SMeART
Making Europe's SMEs Smart

LEARNING AND BUSINESS CONSULTANT NEEDS OF EUROPE'S SMEs IN SMART ENGINEERING

Co-funded by the
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2018

SMeART – Knowledge Alliances for Upskilling Europe's SMEs to Meet the Challenges of Smart Engineering
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Contents

Introduction

Smart Industry is a new phenomenon in the 21st Century. This term brings both risks and chances to the protagonists involved. In particular, small and medium-sized enterprises (SMEs), which are the backbone of Europe's economy, need to adapt their structures, processes, and organisational behaviour to meet the challenges related to Smart Industry in order not to lose contact with international markets and developments.

This was the starting point for the project SMeART, which stands for "Knowledge Alliance for Upskilling Europe's SMEs to meet the challenges of Smart Engineering". The project seeks to support engineering SMEs in Europe to become "smart" by building up cooperation models between researchers and industry in the field of Smart Industry and by designing and delivering practical tools, that can be easily implemented by companies within their daily work to successfully tackle the challenges of smart engineering. The SMeART team, which is composed of 15 partner institutions from the research and business sectors in seven European countries (Austria, Belgium, Germany, Italy, the Netherlands, Slovenia, and Spain), aims to jointly create and test a range of supporting instruments so that companies can become smart as well as becoming interlinked with relevant stakeholders engaged with smart industry across Europe.

Of course, the design and delivery of reliable supporting instruments for SMEs needs to be aligned with real demands within manufacturing companies. To this end, the SMeART team investigated the state of play concerning engineering SMEs in Europe through comprehensive empirical research. Its main findings are contained within this report, entitled Learning and Business Consultant Needs of SMEs in Smart Engineering..

The unique feature of this report is the presentation of real voices from SMEs, highlighting their demands in relation to Smart Industry, and their expectations concerning possible cooperation between business and research in the field of smart engineering. Thus, the report contains valuable information for both higher education institutions (HEIs) and Europe's SMEs. Whilst HEIs gain insights into the real needs, demands and requirements of SMEs, the latter group might recognise themselves through example situations and may reflect upon their own organisational problems whilst reading this report.

Moreover, with this report both HEIs and SMEs are expected to jointly think about possible alternatives and develop strategic tools for companies to move towards becoming "learning organisations". Being "smart" implies, based on our understanding, being able to learn in the sense of developing staff know-how, skills and competences. However, SMEs need specific pedagogic approaches tailor-made to their production processes and business life. This report mirrors the SMEs' vision of such learning approaches and creates a picture of turning the company into a learning organisation working in cooperation with HEIs.

1. Research design

The research design for this report represents a combination of quantitative and qualitative techniques. This mix helped to address the research problem logically and as unambiguously as possible.

The target audience for the research were primarily Europe's small and medium-sized manufacturing companies. The term "manufacturing" is understood as involving the use of machines, tools and a workforce to produce goods for consumption or for sale.

Micro and large manufacturing companies were also addressed by this research. Their responses helped to distinguish the needs of the primary research target groups by comparing the data obtained to create a wider picture of the state of play concerning smart engineering.


DIGITAL
TRANSFORMATION

1.1. Research team

The research team consisted of seven SMeART partners from seven European countries, Austria, Belgium, Germany, Italy, the Netherlands, Slovenia, and Spain. The research team was composed of representatives from the HEI, research and enterprise sectors. This team structure ensured that the interests and views of all the different stakeholders were considered when designing the research tools and addressing the target audience.

The leading research partner was the Chamber of Commerce of East Flanders (Voka), Belgium (www.voka.be/eng). Voka represents about 3000 companies, covering 70% of all employment in the region. Its aims are stimulating economic activity and creating optimal frameworks for successful and innovative enterprises. To achieve this Voka relies on large networks of businesses, knowledge centres, educational providers, plus local, regional and federal policy makers.

Other research partners were:

- Fachhochschule des Mittelstands (FHM), Germany (www.fh-mittelstand.de): FHM is a private, non-profit and state-registered university of applied sciences. Founded in 2000 by small and medium-sized enterprises, the FHM is nowadays one of the most successful private universities in Germany, addressing the needs of German SMEs with its educational services and research activities.

- European Network for Transfer and Exploitation of EU project results (E.N.T.E.R), Austria (www.enter-network.eu): E.N.T.E.R. is a European network with more than 900 member organisations in 44 different countries. Its main purpose is to provide a unique network structure for the best possible dissemination and sustainable use of EU project outcomes by connecting the supply of EU project results with the demand for innovative materials and products.

- Tiber Umbria Comett Education Programme (TUCEP), Italy (www.tucep.org): TUCEP is an association consisting of 11 Italian universities, 1 enterprises and two public entities. TUCEP's mission is the pro-active identification and analysis of training needs and their transformation into effective learning solutions for both the entrepreneurial and academic worlds.

- Chamber of Commerce and Industry (GZS), Slovenia (www.gzs.si): GZS is a non-governmental business organisation representing more than 10,000 member companies from all sectors and all regions of Slovenia. The GZS is a member of numerous governmental bodies, supporting them with know-how and expertise in various fields, and is one of the main partners for preparing the country's smart specialisation strategy.

- Federación Vizcaína de Empresas del Metal (FVEM), Spain (www.fvem.es): FVEM is the largest metal sector business association in Biscay, representing more than 850 SMEs. Its purpose is to exert economic influence on the coordination of issues that concern companies within the metal sector by establishing agreements with public and private institutions.

- Parbleu, the Netherlands (www.parbleu.nu): Parbleu is a company with more than 20 years of experience in supporting Dutch SMEs within the manufacturing and engineering sectors to innovate their products, services, processes and markets. Providing consultation and training to engineering enterprises concerning smart industry is one of Parbleu's key functions.

1.2. Quantitative research

The quantitative research was carried out by means of an online-survey. To this end, a valid and reliable online-based questionnaire was developed in six languages (Dutch, English, German, Italian, Slovenian, Spanish) in order to collect primary data concerning the companies' situation in connection with smart industry (basically focussing on questions such as knowledge/awareness of smart engineering, risks/problems in strategy developed, needs and demands for external support for training and consultation measures, suggestions for pedagogic interventions etc.).

The questionnaire was primarily distributed within seven SMeART partner countries, which were Austria, Belgium, Germany, Italy, the Netherlands, Slovenia, and Spain, during the period June to October 2017. However, enterprises from other European countries were also invited to complete the questionnaire.
The respondents were reached in two ways: they were either contacted directly by the project teams through emails or personal calls, or indirectly through newsletters and cooperation partners, who forwarded the online-survey to the end users. The benchmark of at least 250 respondents had been originally been set, however a total of 257 companies completed the questionnaire.

