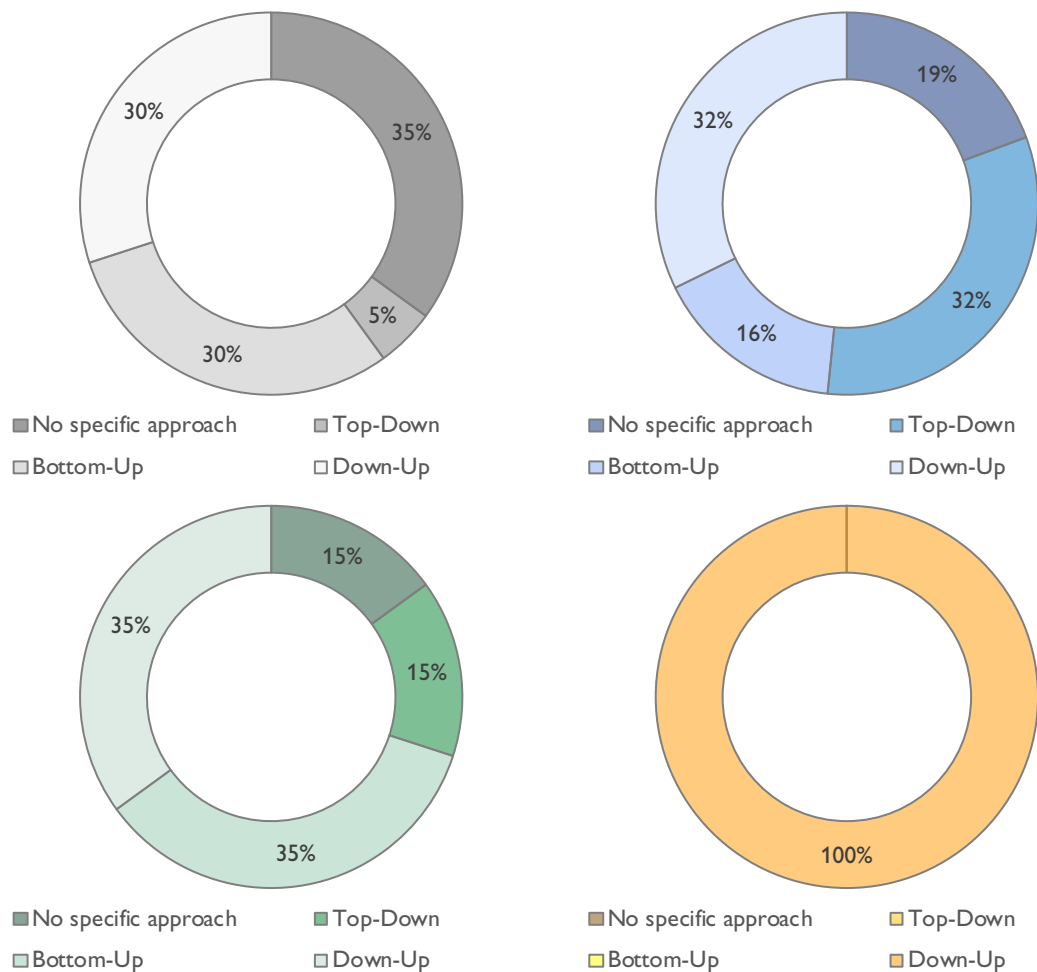


Industrie 4.0 Approach

When it comes to the approach companies choose for dealing with Industrie 4.0, responses are quite similar. However, a closer look reveals that provider companies usually choose a Top-Down or Down-Up approach, whereas user companies select Bottom-Up approaches or don't follow any specific approach.

FIGURE III.3
STRATEGIC
APPROACH

n=101



All of the Successful Practice companies choose a Down-Up approach like this: On the shop floor, in lower and middle management and in the research and development departments, Industrie 4.0 solutions are identified, evaluated and – if they turn out to be a suitable means for a problem – implemented. Thus, existing strategy is enforced, but also new strategic options are created. It is the top-management that tries to guarantee this autonomy of the individual entities within the organisation (decentral responsibilities for budgets and processes). But top-management also ensures that successful solutions are implemented throughout the company. It also coordinates the knowledge exchange between sites and sets standards regarding technologies and interfaces within the firm. Also, it takes up strategic options from Bottom-Up. Top management is drawing the big picture and brings the Bottom-Up approaches together and manages the conflicts resulting from the opposite goals (ensure autonomy and set standards).

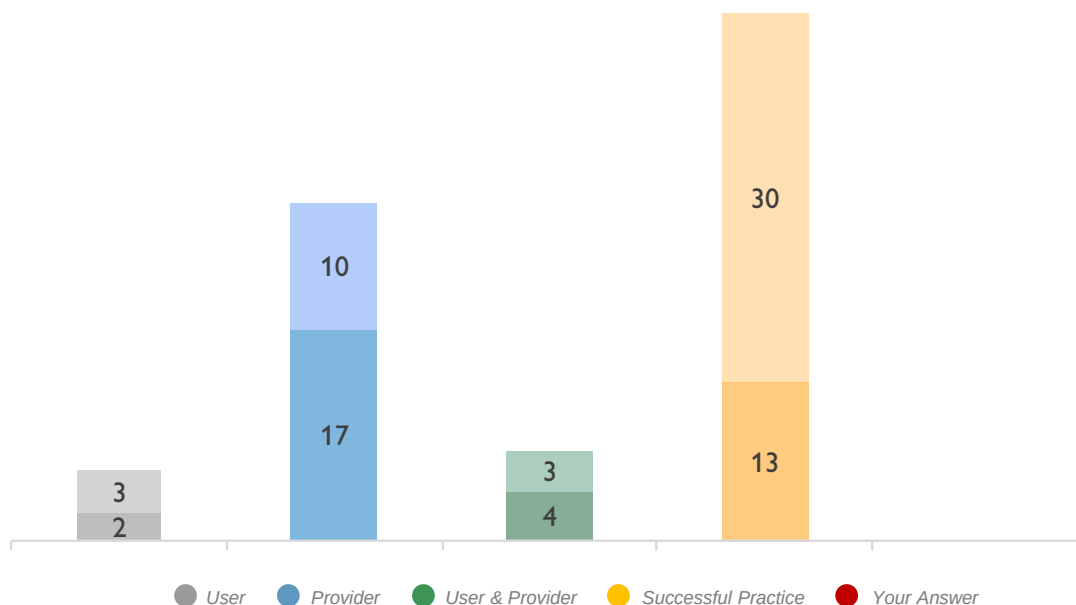
Projects

Continuously re-challenging projects is a very important factor regarding the implementation of Industrie 4.0. Since Industrie 4.0 is an evolutionary approach, each project must be taken as a chance to learn – about production, about the process, about technologies, about people and about what went wrong and why.

The range of what companies call “a project” is quite widespread. Connecting a single machine to the internet can be a project as well as the opening of a new building complex for production, and research & development. Consequently, project expenditures range from some 10,000 EUR up to over 300 million EUR.

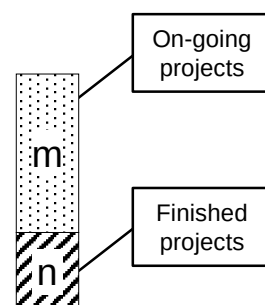
FIGURE III.4
AVERAGE
NUMBER OF
INDUSTRIE 4.0
PROJECTS

n=102



The number of projects is not directly dependent on the size of the company. But usually expenditures per project are higher at larger companies. The maximum number of finished projects related to Industrie 4.0 by one single company was 100, with 200 projects still on-going.

Provider companies have finished a lot more projects and are currently doing more projects compared to user companies. The Successful Practice companies have on average a lot of projects on-going (30) and finished around 13 projects in recent years.



“You need a strong focus on project work in cross-functional, interdisciplinary and international teams – instead of working in closed departments and in teams that don’t change over years.”

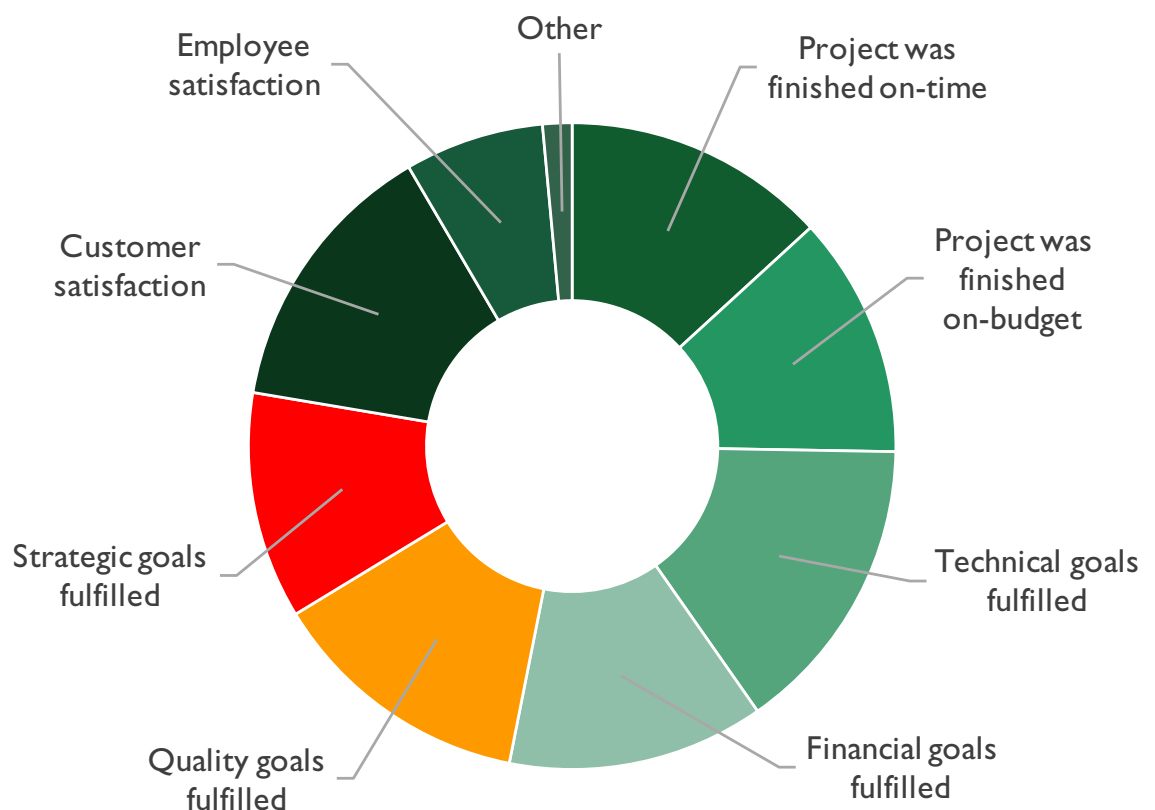
Bernd Waschneck

Manufacturing Excellence
Infineon Technologies AG

Besides focusing on the content of a project, it is important to evaluate how successful it really was. Therefore, the question “Which are Key Performance Indicators to evaluate an Industrie 4.0 project?” arises.

In the chart below, it can be seen that the evaluation methods do not differ much in terms of their popularity. Even Successful Practice companies do not show a common approach when it comes to the evaluation (multiple answers possible).

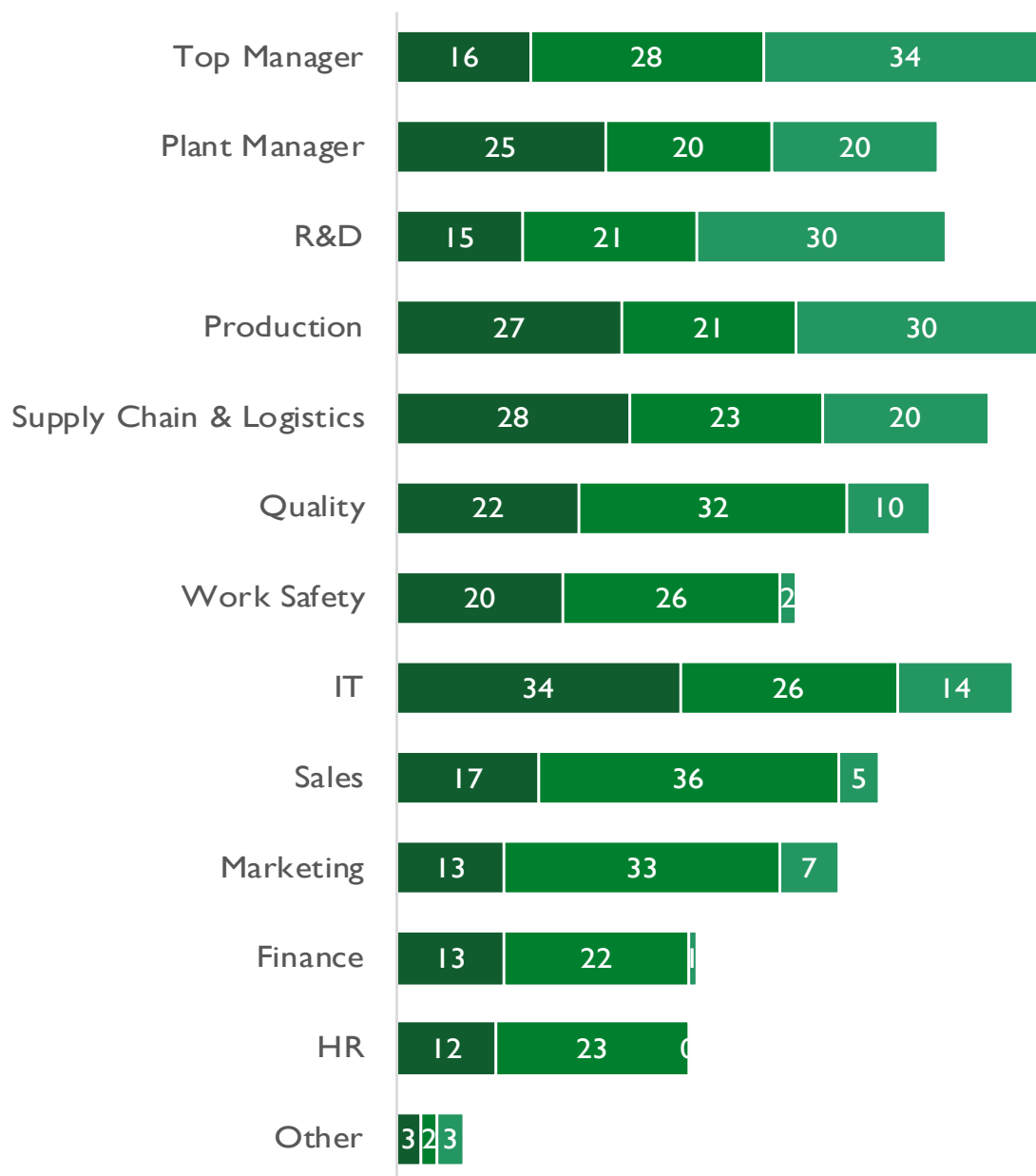
FIGURE III.5
EVALUATION
OF PROJECTS
multiple answers



Our findings indicate that Industrie 4.0 is an integrated concept that involves all functions and hierarchies. Top-management, Production, IT and Supply Chain / Logistics are always represented in Industrie 4.0 projects. Moreover, R&D, Production, and Top-management are the ones that usually initiate new projects in Industrie 4.0 (multiple answers possible).