The participation in the survey by country is shown in Figure 1:

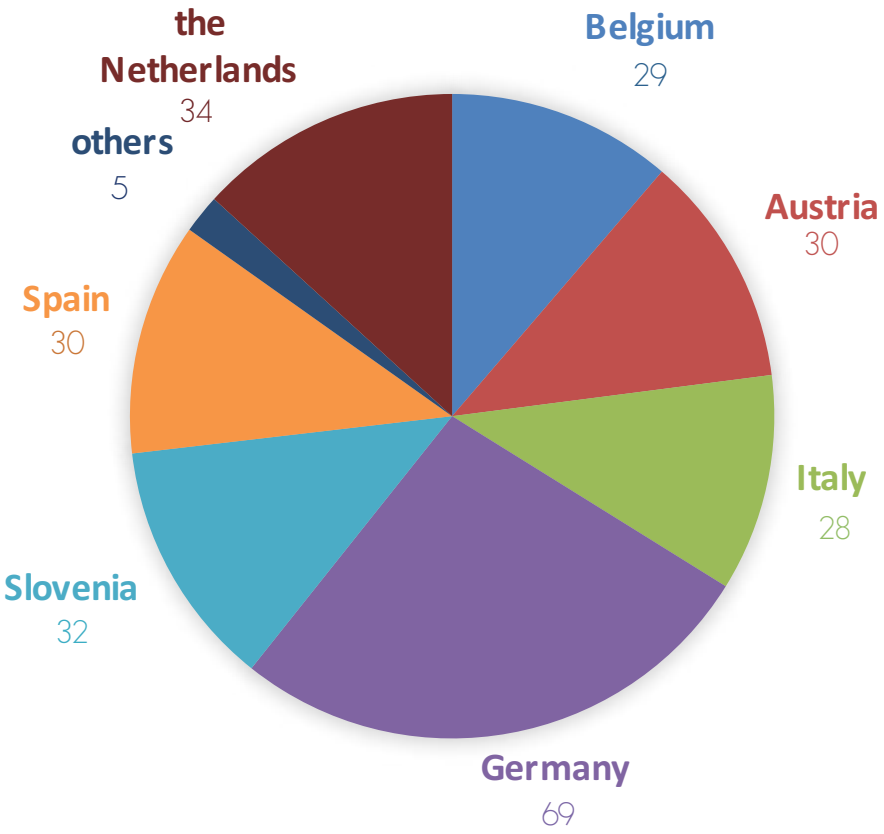


Fig. 1: Countries' representation in the survey (n = 257, in absolute figures)

1.2.1. Structure of the questionnaire

The questionnaire included a total of 91 questions. However, the respondents had flexibility when filling in the survey due to branching, which was used to provide respondents with the option to skip certain questions that were not relevant to them. Therefore, only mandatory questions (marked with '*') were answered by all respondents. The flowchart (Fig. 2) shows the questionnaire's structure:

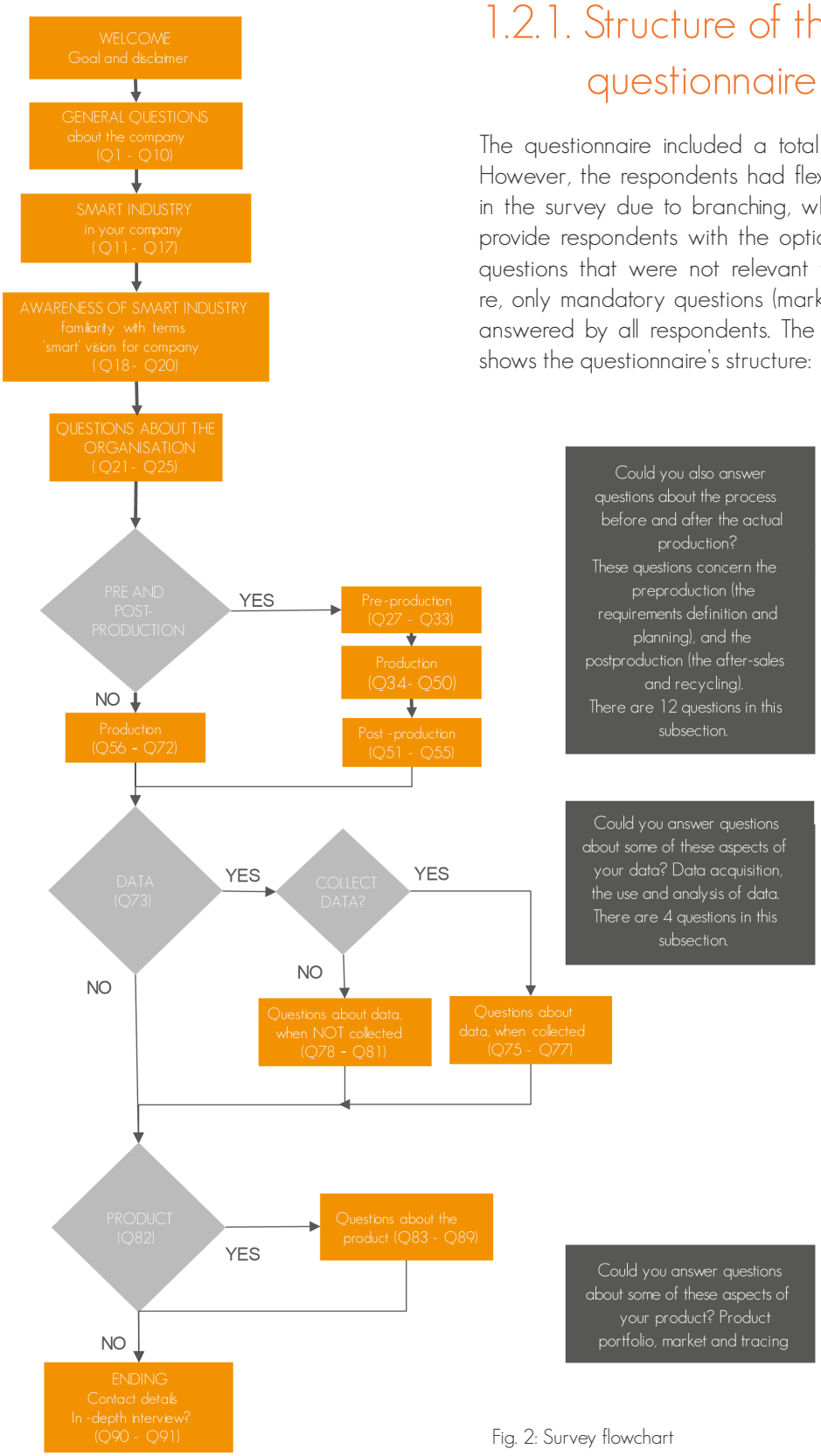


Fig. 2: Survey flowchart

Each question has a number. In this report the questions will be referred to by Q##, i.e. Q15 is question number 15.

The number of answers received per question is shown here in Fig.3:

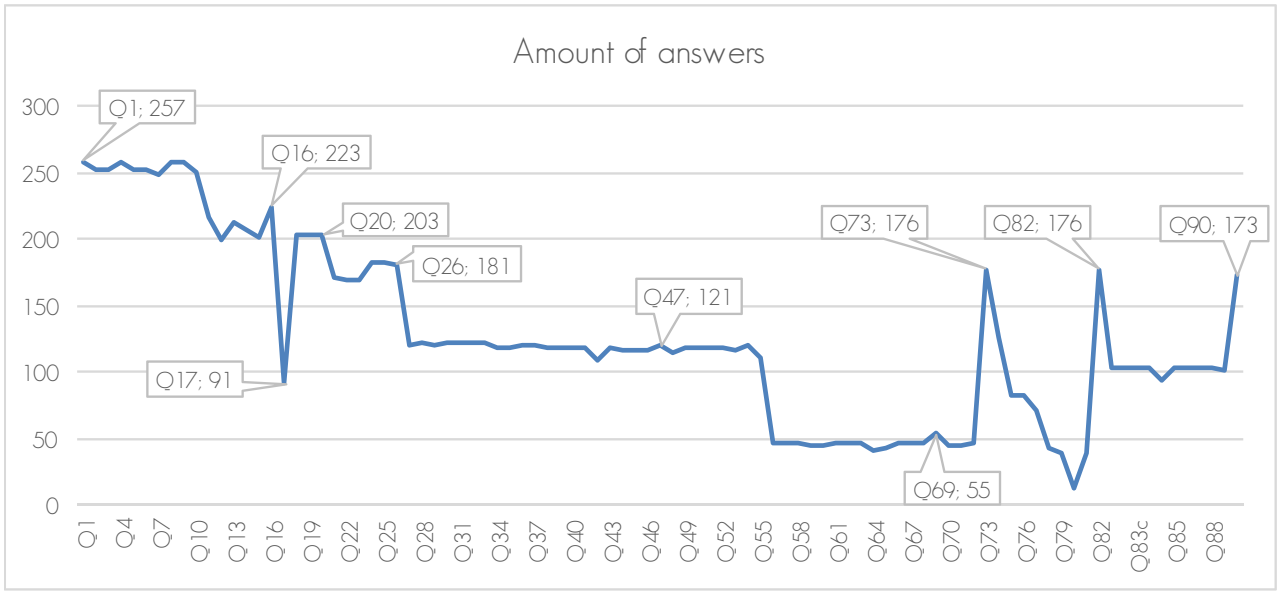


Fig. 3: Number of answers received (in absolute figures).

When giving answers using the survey tool, the answers were only saved when the page had been completely finished and the correspondent had clicked 'Next'.

Therefore, there are specific points at which the respondents stopped filling in the questionnaire, namely the last question of the previous page (Q89 - Q91). In Figure 3, this can be clearly seen.

Q26, Q73 and Q82 were questions where the answer leads the respondents to either continue to Q27, Q74 and Q83 or to skip to Q56, Q82 and Q90.

For example: the 176 respondents who answered question 73 are the sum of the 121 who answered questions 27 to 55 and the 55 who answered questions 56 to 72.

Question 17 seems to have produced very few responses in comparison with the questions just before and after it. This is probably due to the type of question it is. Whilst most questions were formulated (at least partially) as multiple choice, question 17 was an open question.

1.3. Qualitative research

Qualitative research was undertaken to complement the online-survey and was aimed at the in-depth exploration of the state of play concerning manufacturing SMEs in the field of smart industry within participating countries. Whilst the online-survey focused more on the technical aspects of smart industry, the interviews were aimed at learning more about the companies' vision in terms of pedagogical support to become smart, and about desired cooperation models with different stakeholders.

On average, five in-depth interviews with representatives from engineering companies were carried out in each SMeART country, with 45 interviews in total.

Fig.4 indicates participation in the interviews by country:

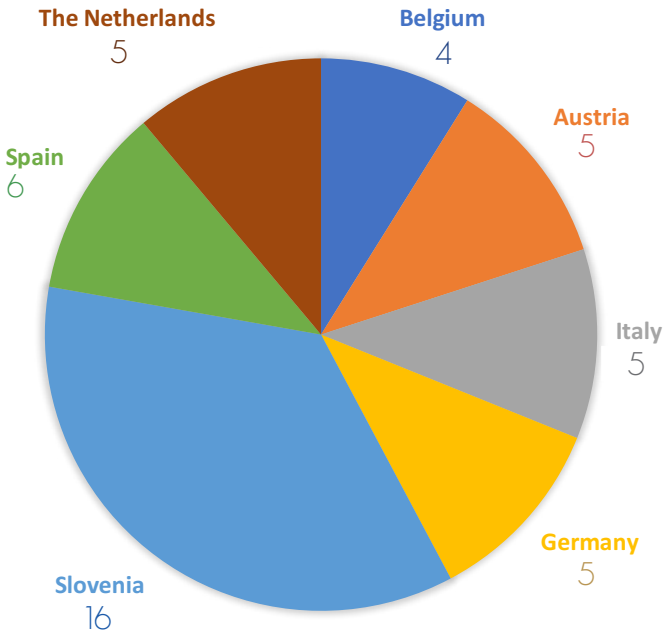


Fig. 4: Countries' representation in the interviews (n = 45, in absolute figures)

To ensure the comparability of the data collected, the semi-standardised interview guidelines were created and used by the SMeART team when conducting the interviews. The interviews were performed in one of these three ways:

- In person, by one of the project partners at the company in question;
- By telephone;
- At an event organised by the project partner where the respondents were gathered.

To facilitate the analysis of the interview results and to formalise them, a unified format was designed into which the most relevant interview findings were transferred.

These results have been anonymised to guarantee the confidentiality of the persons interviewed.

The interview results help in gaining a better understanding of the barriers hampering cooperation and know-how exchange between SMEs and HEIs, and therefore allow alternatives for tailor-made support actions and tools for becoming smart to be considered.

2. Results of the quantitative research

The results of the quantitative research are presented mainly by using diagrams and tables, which contain the scores provided by respondents when completing the online-survey, either in percentage or in absolute figures. The diagrams and tables also contain textual interpretations of the relevant findings related to the survey objectives.

The results are reported in the same order that the related questions were formulated in the survey. To aid for better understanding, the survey results are divided into several thematic sub-sections.


P02

2.1. Profile of respondents and of companies

Firstly the survey sample is described, with relevant statistical data about the functions of the respondents, as well as about the type and age of the company and the products manufactured.

The main survey respondents were general company managers aged between 45 and 54 years (115 persons, see Figure 5). This clearly highlights that the topic of smart industry is regarded as a high priority within many companies.