FIGURE III.6
REPRESENTATIVES

multiple answers



■ Typically represented ■ Should be represented ■ Typically initiates projects

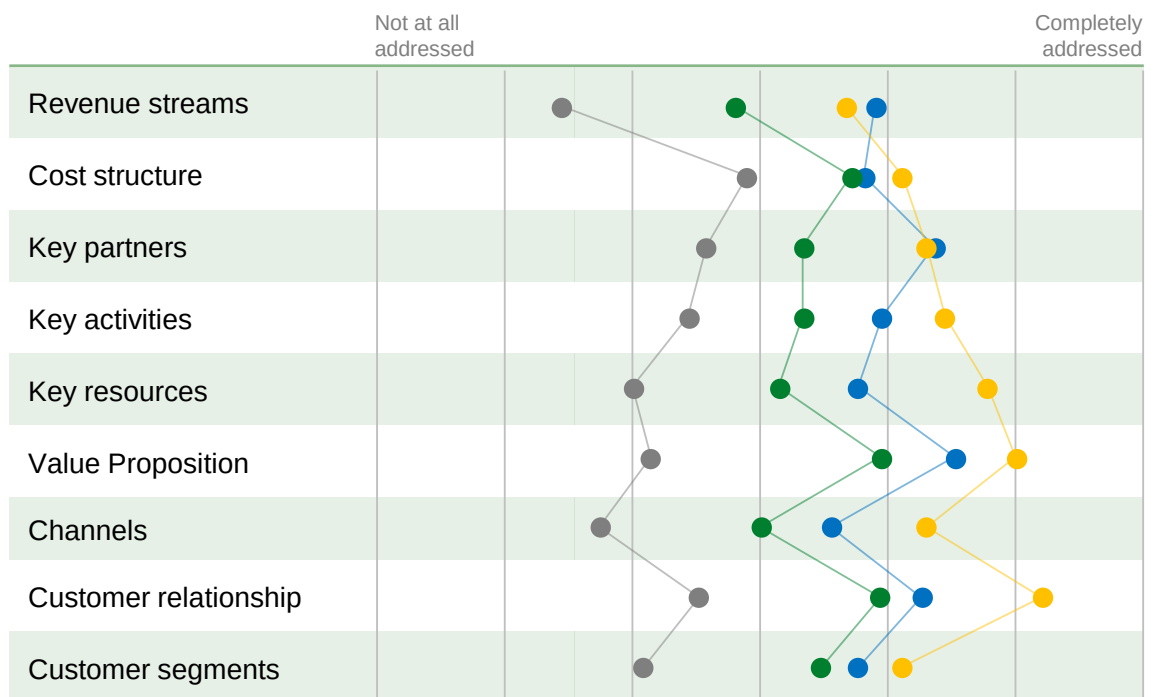
Business Model

Industrie 4.0 is more than just improving the production process through the use of new technologies. It also provides the opportunity to create new business models. For this reason, its implementation is of greater strategic importance than a sole process improvement. Additionally, many existing business models from different companies have been affected by Industrie 4.0. Following the definition of Osterwalder & Pigneur (2010), the key elements of a business model are:

- Customer segments i.e. one or multiple other/new customer segment
- Customer relationship i.e. the way you interact with your customers
- Channels i.e. the use of communication and sales channels
- Value Proposition i.e. the bundle of products or services you offer
- Key resources i.e. the resources needed to offer your value proposition
- Key activities i.e. the most important activities for company success
- Key partners i.e. your suppliers and partners
- Cost structure i.e. the costs generated for your value proposition
- Revenue streams i.e. different ways for earning money

The effects on the business model differ among the companies, the industry and the company category (user, provider or both).

FIGURE III.7
BUSINESS
MODEL
n=101



On average the surveyed companies indicated that all elements of their business model are addressed by Industrie 4.0. However, there are significant differences in regard to company categories: Successful practice companies, companies that are provider of Industrie 4.0 solutions and companies that are both using & providing such solutions face large effects on their business models (NB: remember that most Successful Practice companies are user & provider). User companies experience fewer effects on the elements of their business model. This might be partially explained by the fact that provider companies see manifold new business potential in the offering of new products and services.

Accordingly, user companies experience rather small changes regarding their revenue streams, new or other customer segments to be served and how they interact with their customers. The greatest change in their business model is expected to be the cost structure.

Both, provider and using & providing companies consider all elements of their business models to be somehow affected by their Industrie 4.0 activities. Provider companies are even more convinced of changes in their business model. This, as already mentioned, might be explained by the fact that those companies offer or will offer products and services in the context of Industrie 4.0 that are currently not part of their business model, but are expected to generate new business.

Successful Practice companies form the group with the most radical changes to their business models. As opposed to them, the other companies expect only little changes to their business model, especially the provider companies. Successful Practice companies see much higher impact on the business model elements than the user & provider companies and even more than the provider companies.

“We transform from being a product provider to being a complete solution provider – including all related services and software. Thus, all elements of Trumpf’s business model are affected by Industrie 4.0.”

Philipp Schüll

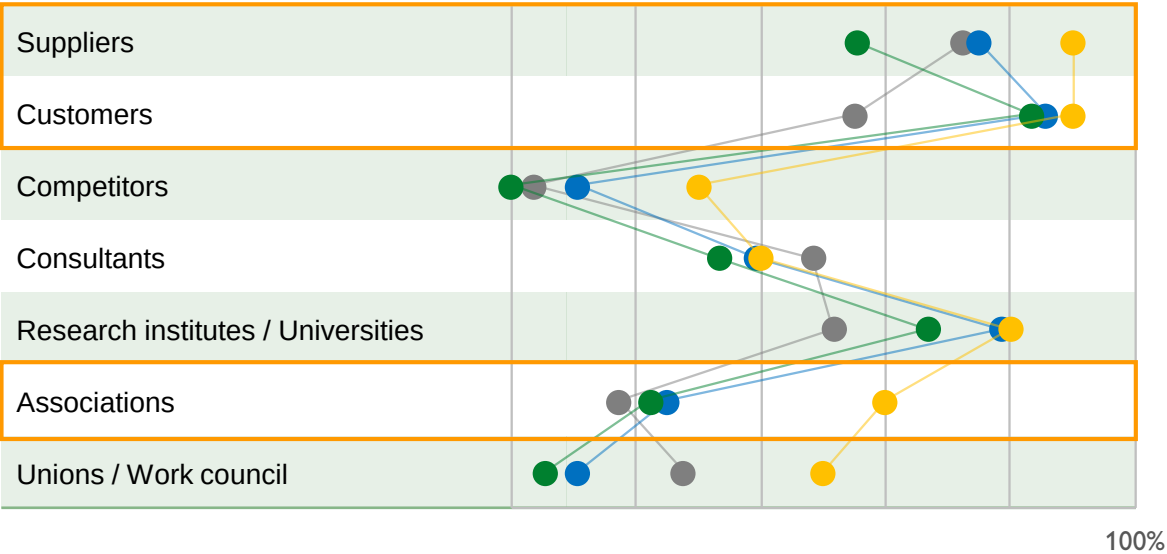
Coordinator Industrie 4.0
TRUMPF GmbH + Co. KG

Collaborations

Interaction and exchange with partners along the value chain, including the customers and suppliers are crucial for successful implementation of Industrie 4.0. For example, exchange of knowledge is essential for reducing costs, shortening innovation cycles and customizing products. The main collaboration partners are displayed below.

FIGURE III.8
COLLABORATIONS

n=95



The interaction with suppliers and customers is most important for the majority of companies. Together with the suppliers, joint solutions are developed to enhance one's own production processes. In terms of data collection, analysis and exchange they play a crucial role as well.

The second very important group of stakeholders are the customers. For instance, individualized products are one possible outcome of the collaboration. They satisfy customer needs and enhance the market position of the company. Customer loyalty resulting from closer cooperation is important to all companies. The third important collaboration partners are research institutes or universities. Well carried out research on specific topics of Industrie 4.0 supports companies and offers a new perspective on the topic. For many companies, academic research on specific problems is a first step in dealing with Industrie 4.0.

Associations, unions and work councils are less popular collaboration partners. Cooperation with competitors is even less common among respondents.

Successful Practices companies tend to cooperate more with different kinds of partners. Around 90% of them cooperate with their suppliers and customers, 80% of them cooperate with universities. The cooperation with associations, unions and work councils are occurring more often compared with the other category companies. 30% of the Successful Practice companies collaborate with competitors.

It is important to mention that almost all Successful Practice companies are directly engaged in the on-going discussions regarding standardisation in the context of Industrie 4.0. Furthermore, most of them are active players when it comes to official committee work in the field of Industrie 4.0.

All kinds of Industrie 4.0 cooperation seem to be very important for the respondents. Even collaborations with competitors are considered as being relevant by Successful Practice companies and provider companies.

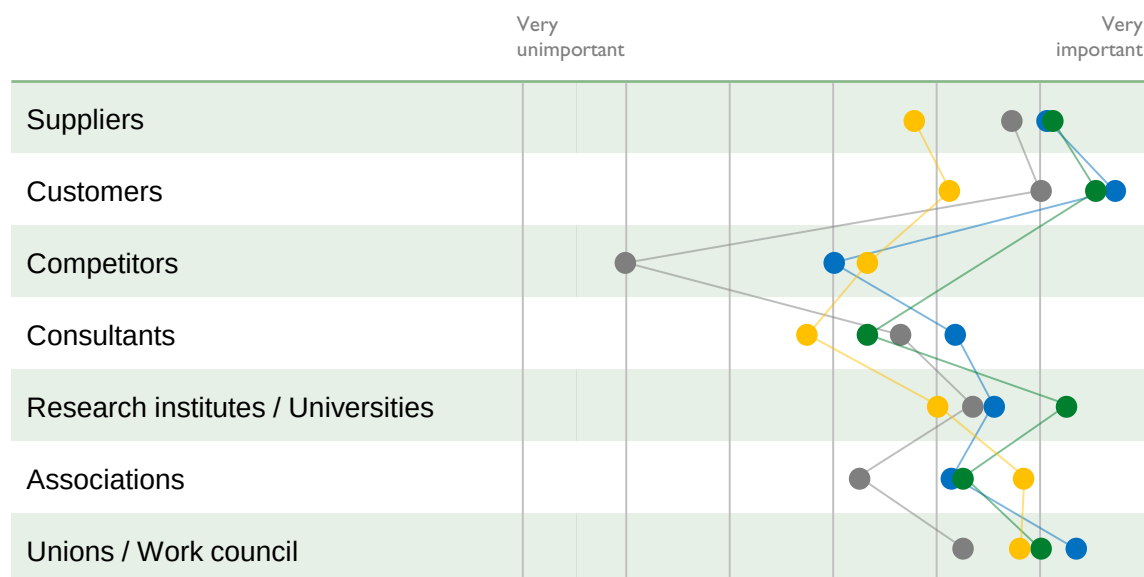


FIGURE III.9
IMPORTANCE OF
COLLABORATIONS
n=95

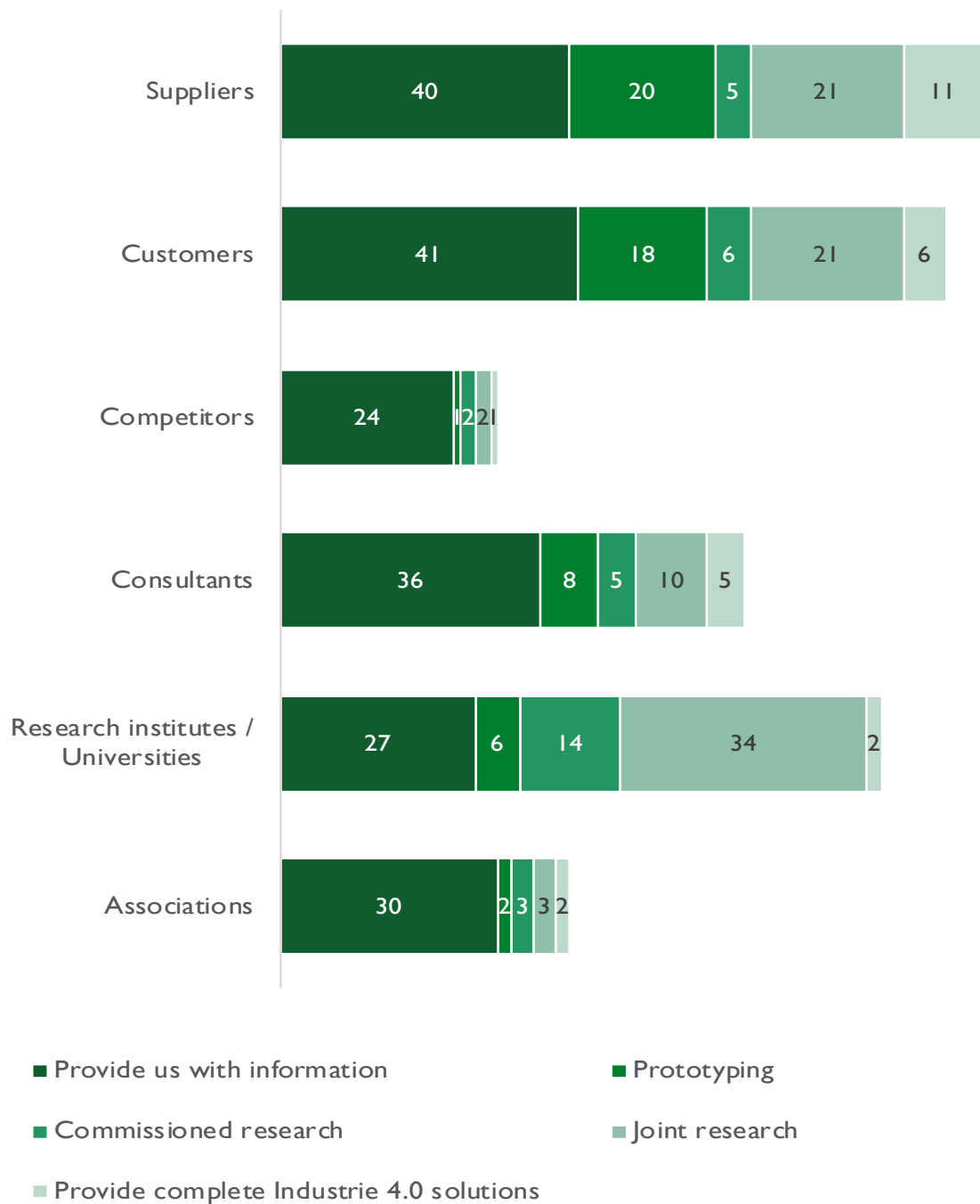
► Please refer to chapter IV to see how the exchange of information is related to the collaboration with the suppliers and customers.

After evaluating the importance of the companies' collaboration partners, the contribution of the stakeholders are investigated.

In particular the suppliers, customers and consultants provide the respondents with information. Research institutes and universities are mainly involved in joint research. The suppliers tend to be the group which is able to provide full Industrie 4.0 solutions. Finally, competitors are the least contributing group here.

FIGURE III.10
CONTRIBUTION OF
STAKEHOLDERS

multiple answers



Location

The term Industrie 4.0 is a vision for advanced and automated manufacturing sponsored by the German government. However, comparable approaches can be found worldwide. For instance, the terms used in the North American area are “Industrial Internet” and “Smart Manufacturing”. Industrie 4.0, the Industrial Internet and other concepts do not immediately compete against one another. The approaches occupy the same real estate of technology and sometimes even share the same members. Today, Europe, the North American area and China are the locations which are mainly working on the production of the future. This result is not too surprising as most companies start their activities in the headquarters, which usually is located in one of those areas.

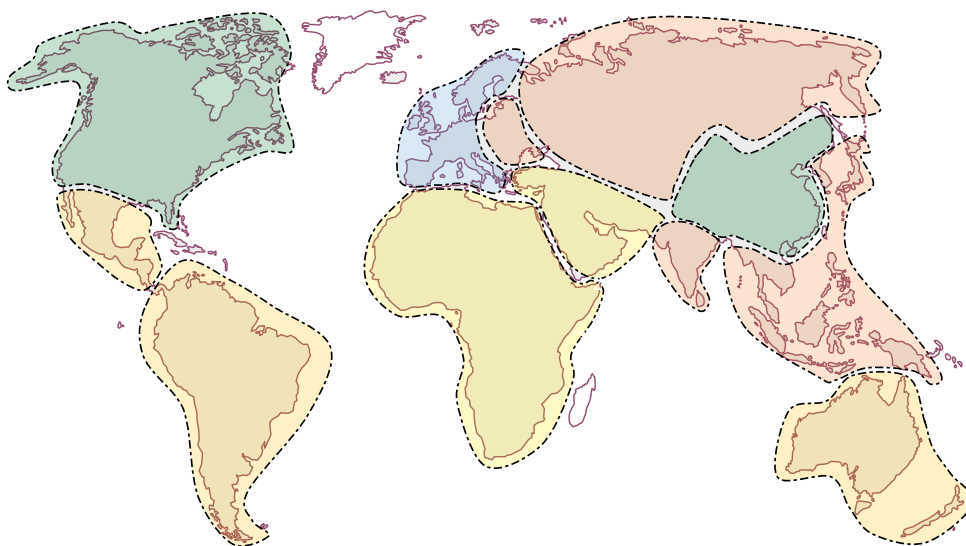


FIGURE III.11
LOCATIONS TO
START WITH
INDUSTRIE 4.0

n=99

In the future, activities concerning Industrie 4.0 will be conducted more globally.