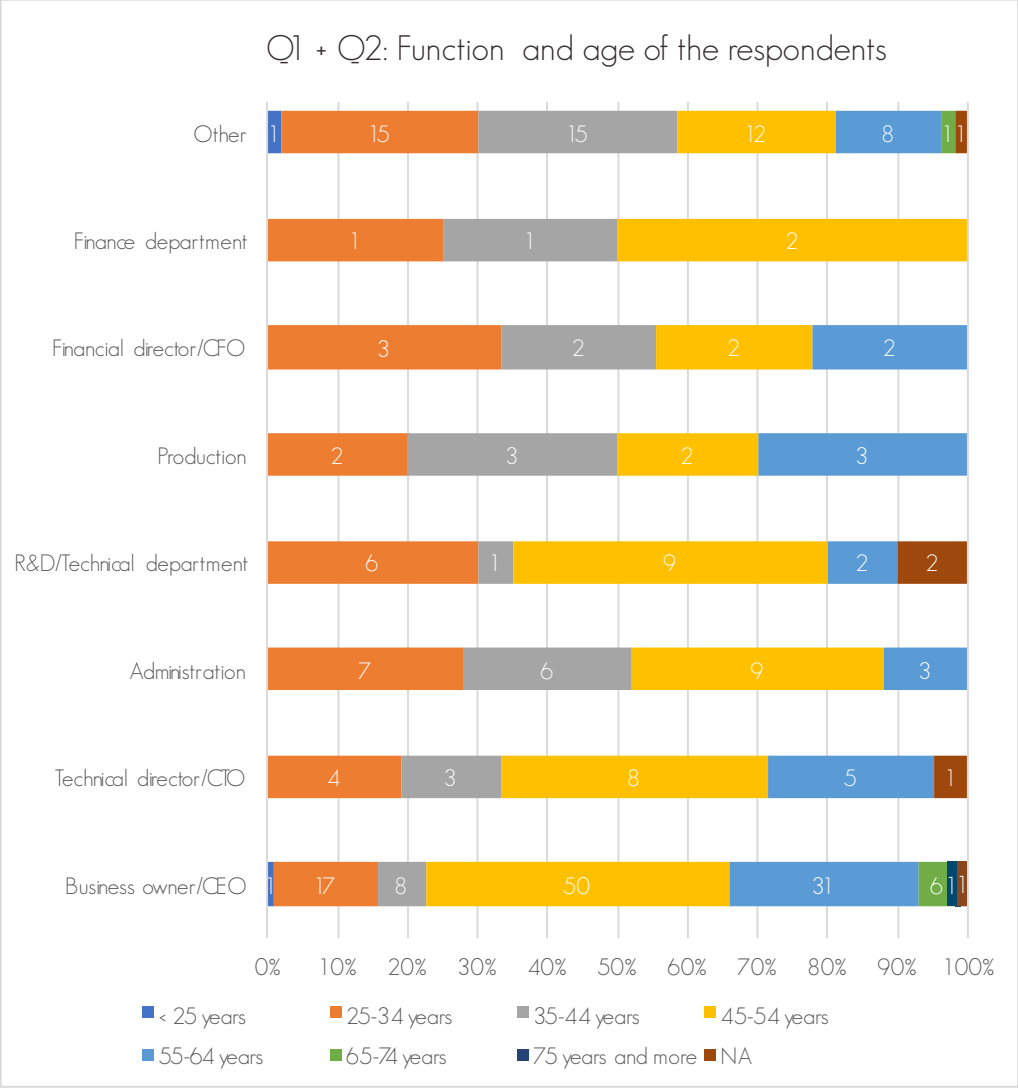


Fig. 5: Function of the respondents and their age (in absolute figures, n = 257)

The companies interviewed were of different sizes (see Fig. 6): micro (57), small (97), medium (65), non-SME (38). This differentiation helped in identifying relevant trends in companies' behaviours and estimations, which will be shown alongside this report.

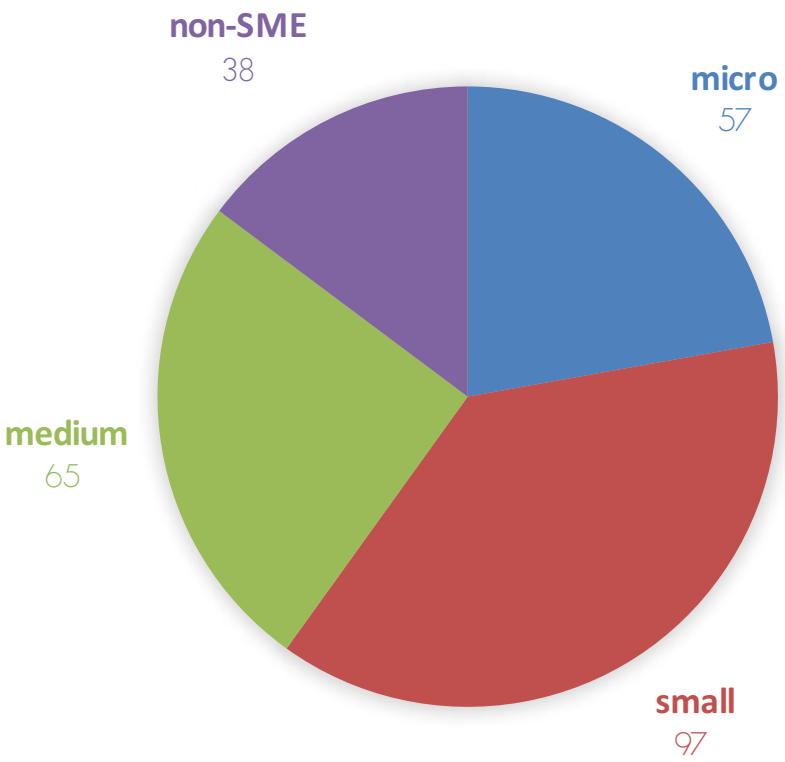


Fig. 6: Size of companies (in absolute figures, n = 257).

Small and medium-sized companies, mentioned 97 and 65 times respectively, therefore represent the largest group of respondents. In total, there were 162 survey participants from these two company groups, which equals 63% of the total number of respondents.