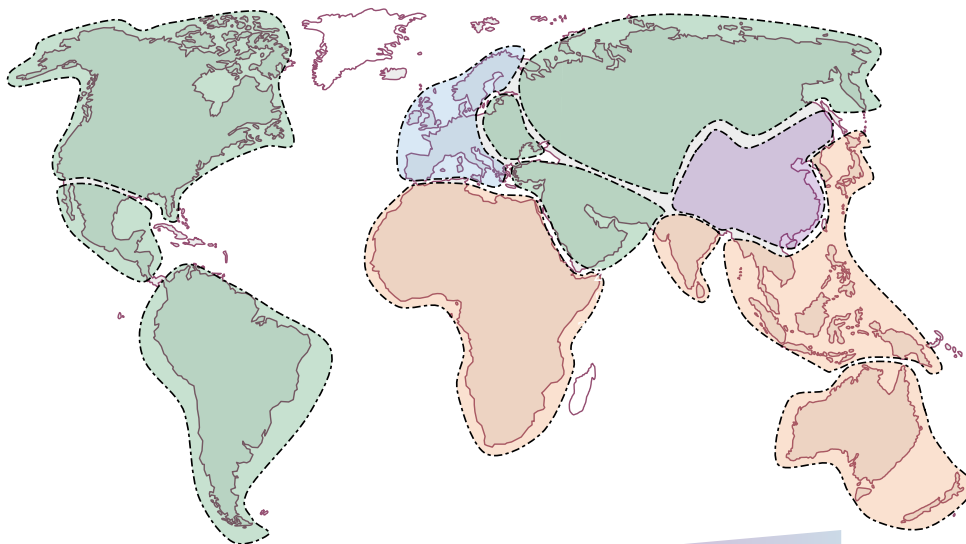


FIGURE III.12
INDUSTRIE 4.0
LOCATIONS OF
THE FUTURE

n=99

Low importance

High importance

"Without Industrie 4.0 the production in Europe doesn't have any chance to survive!"

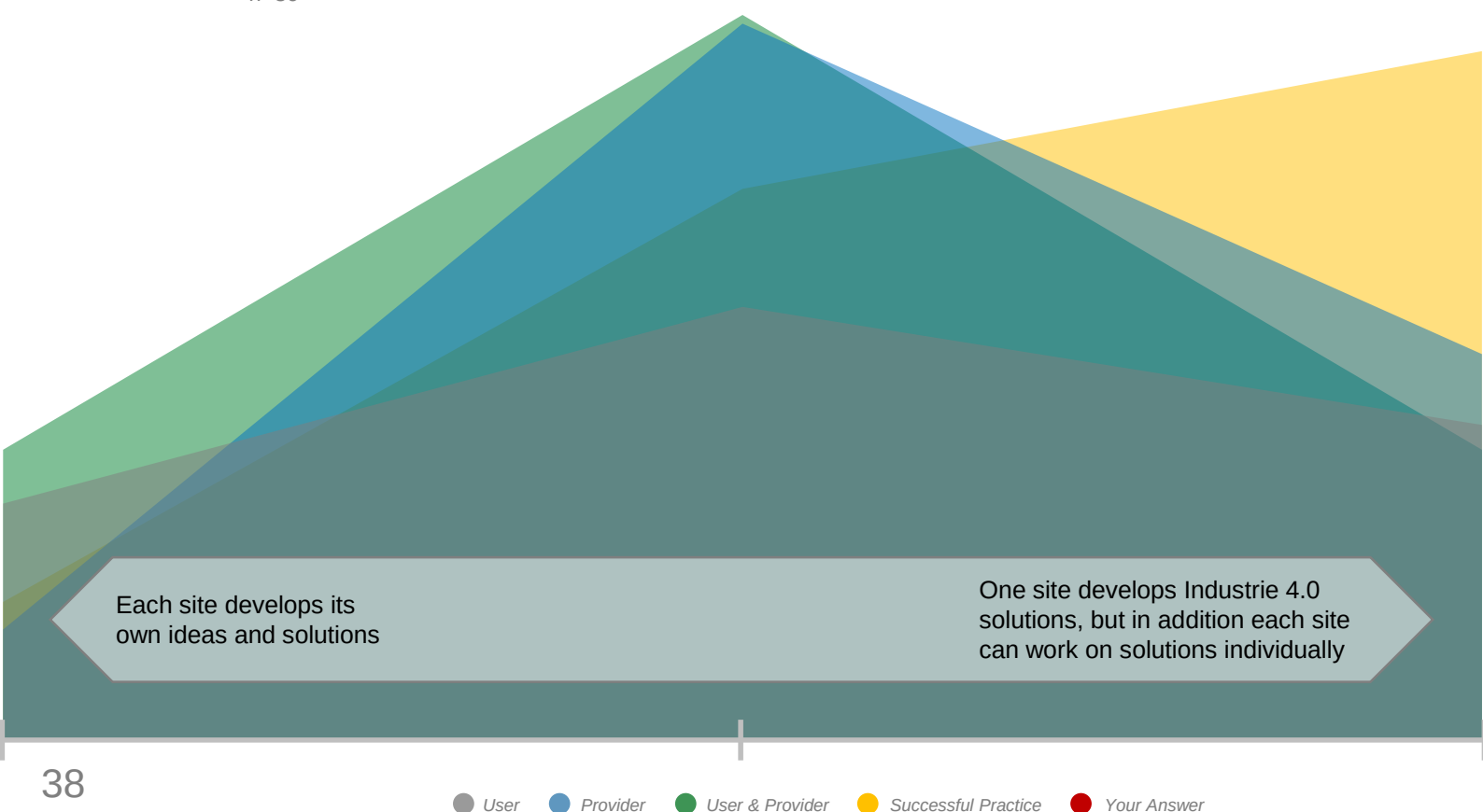
Yann Montagnier

Managing Director Switzerland, France and Benelux
FORCAM GmbH

As mentioned before, it is customary to develop Industrie 4.0 solutions at the headquarters from where the activities are coordinated and steered. Several companies and most of the Successful Practice companies stated that one site is to develop Industrie 4.0 solutions, whilst each site is allowed to work on individual solutions as well. Naturally, this requires even more coordination with clear rules. The rules serve the purpose of preventing overlaps and redundant developments. Provider companies and user & provider companies typically follow a "one site develops Industrie 4.0 solutions and provides them to the other sites" approach.

FIGURE III.13
R&D LOCATIONS

n=89



"Functions that support Smart Manufacturing have gained importance and leaders rely on those experts. Decisions are increasingly based on data and facts."

Bernd Waschneck
Manufacturing Excellence
Infineon Technologies AG

"The key task is to re-think processes, products and business models based on the potential of on-board sensors for products and the resulting merge of the physical and digital world."

*One example: the automobile was mechanical, before electronics entered the field, merging to mechatronics. Today, the digital world embraces the car and we need to re-define it:
from "drivability" to "self-driving"*

Dr. Kai Millarg
Executive Director
Intellion AG

IV Technology & Stakeholders

Technology

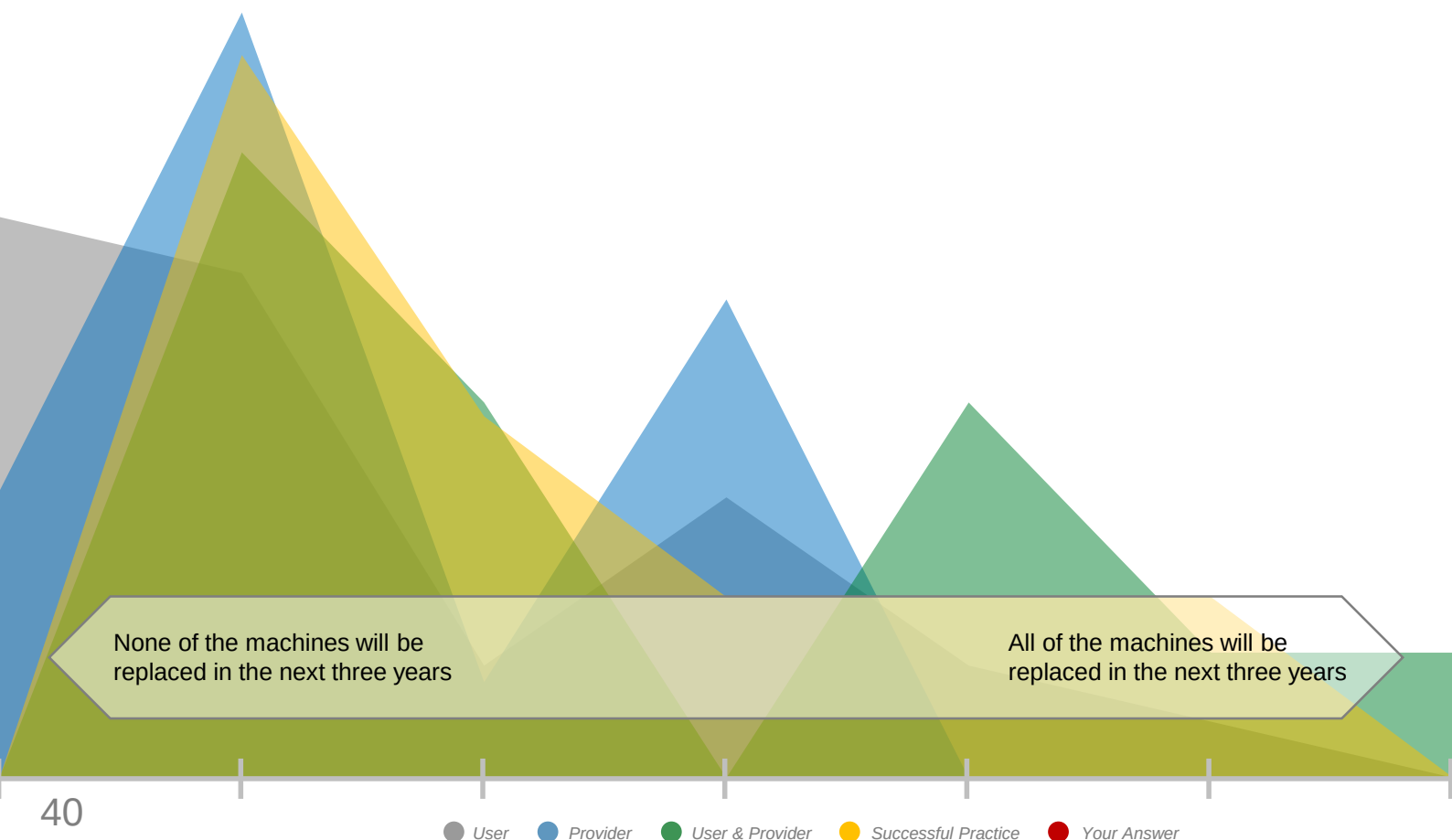
The usage of technology is a central aspect of Industrie 4.0. Without new and innovative technological solutions, it would not be possible to achieve a seamless and fully connected value chain. In this sub-chapter all questions and answers concerning technology usage, including manufacturing principles, lean and data management are presented.

Before a company may implement a new technology, it is advisable to carefully examine existing technologies. Since technological production equipment is the basis for Industrie 4.0 it is interesting to see how old the current machine infrastructure is on average. Of course this depends a lot on the company's industry.

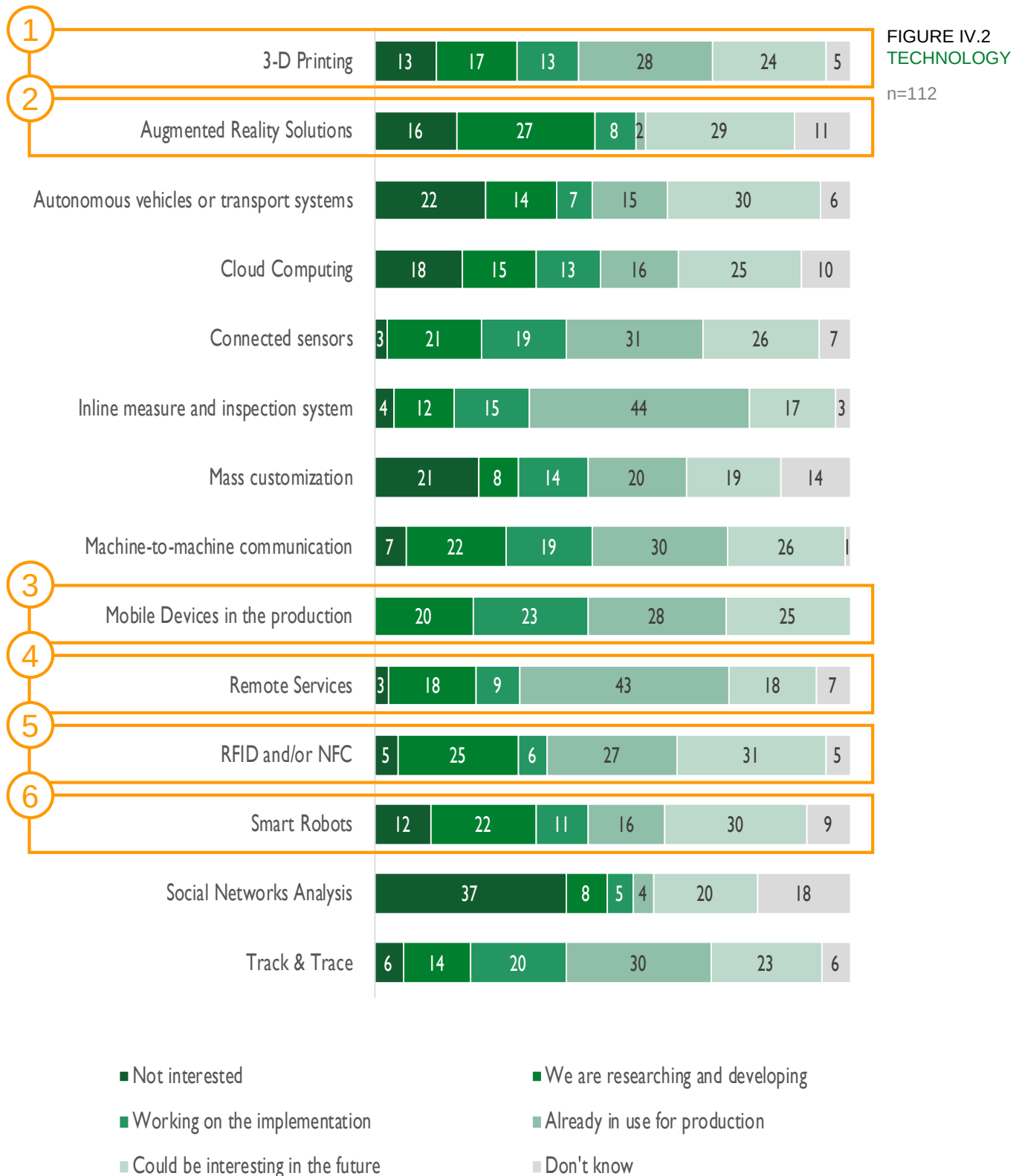
In this benchmarking sample the average age of machine infrastructure is 8.41 years. The graph below indicates how many machines will be replaced in the next three years. From the results, one can derive that companies already have machines that allow certain Industrie 4.0 activities.

FIGURE IV.1
REPLACEMENT OF
MACHINES

n=78



The following chart depicts several technological Industrie 4.0 solutions and indicates where companies currently stand in the implementation process of the respective technological solution. Especially inline measure and inspection systems as well as remote services are already widely implemented. Also, the survey found that industry-wide standards are hardly in place yet.

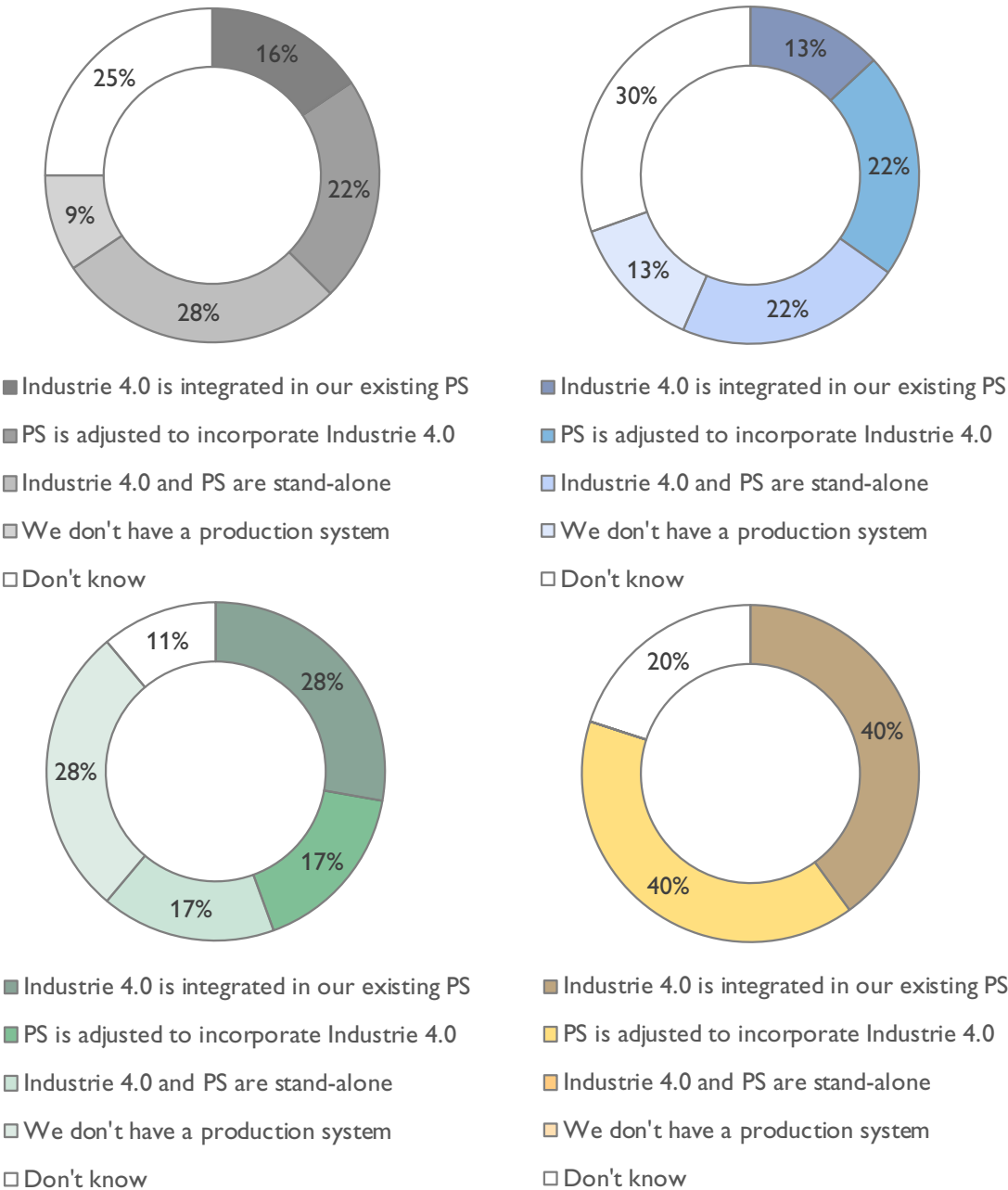


- ① **3-D printing** is a widely used technology, and especially common with the Successful Practice companies. The area of application (polymer, metal or ceramic) extends from the prototype manufacturing in the research and development department, for the spare parts production to guarantee long product life cycles as well as small batch production for customized products and customized product wishes. Most companies appreciate the fast, high-quality production at the lowest cost.
- ② **Augmented Reality** solutions such as intelligent glasses can rarely be found nowadays. However, many companies are researching and developing augmented reality solutions or plan to do so in the future. Admittedly, that is a very early stage and far away from a state of full integration. Initial projects show that augmented reality solutions are quite convincing in several companies. For example, one Successful Practice company tested intelligent glasses in a pilot project. First results show a huge work simplification and faster work execution in the assembly and maintenance departments.
- ③ **Mobile devices** are frequently implemented in production, mostly in the form of tablets and sometimes as smart watches. They are mostly used to facilitate maintenance tasks, for fault notifications, order visualisations, etc. Other fields of application are the visualization of work plans or return processes. For the successful implementation of mobile devices, data must be collected, analysed, processed and presented in an efficient way. Depending on the respective process needs, the usage of mobile devices is already more or less attractive. However, mobile devices are the only technology category no respondent marked as “not interested” or “don’t know”.
- ④ **Remote Services** are widely implemented or investigated as well. This technological solution offers considerable potential for new business and new market entries. Companies which are able to offer extra services in addition to their products typically generate more income and have a stronger customer loyalty.
- ⑤ **RFID and/or NFC** is a key element for a fully automated facility. Thus, RFID technology is often used for identifying products and for various logistic applications. Several companies use it to connect products, machines and employees. Products equipped with RFID can be identified at each work station (products autonomously log in and out at work stations), and use machine-to-machine communication for automatic routing through the production process. RFID seems to be interesting for almost all participants.
- ⑥ **Smart Robots** are often mentioned in context of Industrie 4.0. The usage is still limited to a few companies today, but in the future the usage will increase enormously. Autonomous manufacturing and assembly as well as active human-machine interaction are only two very promising future scenarios.

Production System

Larger companies usually have an integrated production system (PS), that corresponds to their strategy. It typically includes different principles and practices. The most famous example of a PS is the Toyota Production System (TPS). With the increasing attention given to Industrie 4.0, companies wonder how the PS and Industrie 4.0 are related. About one third of the respondents see an integration of the PS and Industrie 4.0. Between 15% and 26% consider the two topics as being stand-alone topics. Between 30% and 50% do not know how the two topics relate or do not have a PS. Two thirds of the Successful Practice companies think the two topics will be integrated – yet, the direction is unclear.

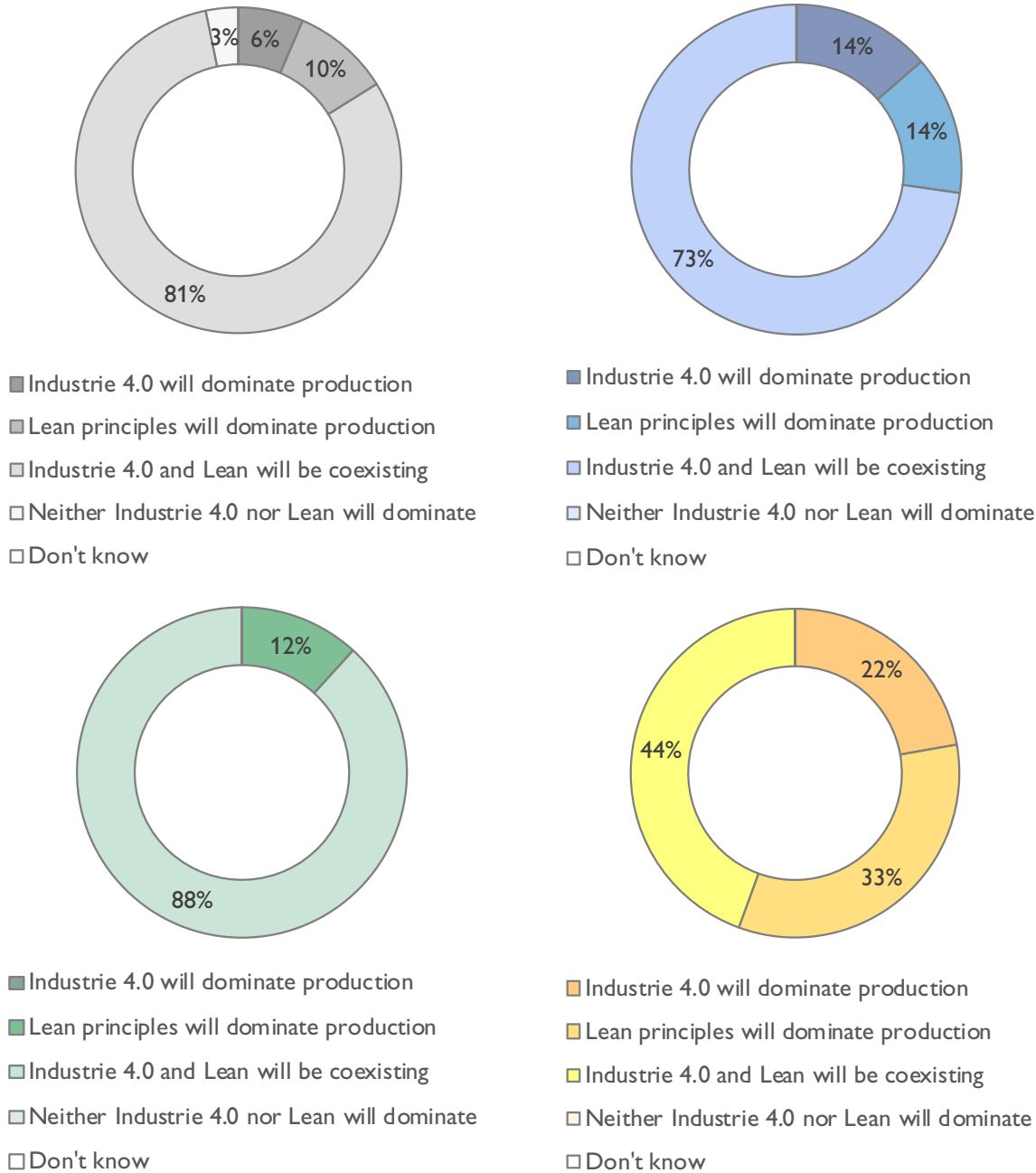
FIGURE IV.3
PRODUCTION
SYSTEM
n=85



Lean production and Industrie 4.0

Lean production has been a hot topic for many years in the manufacturing sector. Industrie 4.0 is a new concept that makes many people wonder how the two issues will develop in the near future. Generally, respondents expect both topics to coexist in the future. Among Successful Practice companies, opinions are more diverse: 22% of the respondents believe that Industrie 4.0 will dominate the future, one third expects lean to do so. Only 44% of the Successful Practice companies expect a coexistence of the two topics.

FIGURE IV.4
DOMINATING PRINCIPALES
n=101



“Lean principles will be in force, but the ways they are implemented will change – for instance Kanban will be used in a digital version.”

Dr. Thorsten Widmer

Manufacturing Coordination - Manufacturing Strategies and Investment Planning
Robert Bosch GmbH

Besides the question which of the two topics (lean and Industrie 4.0) will dominate in the future, respondents were asked how the two affect each other. Provider companies consider Industrie 4.0 as an enabler for lean production. User companies and Successful Practice companies think the other way around.

Many respondents think that Industrie 4.0 will support the implementation of lean principles in the future. For example the automation of Kanban: instead of using paper cards, digitalization of the displays will show how many parts are still in storage and reorders will be released automatically.

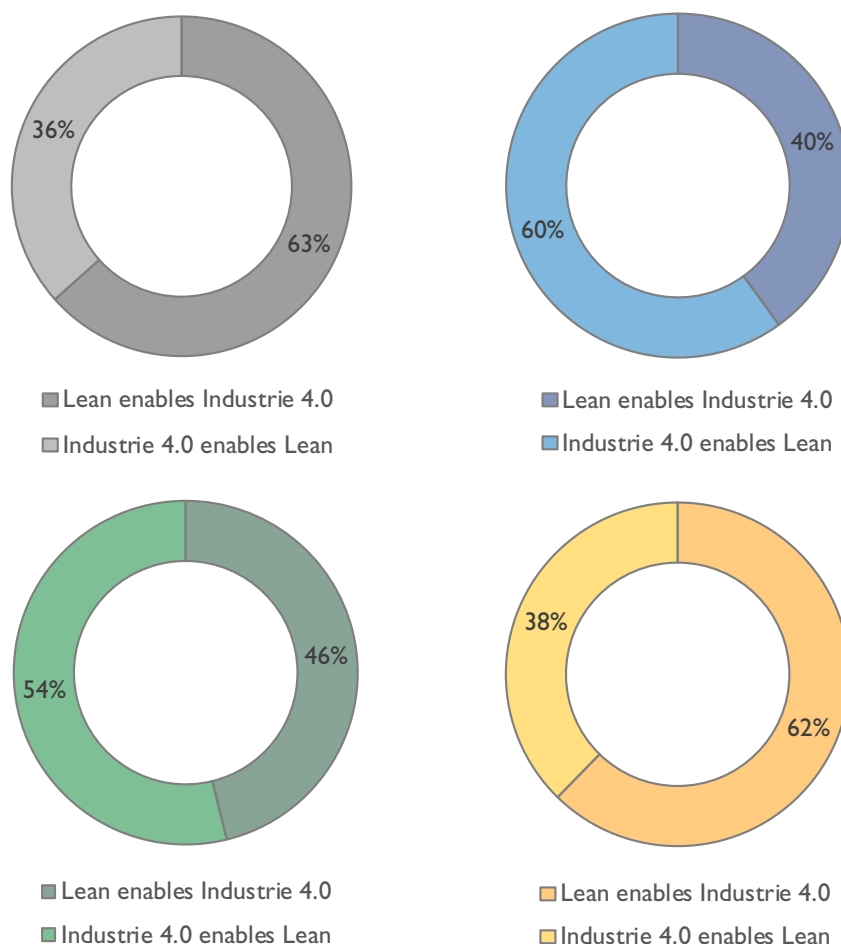


FIGURE IV.5
LEAN AND
INDUSTRIE 4.0

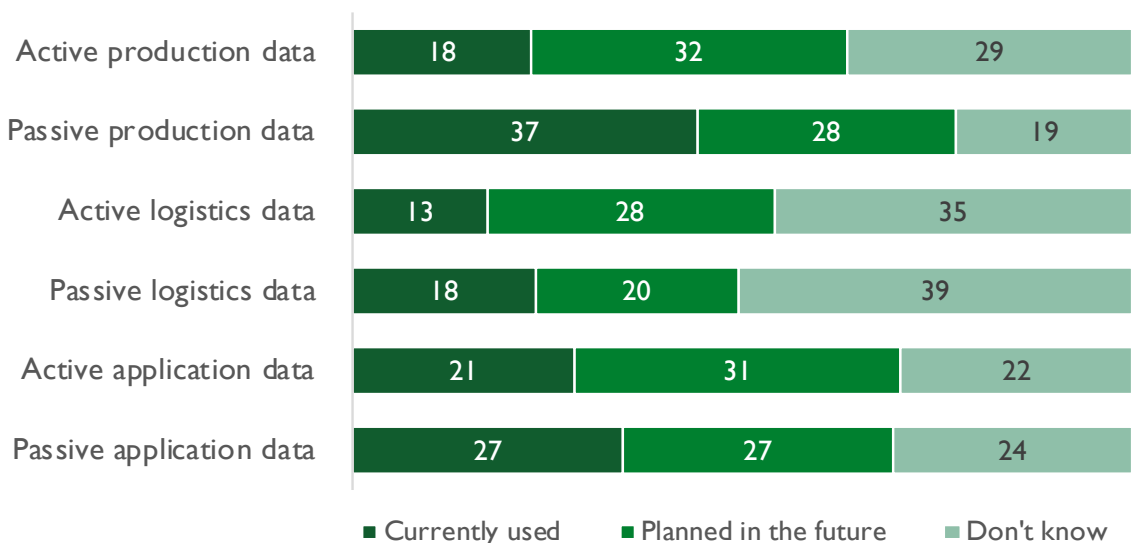
n=95

Data

Nowadays, managing data is as important as managing raw material for many companies. In the future, all machines and systems of the value chain will produce and transmit significantly more data than today. For example, the increasing use of sensors to control production processes leads to accelerating data generation. In this benchmarking study, the usage of different kinds of data was prompted (multiple answers possible). We distinguish between active and passive data as follows:

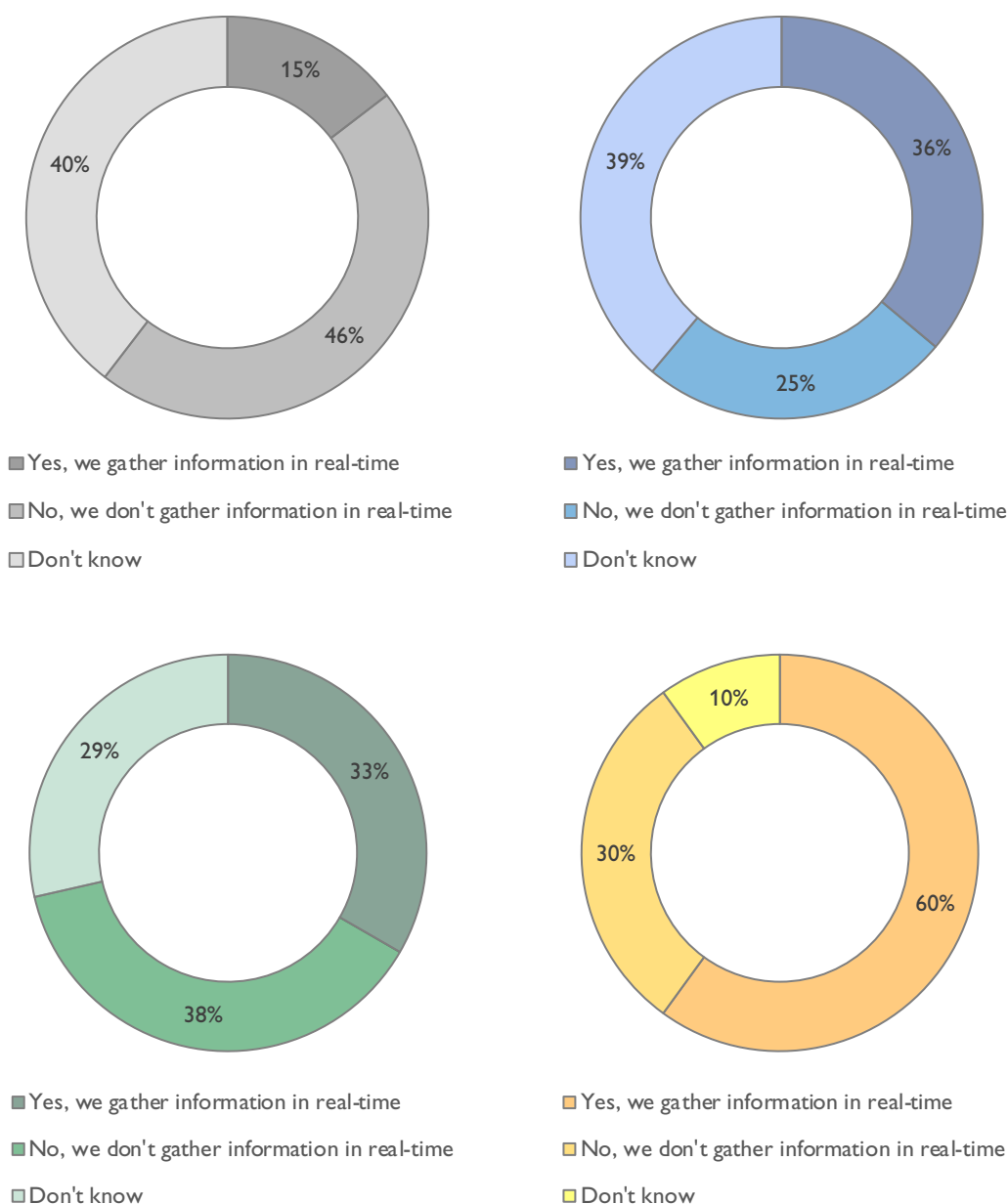
- Active production data e.g. product tells robot what to do with it
- Passive production data e.g. product memorizes the ID of a component attached to it
- Active logistics data e.g. product tells packaging machine how to wrap it
- Passive logistics data e.g. product memorizes details about the distribution cold chain
- Active application data e.g. product tells operator how to be handled
- Passive application data e.g. product memorizes how it was treated for guarantee claims

FIGURE IV.6
ACTIVE AND
PASSIVE DATA
multiple answers



Passive production data is already widely used by companies. Furthermore, most companies are planning to use all these kinds of data in the future. Especially the Successful Practice companies currently use passive production and logistic data as well as active production data. In general, active production data is a key element regarding automation and implementation of Industrie 4.0.

The following categorization visualizes differences between the companies regarding real-time gathering of information. Companies of the respective categories largely differ in their ability to gather production and product information in real-time.

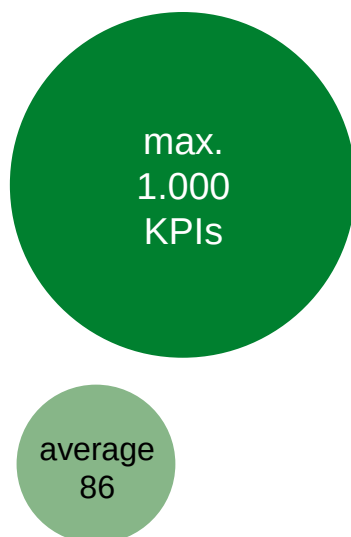


Successful Practice companies are the group of companies which are the most advanced concerning the collection of production and product information in real-time. In contrast, the user companies are usually not able / do not want to collect data in real-time. Provider companies tend to perform in a similar way to Successful Practices. As mentioned before, providers often collect and analyse data for customers. This kind of remote service is becoming more and more popular for many user-provider relations. Nonetheless, a lot of companies still hesitate to share data with other stakeholders.

“Imagine you could collect any kind of information on your products anytime, anywhere – how would you improve or even re-invent your business?”

Dr. Kai Millarg
Executive Director
Intellion AG

FIGURE IV.8
KPIs IN
REAL-TIME
n=88



Several companies stated that they are able to gather around 1,000 KPIs in real-time. But this large number is an exception. Most companies collect around 100 KPIs in real-time.

Updating and synchronizing data for efficient use is an issue many companies struggle with. Often, companies collect a diverse variety of data – seldom they are able to make as much use of it as they could do.

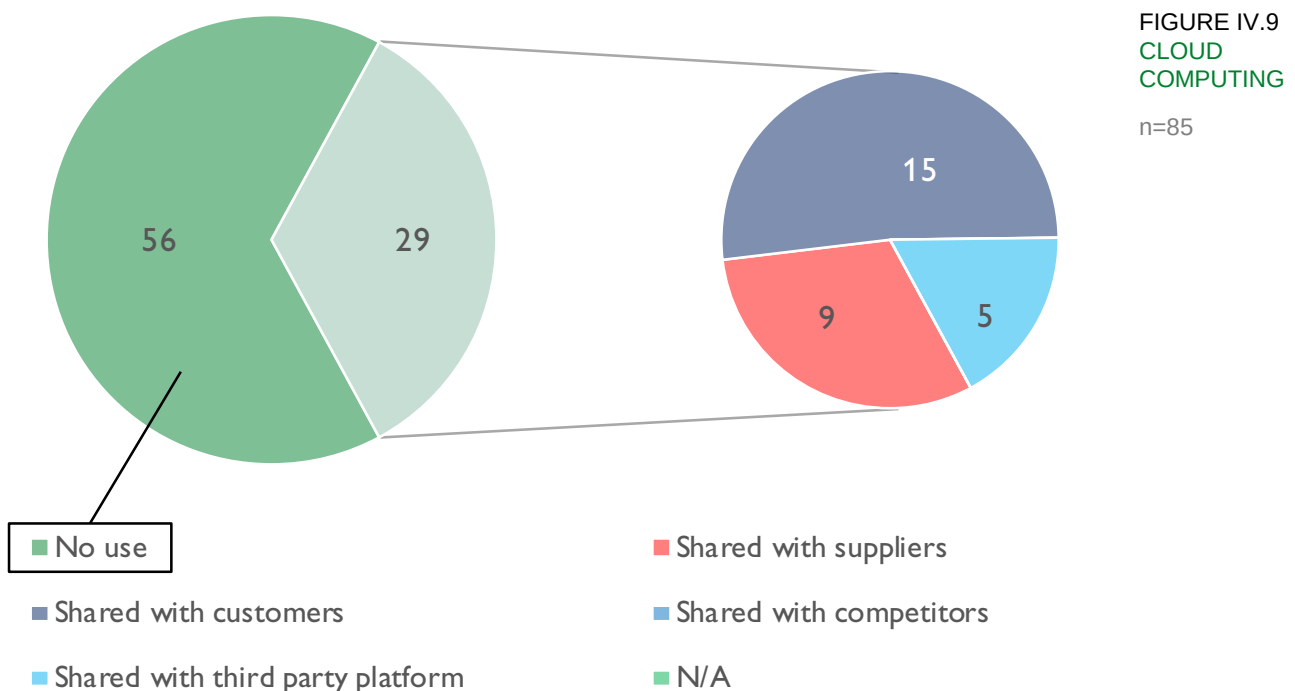
Cloud Computing

Cloud Computing is an internet-based system, that enables sharing of resources, data and information across physical boundaries. Often, use of Cloud Computing is associated with using tablets and mobile devices.

Cloud Computing is a model for enabling ubiquitous, on-demand access to a shared pool of resources. This allows providing employees with access to data at different locations at any time. This scenario sounds very promising, but also offers many challenges – particularly IT security problems.

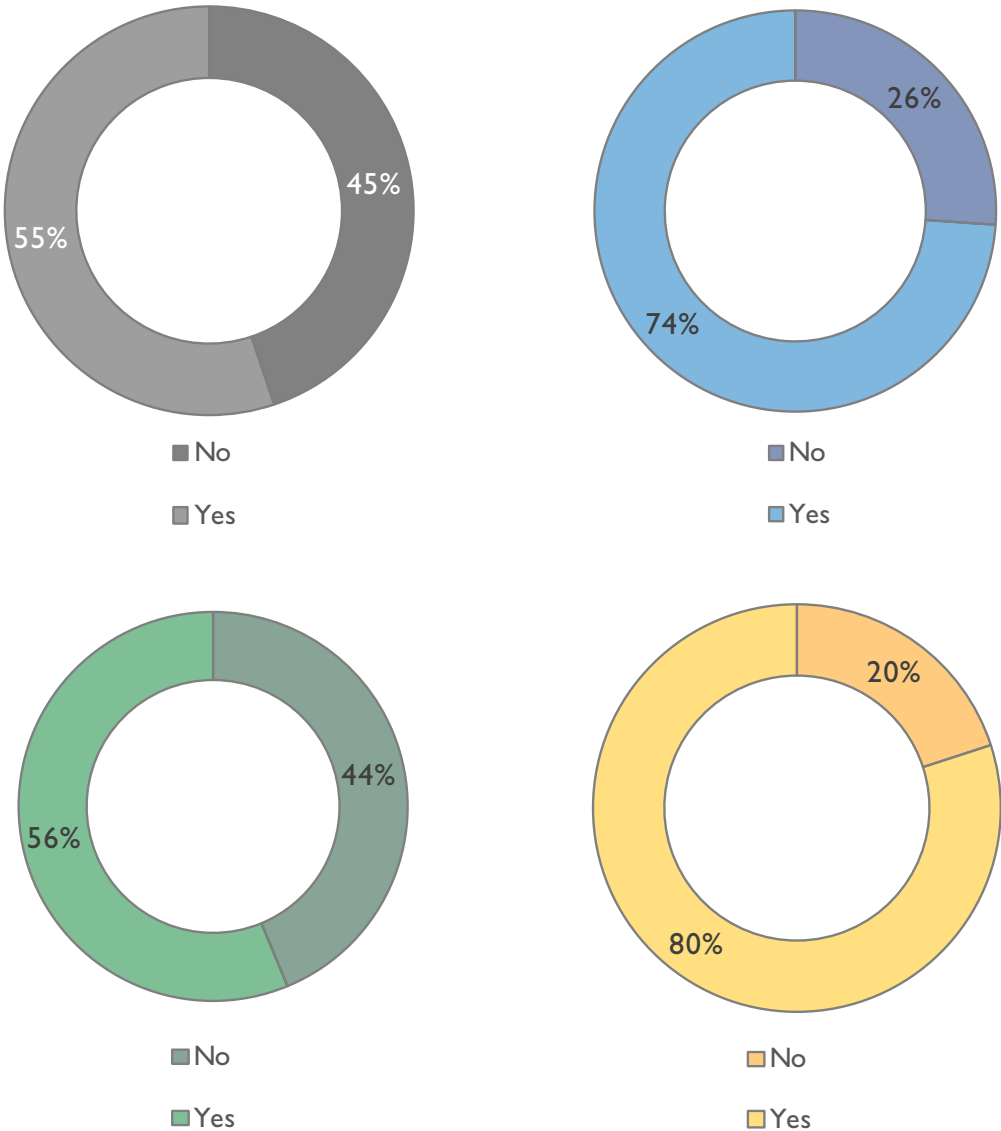
The survey results indicate that Cloud Computing is not widely implemented. However, some companies already make use of Cloud Computing. Mostly, data and information put in the Cloud are shared with customers and suppliers of the company. Companies using Cloud technology often use a proprietary Cloud solution. Third party platforms are not that popular right now.

Especially in the North American area, companies are more eager to use Cloud solutions today.



Is Cloud Computing an important technological solution for the future of manufacturing? Companies are very diverse regarding their opinion on this question. User companies are rather sceptical concerning the future of Cloud Computing for data management. The same applies for user & provider companies. Contrasting those rather restrained opinions, provider companies as well as Successful Practice companies are very positive regarding this question.

FIGURE IV.10
FUTURE
OF CLOUD
COMPUTING
n=82



Management & Employees

Apart from technological changes, the human factor is a crucial element of any organization dealing with Industrie 4.0. Further, Industrie 4.0 affects all groups of stakeholders, from employees to board members. With upcoming changes in the environment of manufacturing jobs (e.g. increasing use of robots, assisting systems etc.), middle and top-management have to prepare the organization accordingly. Managers must also be aware that Industrie 4.0 will not only change blue collar jobs, but management jobs will change as well. Our study shows that companies must anticipate certain cultural changes as a result of Industrie 4.0.