Many respondents indicated the age of their companies, which is mainly between 20 - 49 years for small and medium-sized enterprises, between 10 – 19 years for micro-companies, and rather predictably between 50 – 74 years for large companies. The correlation between company size and its age is represented in Figure 7:

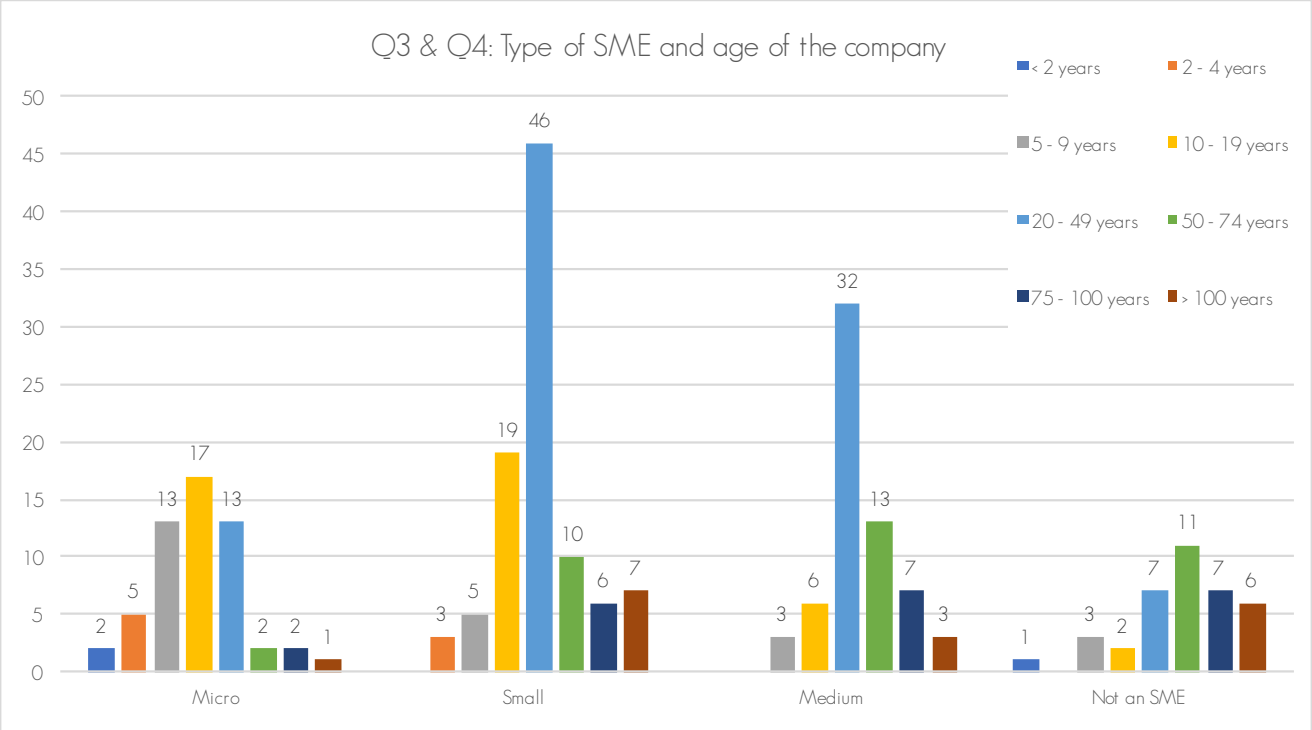


Fig. 7: Size of companies and their age (in absolute figures, n = 252).

The respondents were asked about the geographical location of their companies and countries of operation. The results obtained are represented in the Figures 8 and 9:

Q5: In which country is your company located?

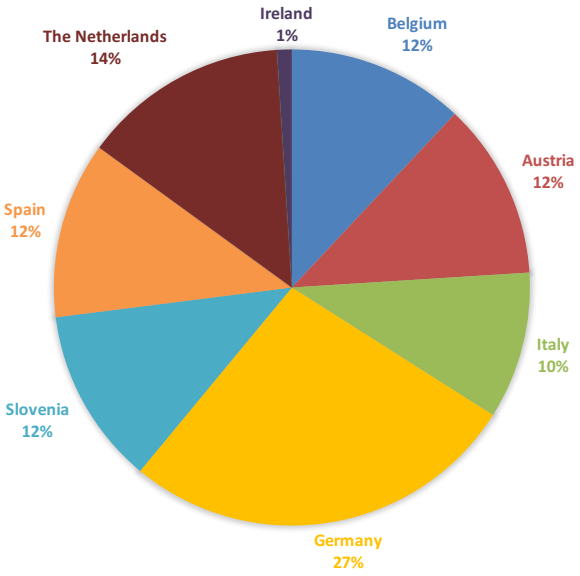


Fig. 8: Geographical location of companies (n = 253, in %)

Q6: Where does your company mainly operate?

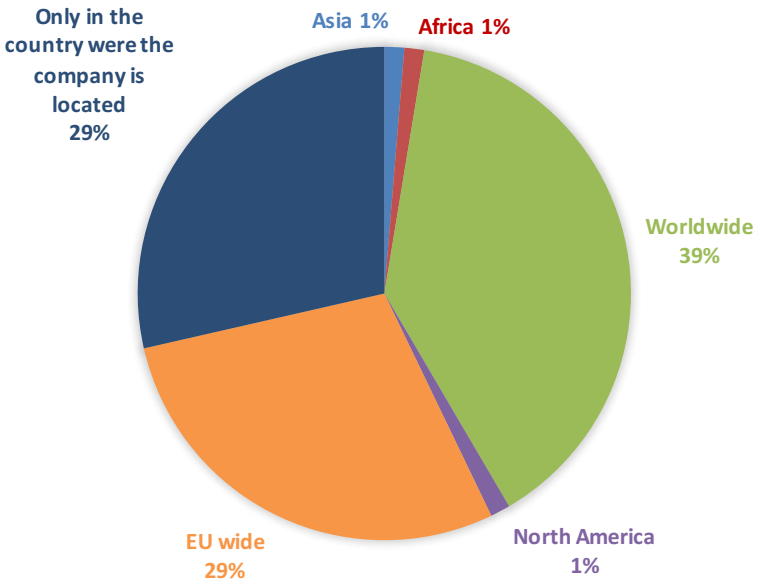


Fig. 9: Countries of operation (n = 252, in %)

As can be expected, the companies are mostly located in one of the project partner countries where the survey was undertaken. Germany is represented with the highest number of companies, 28%, and therefore it provides the largest number of answers (see Table 1). This logic also applies to the whole of Figure 8.

The representation of the companies in the world and their location are aggregated and demonstrated in absolute figures in Table 1:

Where does your company mainly operate?	Austria	Belgium	Bulgaria	Croatia	Germany	Italy	Ireland	The Netherlands	Portugal	Romania	Slovenia	Spain	Total (all countries)
Only in the country where the company is located	3	11	1		10	7	1	8		1	5	11	58
EU-wide	16	7		1	38	8	1	12			16	11	110
North America	3												3
Worldwide	8	11			19	11	1	14	1		7	6	78
Africa												1	1
Asia					2								2
Total	30	29	1	1	69	26	3	34	1	1	28	29	252

Tab. 1: Relation between company location and areas of operation (n = 252, in absolute figures)

Approximately 74% of the companies operate either in the EU or worldwide. Marked in orange are the highest scores for each country.

Type of products: a wide range of products manufactured by companies were indicated, as Figure 10 demonstrates. The most commonly manufactured items are metal products, plus machinery and equipment.