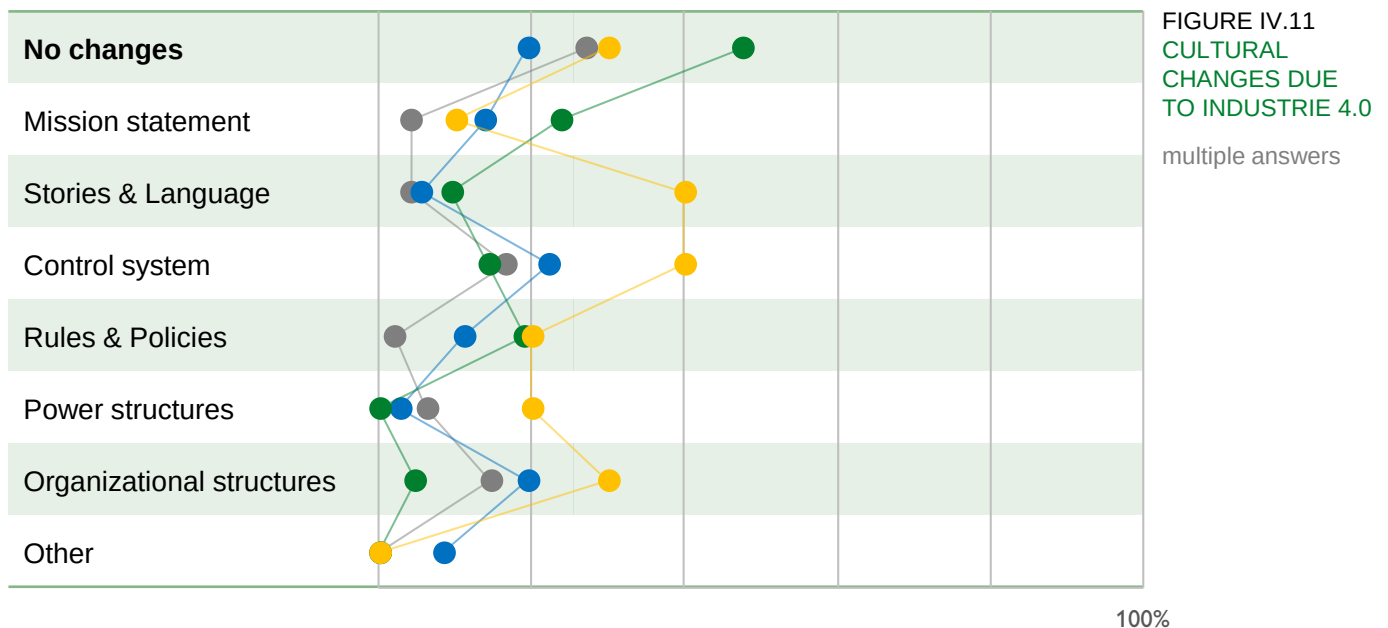
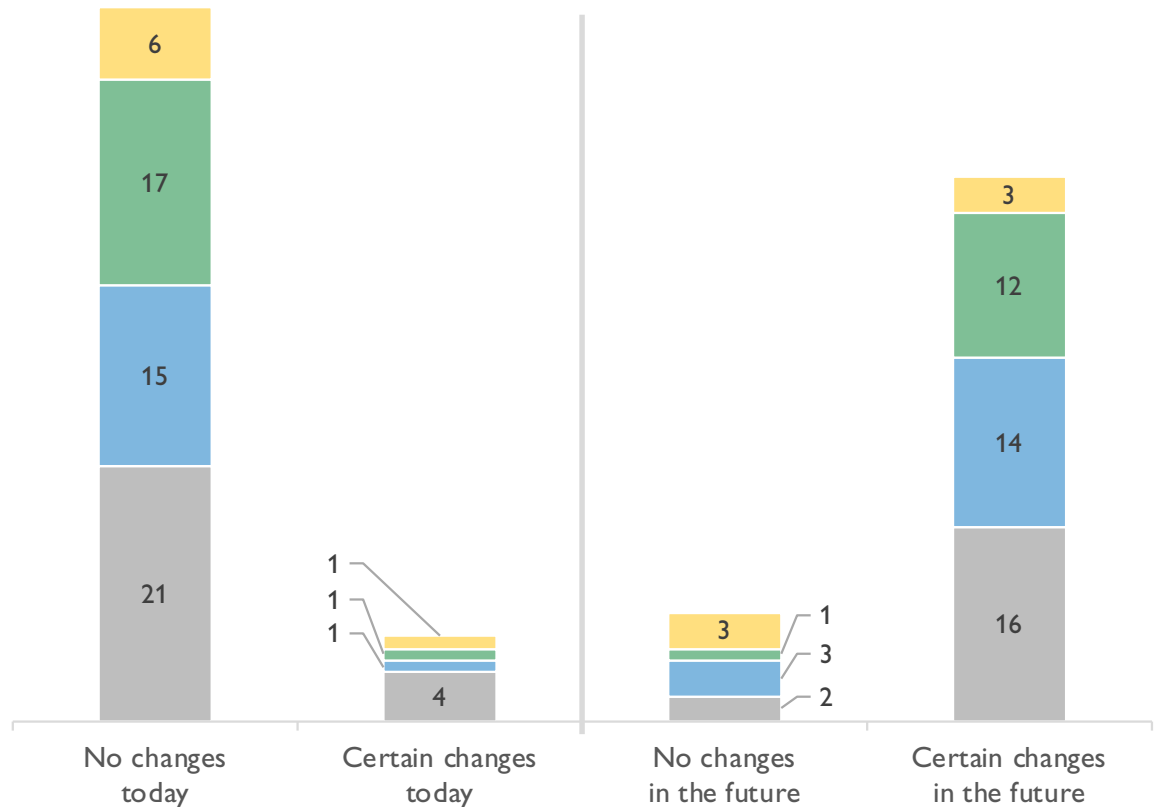


FIGURE IV.12
CHANGE OF
LEADERSHIP
STRUCTURE

n=96



Today:

Leadership structure is stable and nearly all companies do not experience any changes of it, today. Few respondents stated that some changes are noticeable already. Those are changes such as:

- “The control system got more decentralized.”
- “Increased responsibility on the workshop floor.”
- “Entrepreneurial thinking and actions of middle management are encouraged.”
- “Own organizational unit which is reporting directly to the board of directors.”

In the future:

Almost all respondents that do not experience any changes today expect certain changes of the leadership structures in the future. These findings correspond with the results presented in figure IV.11 – organizational structure.

“Employees are receiving higher levels of responsibility and leaders have more time to focus on their original task: leading.”

Dr. Uwe Kaltenborn

Product-Portfolio-Management

Maschinenfabrik Reinhausen GmbH

“It needs a lot of communication and also leaders need the courage to stop projects without any benefit. This is the most important point. The technicians would like to develop everything which is possible, some of them without any benefit.”

Ernst Schönauer

General Manager Production
SFS Intec

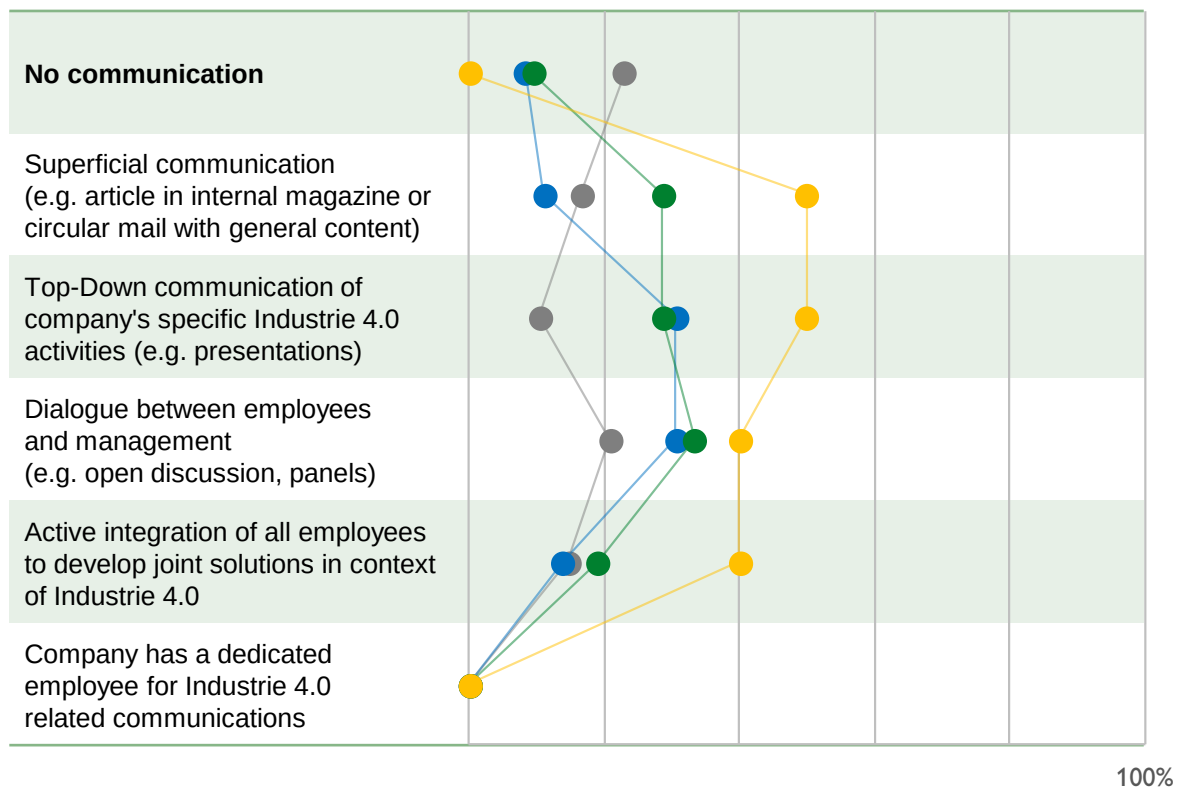
Communication

The fourth industrial revolution will impose many changes on companies and the way that employees interact and work.

Experts agree that especially easy and manual work steps will be done by machines or robots in the future. Thus, the need for blue collar workers is expected to decrease in the long term. Other work steps are expected to be supported by machines, i.e., man-machine interactions. Many companies report certain, mostly minor concerns of their employees concerning the developments of Industrie 4.0. As a result, communication should be considered as a relevant factor for the implementation of Industrie 4.0.

FIGURE IV.13
COMMUNICATION

n=88



User companies tend to not really manage communication about the topic Industrie 4.0. Successful Practice companies engage in communication of the topic using various types of communication. Particularly, the superficial and top-down communication is used by half of the Successful Practice companies. Dialogue between employees and management is used by about one third of the companies. Fewer companies have decided (so far) to actively integrate all employees. None of the respondents reported having a dedicated employee for communication affairs regarding Industrie 4.0.

Future Professionals and Skills

Employees knowledgeable regarding IT and digitalization and equipped with strong “process thinking” and the will to embrace change are of utmost importance for companies regarding Industrie 4.0 implementation.

Furthermore, engineers must be able to communicate the IT-needs of the products and processes they are working on.

When looking for job descriptions, certain jobs seem to be more important in the future than others. According to the benchmarking results (similar jobs were clustered), production engineers are most important (21 times mentioned), followed by data scientists (17), IT specialists (15), software engineers (11), data analysts (10), process engineers (6) and mechatronic experts (5) (multiple answers possible).

Several other professions mentioned are displayed below. The font size represents the frequency the respective profession was mentioned. Engineers and all kind of IT experts (including data professionals) are evidently considered to be the most needed ones in the future.



FIGURE IV.14
FUTURE
PROFESSIONALS
FOR INDUSTRIE 4.0

multiple answers

“The more we move towards Industrie 4.0, the more important it will be to really have process and system know-how on all levels of the company [...]. I think that we need to have specially qualified people with this know-how to keep a production running with Industrie 4.0.”

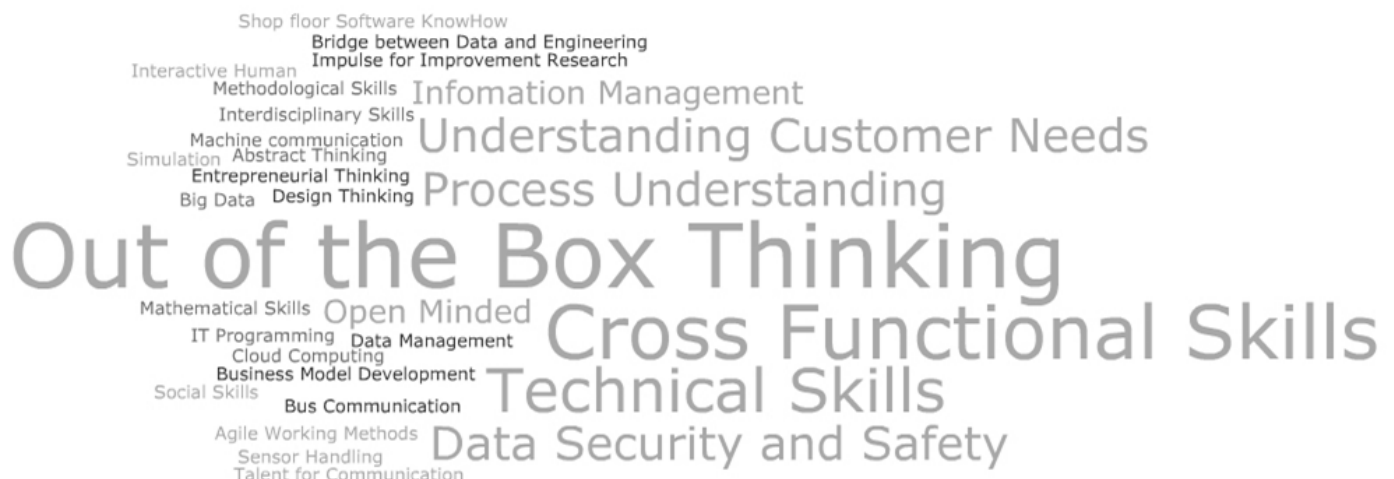
Thomas Scheermesser

Head of Competence Pool Production Engineering
SIG Combibloc Group AG

In addition to professions needed in the future, respondents indicated which skills are needed in the context of Industrie 4.0. IT knowledge, data management and engineering skills are the most frequently given answers. However, some soft skills, for instance cross-functional thinking, understanding customer needs or out-of-the-box thinking, are presumed to become more important in the future.

FIGURE IV.15
INDUSTRIE 4.0
SKILLS

multiple answers



Customer

Eventually, implementing Industrie 4.0 is expected to be a rewarding endeavour for the company. Those expectations are closely linked to being successful in the market, thus with the benefits Industrie 4.0 offers the customers. The open question is what the customers' benefit resulting from Industrie 4.0 will be.

Our study reveals that customers typically enjoy positive results from products enabled by Industrie 4.0. They are especially satisfied with the delivery speed and the improved quality or reliability.

Industrie 4.0 can also take customer satisfaction to a whole new level. Expected developments in context of Industrie 4.0 like mass customisation and batch size one may lead to unprecedented levels of personalisation without increasing product prices. But the question is whether this development has already taken place. How satisfied are the customers today with aspects of the company's products and services enabled by Industrie 4.0?



FIGURE IV.16
CUSTOMER
SATISFACTION
CONCERNING
PRODUCTS
n=85

Respondents' agreement is similar for the standard competitive priorities price, delivery speed, on-time delivery, quality and flexibility. Nonetheless, customers are not too satisfied concerning the factors price and delivery speed. This is the same for increased transparency and offering individualized products. Only provider companies strongly agree that their customers are very satisfied concerning the innovativeness.

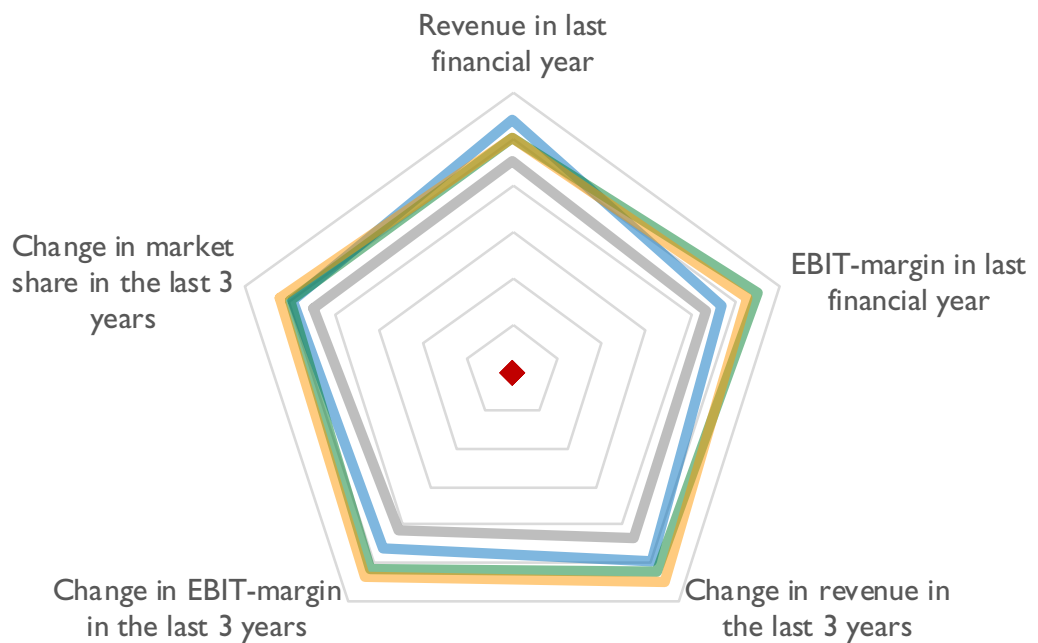
We conclude that there is still room for improvement regarding customers' benefits of Industrie 4.0. On average, companies – including the Successful Practice companies – are not able to fully satisfy their customers with their Industrie 4.0 activities. So far, Industrie 4.0 seems to be an internal issue rather than a market oriented topic.

V Performance

In this chapter the performance of the companies is to be examined. Financial performance is measured by EBIT and changes in EBIT, revenue and changes in revenue as well as changes in market share compared to competitors.

User companies and provider companies display a similar financial performance concerning EBIT-margin, market share and revenue, whereby the revenue of the last financial year is a bit worse. Financially, user & provider companies and the Successful Practice companies tend to perform better.

FIGURE V.1
FINANCIAL
PERFORMANCE
n=82



The same analysis of financial performance was conducted for the products manufactured with Industrie 4.0. Companies from the different categories are much more similar regarding their financial performance.