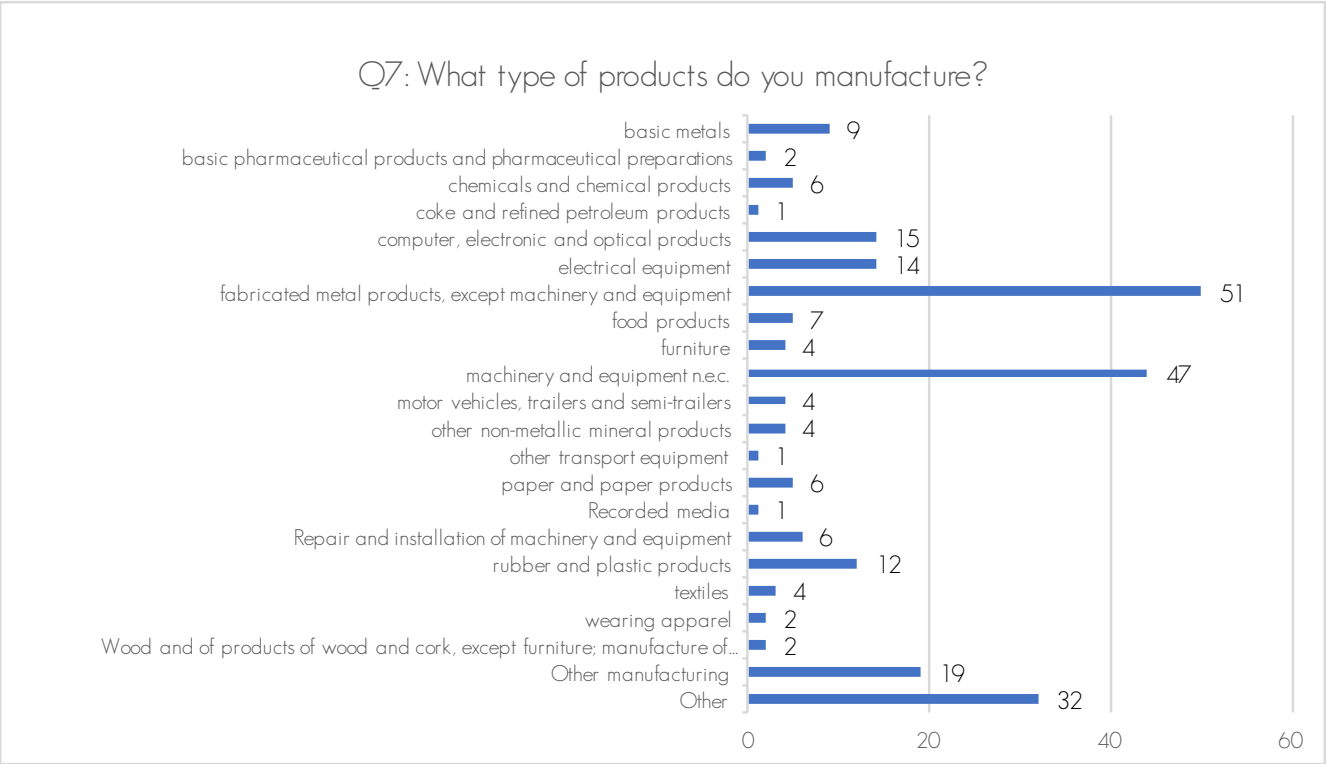


Fig. 10: Types of products (in absolute figures, n = 249)

Type of customers: As Figure 11 shows, about 80% of the respondents work Business to Business (B2B), meaning they deliver products to other businesses. 40% of them are small companies. The second highest customer group is the B2C (Business-to-customer) category (36% of respondents), followed by distributors/ agents/ dealers (28% of respondents). These customer groups are quite typical for small and medium-sized businesses.

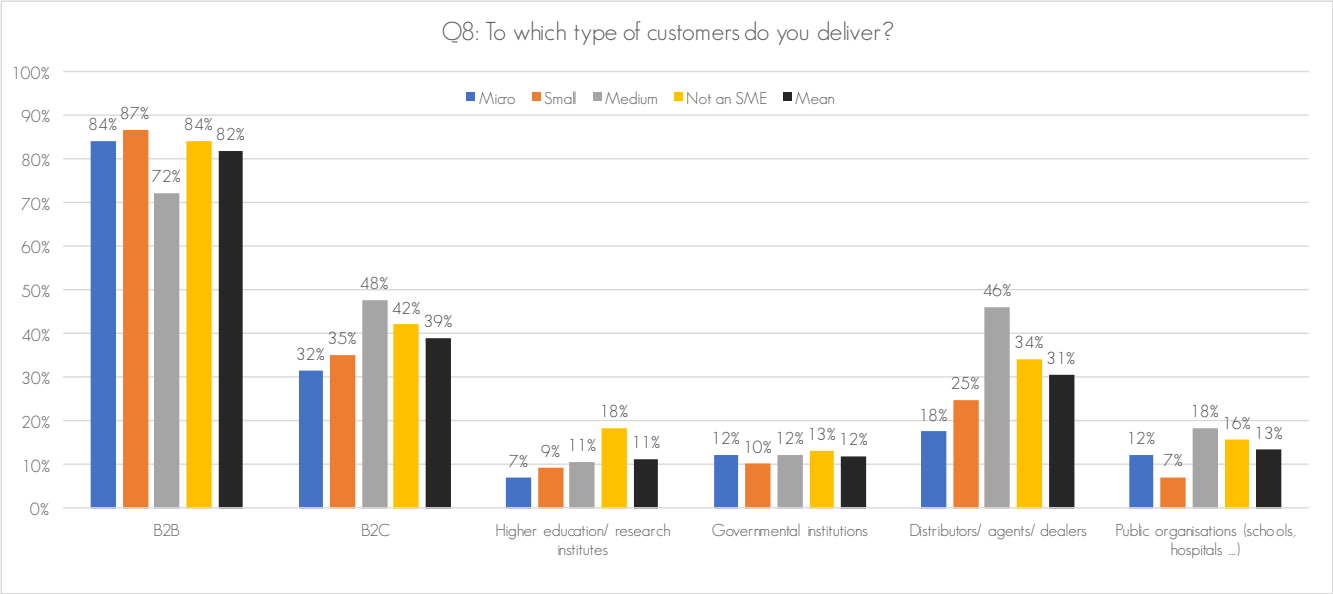


Fig. 11: Type of customers (in %, n = 257, many answers possible)

Type of manufacturing: customised production has 157 answers (see Figure 12) and is the highest recorded manufacturing form in this survey. It involves the production of personalised or custom-made goods or services to meet the diverse and changing needs of consumers:

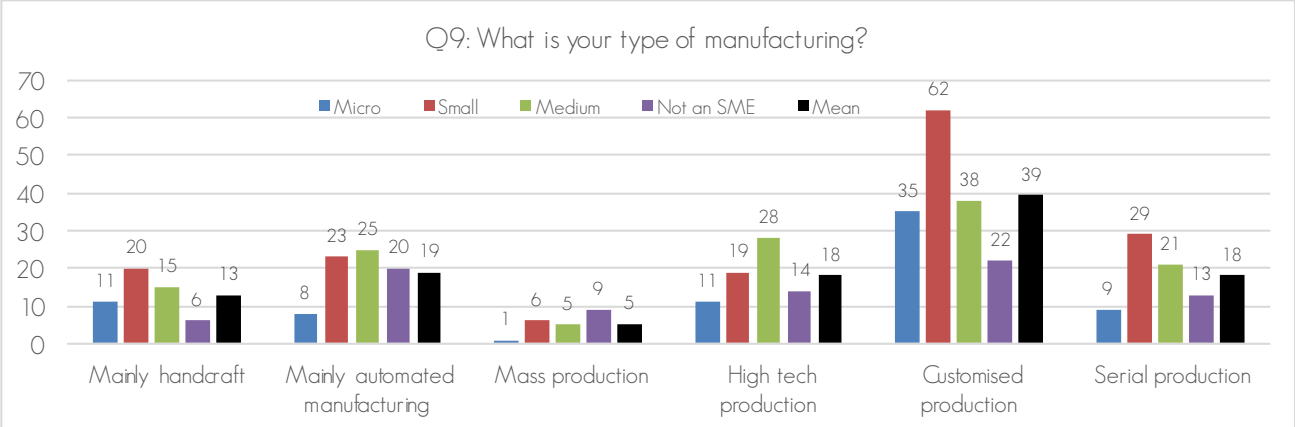


Fig. 12: Type of manufacturing (in absolute figures, n = 257)

Considering that the enablers for customised production include computerisation, internet, product modularisation, and lean production, then smart industry is a crucial issue for this kind of company.

When matching the type of products indicated and the corresponding manufacturing techniques, the following results appeared (see Figure 13):

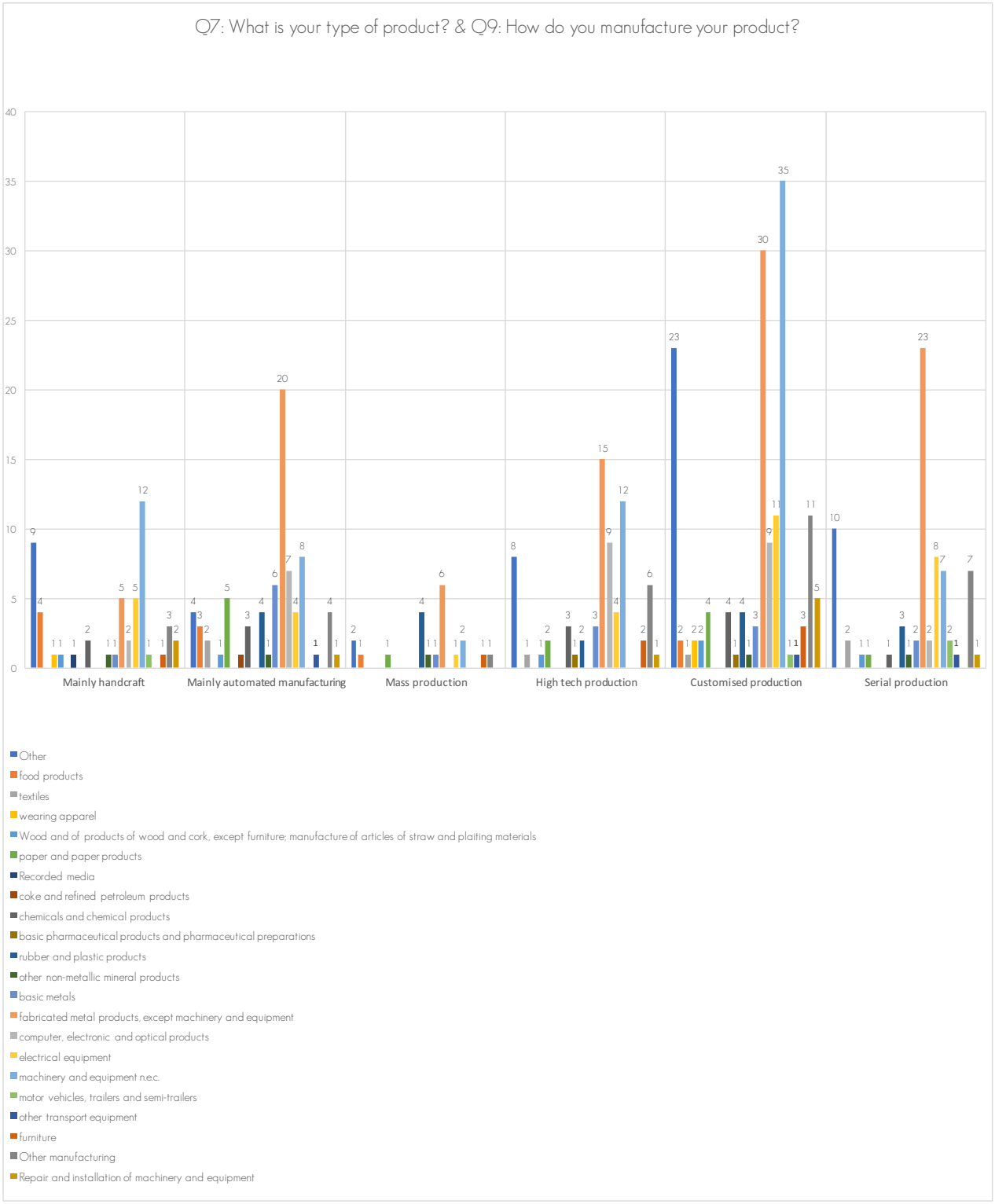


Fig. 13: Relation between products and manufacturing techniques (n = 249, in absolute figures)

The most popular products, fabricated metal products and machinery and equipment, are mostly produced using the customised production technique of manufacturing.

Fabricated metal products are produced using different manufacturing techniques.

2.2. Current integration of smart industry within companies

With the next step, the state of play concerning smart industry within engineering companies was scrutinised. The related questions asked about companies' awareness of smart industry, the level of penetration of digital technologies and estimations in terms of benefits and obstacles.

Firstly, companies were required to estimate their general level of competitiveness in the market. The results produced are represented in Figure 14, which highlights quite a high degree of consciousness about their competitive standing (at least 65% for each company type).

When asking companies about recognising themselves in the definition of smart industry, which was formulated here as being intelligent IT-based components and systems within all key areas of supply, production and distribution chains, a slight decrease was noted (see Fig.15). An average of 51.4% of respondents recognised themselves in this definition of smart industry. However, their answers to further questions seem to contradict this. It might be that they are 'unconsciously incompetent'.