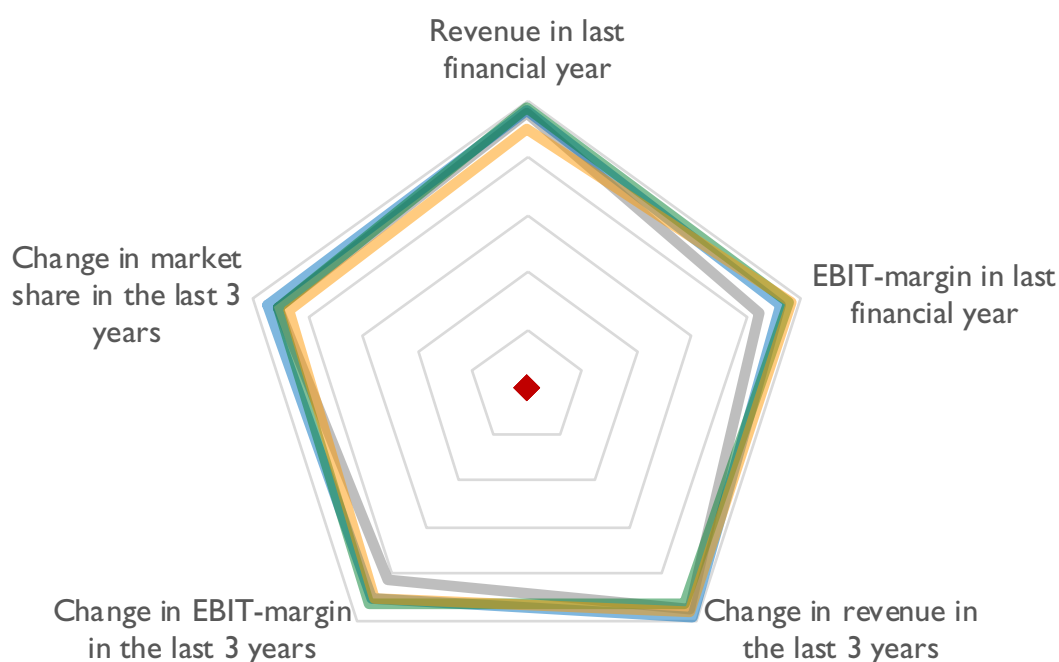


FIGURE V.2
FINANCIAL
PERFORMANCE
CONCERNING
INDUSTRIE 4.0

n=74

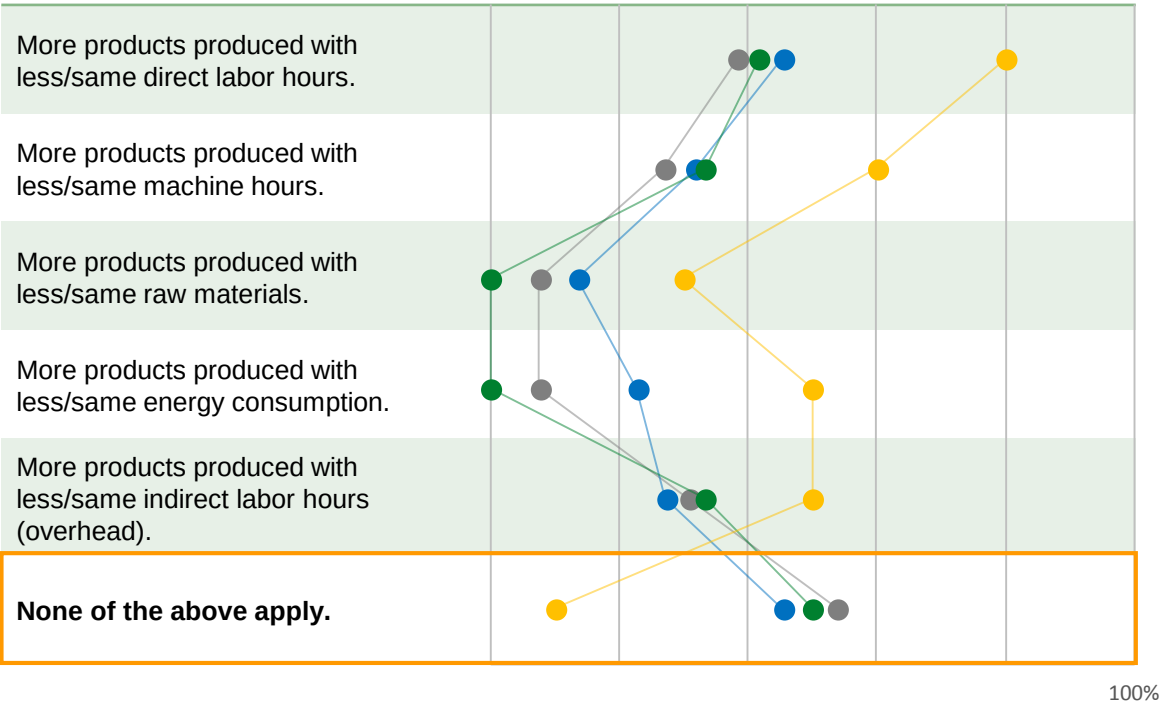
Compared to their customers, companies' financial performance is much better for products produced with the help of Industrie 4.0 than it is for conventionally produced products. The revenue, EBIT and market share are rated much higher compared to the other products.

Productivity

Productivity is defined as the ratio between volume of output and volume of input. In other words, it measures how efficiently production inputs, such as labour or raw materials, are being used to produce a certain output. Usually, productivity is considered as a key indicator of competitiveness and economic growth.

Industrie 4.0 is expected to improve productivity in many ways. Approximately 40% of the respondents indicate that they are able to produce more products with fewer or the same direct and indirect labour hours as well as fewer or the same machine hours thanks to Industrie 4.0. Factors such as raw materials and energy consumption are less affected by Industrie 4.0 for productivity gains. Successful Practice companies and provider companies tend to experience higher gains in productivity due to Industrie 4.0 compared to user companies.

FIGURE V.3
PRODUCTIVITY
n=83

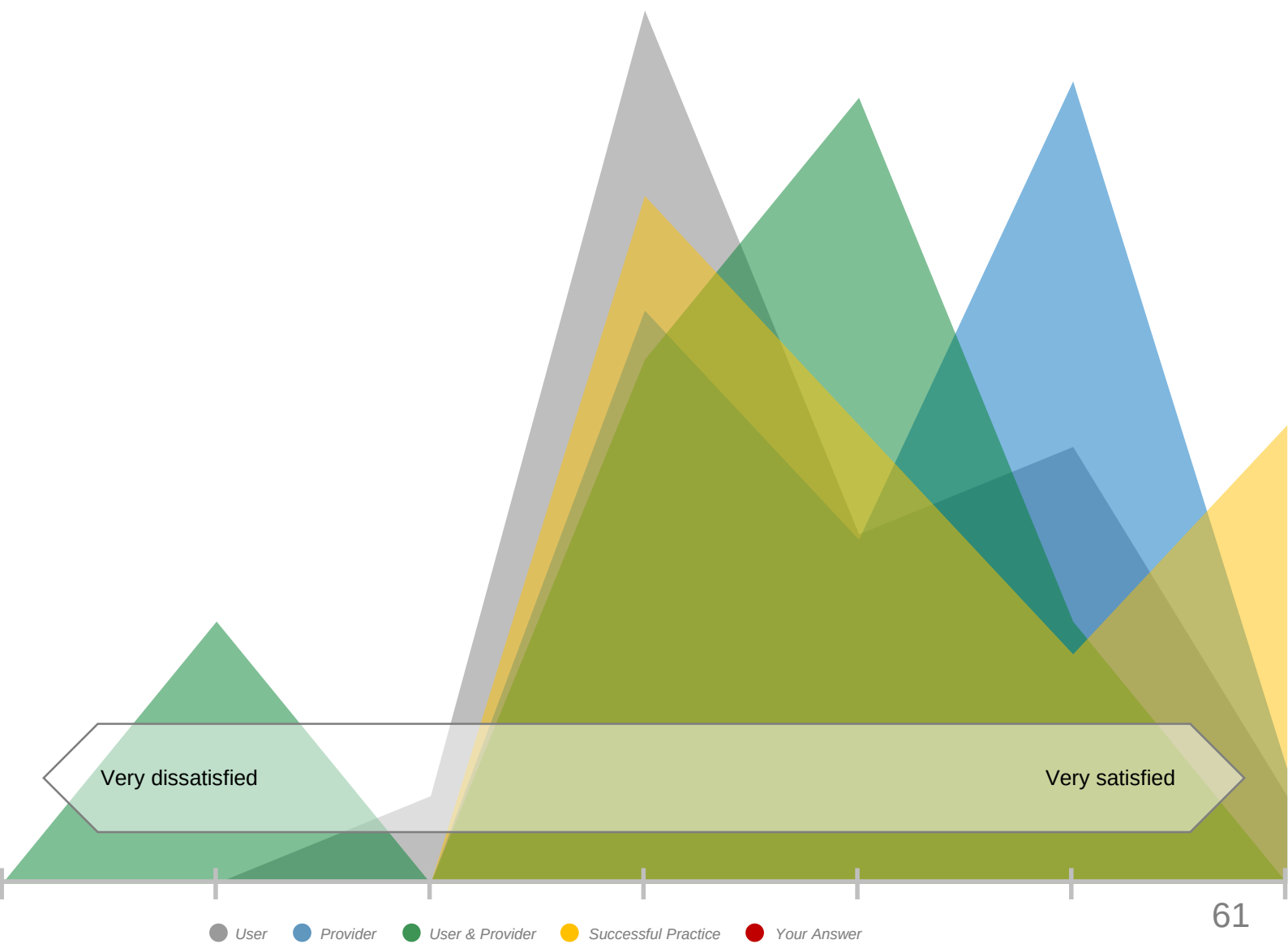


As indicated above, Successful Practice companies report outstanding productivity gains due to Industrie 4.0. Particularly the input factory direct labour hours and machine hours decreased due to the use of Industrie 4.0. Many of the Successful Practice companies link implementation of Industrie 4.0 with implementation of other production principles like lean and an improved process understanding in general. Thus, productivity gains can not solely be assigned to Industrie 4.0 technologies.

Suppliers' Satisfaction

Respondents estimate their suppliers' satisfaction with their Industrie 4.0 activities to be medium to high. Compared to user companies, provider companies state that their suppliers are mainly very satisfied with their Industrie 4.0 activities. Successful Practice companies tend to rate suppliers' satisfaction with their Industrie 4.0 activities less strongly.

FIGURE V.4
SUPPLIERS'
SATISFACTION
n=62



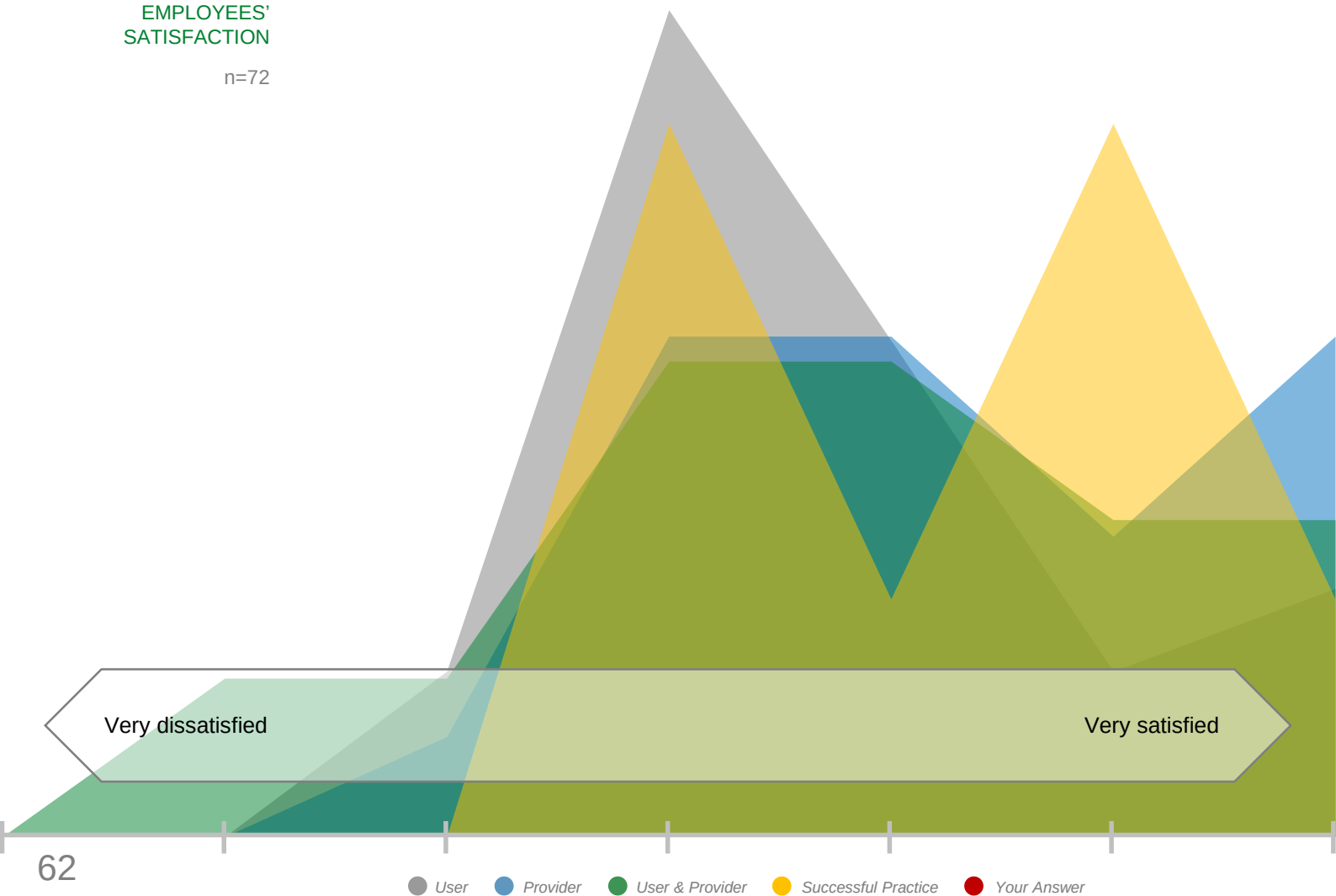
Employees' Satisfaction

Our research suggests that generally, employees are fairly satisfied with the companies' Industrie 4.0 activities. Even more so, if the company chose a human-centred approach. Such approaches focus on the empowerment and integration of employees regarding the challenges coming along with Industrie 4.0.

Yet, several respondents state that their employees are dissatisfied because of the unpredictable development of Industrie 4.0 and because of the manifold changes expected to come along with Industrie 4.0.

Many provider companies and 50% of the Successful Practice companies estimate their employees' satisfaction with the companies' Industrie 4.0 activities to be rather high.

FIGURE V.5
EMPLOYEES'
SATISFACTION
n=72



Unions' & Work Councils' Satisfaction

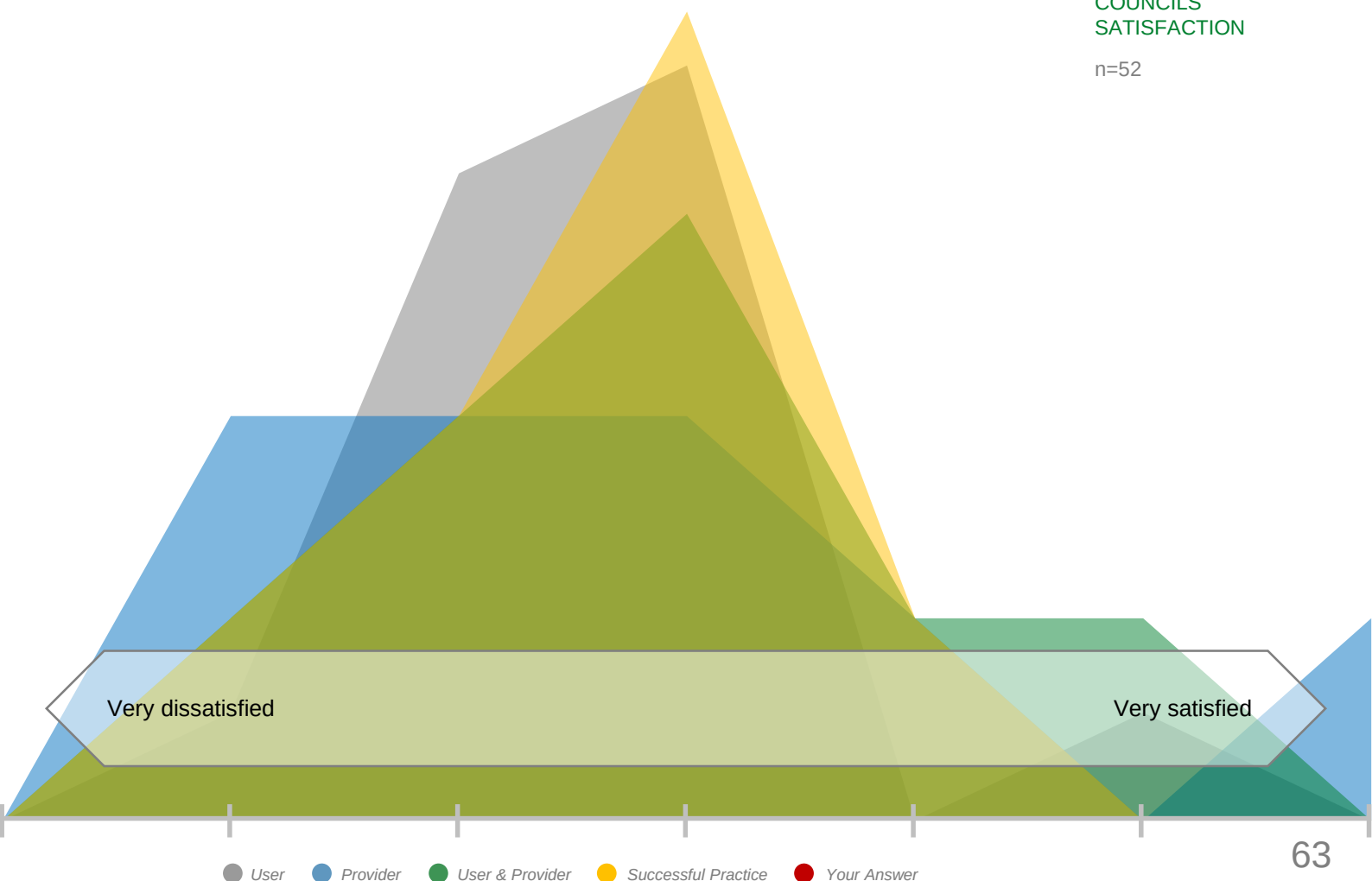
Unions and work councils tend to be rather dissatisfied regarding the companies' Industrie 4.0 activities. This is a general finding regardless of company category.

Unions and work councils have a representative role and take responsibilities in place of employees. Although Industrie 4.0 is said to support some of their interests, for example better work environment, a certain scepticism about future developments can be observed.

This is the more alarming since Industrie 4.0 will cause organizational changes that require support of all stakeholders.

FIGURE V.6
UNIONS' & WORK
COUNCILS'
SATISFACTION

n=52



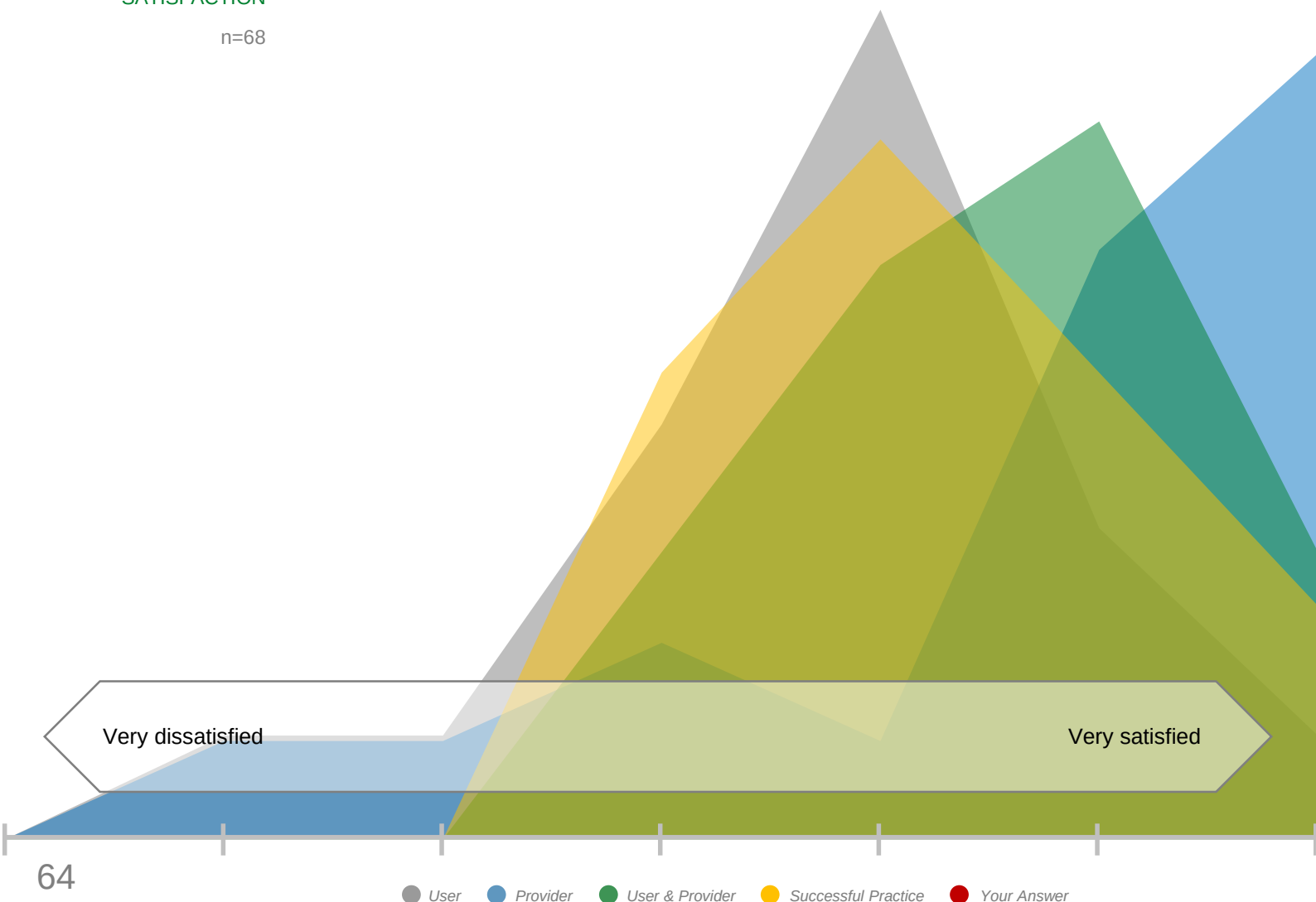
Customers' Satisfaction

Customers tend to be very satisfied with the companies' Industrie 4.0 activities. Especially respondents of provider companies view their customers as very satisfied with their Industrie 4.0 activities. User & provider companies sometimes refer to the advantage of using and selling Industrie 4.0 solutions at the same time. This makes it possible to demonstrate to customers that the technologies really do work in an operations environment.

Our analysis of the data indicates that several benefits for the customer result from a company's activities regarding Industrie 4.0. Mostly, shorter delivery times (example: reduced from 6-8 weeks to 10 days), higher flexibility regarding order fulfilment (even late stage customization and short-term changes of customer requirements are possible) and higher quality are already mentioned benefits customers enjoy from the company's Industrie 4.0 activities.

FIGURE V.7
CUSTOMERS'
SATISFACTION

n=68



VI CONCLUSION

Our benchmarking results show that it is already possible to generate certain positive outcomes from being active in the very broadly defined field of Industrie 4.0. Industrie 4.0 is understood as a technology driven paradigm that affects the entire value chain and the whole organisation on all levels. Outcomes of Industrie 4.0 activities were reported to mainly be: productivity gains, reduced costs of poor quality, higher financial performance, improved delivery speed and dependability, more innovations. Furthermore, companies report high satisfaction of employees, customers and suppliers with their Industrie 4.0 activities. Most companies view Industrie 4.0 as a useful means to achieve mainly two goals: increase of productivity and to keep production in a high-wage country.

Currently, most companies are evaluating and/or researching and developing solutions regarding Industrie 4.0. However, some companies are implementing or are already selling products produced under the new paradigm Industrie 4.0. The benchmarking study at hand took this and a set of other criteria to select those ten companies from the sample that are Successful Practice companies (SPC) regarding Industrie 4.0. Those companies possess the following characteristics: they are significantly bigger than other companies, have more resources, have worked on Industrie 4.0 for more than 3 years, mostly follow a Make-to-Order fulfilment strategy (7 out of 10) and are all headquartered in central Europe. The benchmarking study at hand provides insights into those companies' activities and reveals how the overall sample deals with Industrie 4.0.

It is agreed upon that Industrie 4.0 will change production comprehensively. Lean and Industrie 4.0 will somehow coexist in the future, but there is no clear tendency how Production System and Industrie 4.0 will relate to each other. SPC use the Down-Up approach, fulfilling the given strategy with help of Industrie 4.0 and meanwhile creating new strategic options through it. Decentral responsibility (the shop floor knows best what improves the process) must be aligned with company-wide standards and goals. Top-management takes over responsibility for setting the right coordination framework. Top-management commitment is important for being successful. So is an overall "process thinking" as well as IT-understanding and digitalization knowledge.

Companies are explicitly hiring personnel for Industrie 4.0. Nevertheless, they experience a shortage of manpower with the required qualifications (see pp. 55-56). Other barriers for successfully implementing Industrie 4.0 are deficits regarding IT-security, budget restrictions and still missing norms and standards.

When addressing the topic, companies collaborate with suppliers, customers and research institutes. They mainly exchange information and do joint research with the latter group.

SPC consider Industrie 4.0 more as a toolbox useful to improve the production process. However, they also think that all elements of their business model are affected by Industrie 4.0.

Differentiating between user and provider companies is a useful step as their approaches and aims are often quite different. Most of the SPC are both, user and provider of Industrie 4.0 solutions.

We would like to cordially thank everyone who participated in our benchmarking! Together we made a big step towards a deeper understanding of Industrie 4.0.

ABOUT US

The Institute of Technology Management was founded in 1988. We maintain close links to industry through intense collaboration with Swiss and European organisations by means of major research and consulting projects.

Our Division Production Management offers industrial organizations both industry and functional expertise, advisory and benchmarking competencies, and academic research. An experienced team of 60 researchers supports you in order to increase your future competitive advantages, from identifying the greatest improvement opportunities to their implementation.

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NOTES

NOTES



Universität St.Gallen

Forschungsplattform - Hochlohnstandorte in Produktionsnetzwerken

Individuelle Lösungen & Unternehmensübergreifender Austausch

Ein Produktionsnetzwerk sollte mehr sein als die einfache Aggregation seiner Einzelstandorte. Unternehmen stehen heute jedoch vielfach vor einem Konglomerat an Standorten, das historisch gewachsen oder durch verschiedene Zukäufe entstanden ist. Hinzu kommt, dass Hochlohnstandorte immer stärker im Wettbewerb mit netzwerkinternen Standorten stehen und einer klaren Differenzierungsstrategie bedürfen. Daher ist nicht länger die Optimierung des Einzelstandorts maßgeblich für den Erfolg weltweit operierender Unternehmen. Vielmehr muss das Ziel eine bestmögliche Ausgestaltung des gesamten Netzwerks sein, da für die langfristige Wettbewerbsfähigkeit des Produktionsverbunds eine holistische Herangehensweise unerlässlich ist.

In den vergangenen Jahren haben wir auf der Basis verschiedener Benchmarkingstudien sowie Industrie- und Forschungsprojekten einen strukturierten Ansatz zum ganzheitlichen Management von Produktionsnetzwerken entwickelt. Ziel dieses Ansatzes ist es, einen „fit“ zwischen den drei Dimensionen Strategie, Konfiguration und Koordination im Netzwerk zu erreichen. Dieser Ansatz lässt sich flexibel an den jeweiligen Unternehmenskontext anpassen und wurde in der Praxis bereits bei über 65 Industrieunternehmen erfolgreich angewendet.



Globale Produktionsnetzwerke eröffnen neue Möglichkeiten zur Stärkung der Wettbewerbs-

position von international agierenden Unternehmen. In einer dynamischen Umwelt stellt das Management dieser globalen Aktivitäten eine komplexe Herausforderung mit grossem Einfluss auf den Unternehmenserfolg dar.

Ich lade Sie herzlich ein an unserer Forschungsplattform teilzunehmen. Gemeinsam können wir die Zukunft globaler Produktionsnetzwerke gestalten und die Wettbewerbsposition von Hochlohnstandorten stärken.

Prof. Dr. Thomas Friedli

Direktor Institut für Technologiemanagement

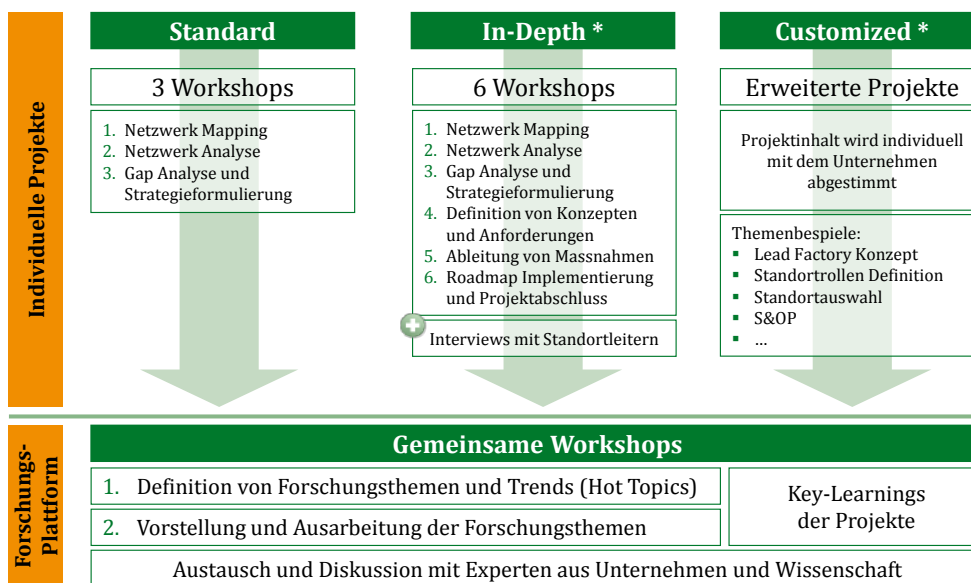
“The critical issue is no longer where to produce a product but where to perform individual production tasks”

Kasra Ferdows - Leading expert in operations management and professor at Georgetown University, USA



Die Forschungsplattform – **Hochlohnstandorte in Produktionsnetzwerken** – setzt sich mit den aktuellen Herausforderungen auseinander, denen Unternehmen im Rahmen des Managements globaler Produktionsnetzwerke

begegnen. Dabei sollen die Rollen der einzelnen Standorte definiert werden und insbesondere die zukünftige Rolle von Hochlohnstandorten in Netzwerken verstärkte Berücksichtigung finden. In individuellen Workshops wird Ihr Netzwerk analysiert und spezifische, an die Bedürfnisse Ihres Unternehmens angepasste Lösungen entwickelt. Zusätzlich werden aktuelle Forschungsthemen und deren Implikation auf die globale Produktion im Rahmen eines unternehmensübergreifenden Austauschs diskutiert. Der zweistufige Aufbau dieser Forschungsplattform bietet massgeschneiderte Lösungsansätze für Ihr Produktionsnetzwerk sowie einen Rahmen für den Austausch mit Experten aus Praxis und Wissenschaft.



* Exklusive, kostenlose Teilnahme am Expertenforum in Frankfurt am Main

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St.Galler Produktionsmanagement-Tagung 2016

„Make or Break“

Herzliche Einladung

In diesem Jahr möchten wir den steinigen aber lohnenden Weg der Produktion und die damit verbundenen Herausforderungen beleuchten. Insbesondere wird die Aufrechterhaltung und Belebung durch techno-logische Lösungen und Managementansätze thematisiert.

„Make or Break“ ist daher das Motto der diesjährigen Tagung.

18./19. Oktober 2016

Kongresszentrum Hotel Einstein I St.Gallen
www.einstein.ch

Anmeldung & weitere Informationen

www.produktionsmanagementtagung.ch

Wir freuen uns auf Ihre Anmeldung und darauf, Sie im Oktober 2016 in St.Gallen persönlich willkommen zu heissen.

Freundliche Grüsse

Prof. Dr. Thomas Friedli
Titularprofessor für Produktionsmanagement
Direktor ITEM-HSG

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