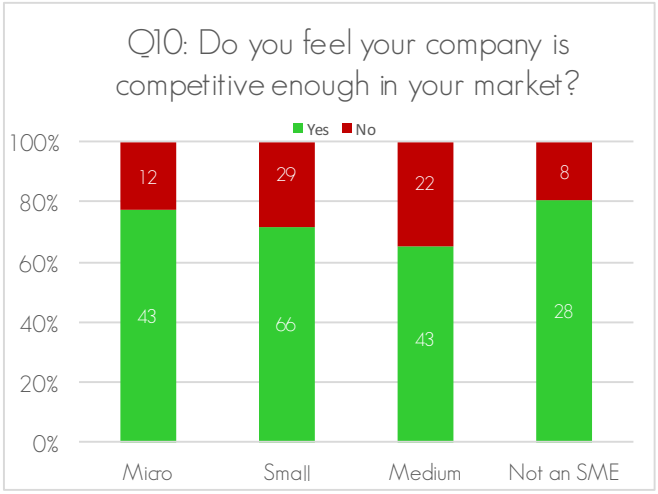


Fig. 14: Self-estimation of competitiveness (in absolute figures, n = 251)

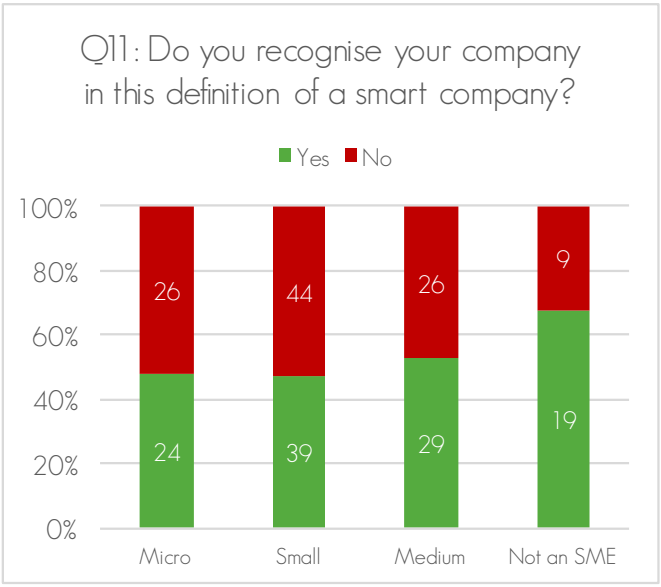


Fig. 15: Companies' self-identification with smart industry (in absolute figures, n = 216)

Table 2 below presents the combined answers to both questions Q10 and Q11, aiming therefore to identify correlations between feeling competitive and feeling smart using the matrix principle.

How to read this table (example): In total, 108 respondents indicated they do recognise themselves in this definition of a smart company.

Of these 108, 85 respondents feel competitive enough in their market.

Of these 108 competitive respondents, there were 55 answers from medium-sized companies.

Of these 55, 52.7% or 29 respondents do recognise themselves as smart.

Of these 29, there are 22 who feel competitive.

Q11: Do you recognise your company in this definition of a smart company?	Yes (Yes, I recognise myself)		No (No, I do not recognise myself)		Total	
Q10: Do you feel competitive enough in your market?	Yes (I recognise myself and Yes, I feel competitive)	No (I recognise myself and Yes, I feel competitive)	Yes (I recognise myself and Yes, I feel competitive)	No (I recognise myself and Yes, I feel competitive)	Yes	No
Micro	23 (47,9%)		25 (52,1%)		48	
	19 (82,6%)	4 (17,4%)	18 (72%)	7 (28%)		
Small	39 (48,1%)		42 (51,9%)		81	
	31 (79,5%)	8 (20,5%)	27 (64,3%)	15 (35,7%)		
Medium	29 (52,7%)		26 (47,3%)		55	
	22 (75,9%)	7 (24,1%)	14 (53,8%)	12 (46,2%)		
Not an SME	17 (65,4%)		9 (34,6%)		26	
	13 (76,5%)	4 (23,5%)	8 (88,9%)	1 (11,1%)		
Total	108 (51,4%)		102 (48,6%)		210 (100%)	
	85 (78,7%)	23 (21,3%)	67 (65,7%)	35 (34,3%)	152 (72,4%)	58 (27,6%)

Tab. 2: Interconnections between feeling competitive and feeling smart (n = 210)
Legend: blue – self-estimations of being smart
orange – self-estimations of being competitive

TABLE 2 PROVIDES THE FOLLOWING INSIGHTS:

- Feeling smart incorporates feeling competitive: of the respondent who do recognise themselves in the definition of a smart company, the majority (78.7%) feels competitive.
- Company size does not have a significant impact upon feeling competitive and smart: there is only a small difference of approx. 2%.
- Not feeling smart leads to a reduced feeling of competitiveness: from 78.7 to 65.7% (decrease of 13%).
- Particularly with medium-sized companies, being a non-smart company makes a difference in terms of the perception of their own competitiveness (from 75.9% to 53.8%).

Therefore, being smart contributes to increased competitiveness for all company types.

Furthermore, the respondents were asked to estimate the timeframe needed to implement smart solutions within their companies. The answers were compared with the data related to the companies' self-estimation of smartness and competitiveness, and was analysed separately for each company size (micro, small, medium, and non-SME), and summarised in Table 3:

Company size: MICRO

What could be the timeframe to implement smart solutions within your company?	already implemented or within 1 year		between 1 and 5 years		longer than 5 years/ never		Total
Do you feel competitive?	Yes	No	Yes	No	Yes	No	
I recognise myself in the definition of a smart company	14		7		0		0
	12	2	7	0	0	0	
I do not recognise myself in the definition of a smart company	3		19		3		25
	3	0	12	7	2	0	1xNA

Company size: SMALL

What could be the time-frame to implement smart solutions within your company?	already implemented or within 1 year		between 1 and 5 years		longer than 5 years/ never		Total
Do you feel competitive?	Yes	No	Yes	No	Yes	No	
I recognise myself in the definition of a smart company	19		16		1		36
	17	2	11	5	0	1	
I do not recognise myself in the definition of a smart company	8		22		7		37
	6	2	12	10	4	2	1xNA

Company size: MEDIUM

What could be the time-frame to implement smart solutions within your company?	already implemented or within 1 year		between 1 and 5 years		longer than 5 years/ never		Total
Do you feel competitive?	Yes	No	Yes	No	Yes	No	
I recognise myself in the definition of a smart company	14		13		1		28
	9	5	11	2	1	0	
I do not recognise myself in the definition of a smart company	3		18		3		247
	3	0	9	9	0	3	

Company size: NOT a SME

What could be the time-frame to implement smart solutions within your company?	already implemented or within 1 year		between 1 and 5 years		longer than 5 years/ never		Total
Do you feel competitive?	Yes	No	Yes	No	Yes	No	
I recognise myself in the definition of a smart company	12		16		1		19
	9	2	4	1	0	1	2xNA
I do not recognise myself in the definition of a smart company	1		5		1		7
	1	0	4	1	1	0	

All company types combined

What could be the timeframe to implement smart solutions within your company?	already implemented or within 1 year		between 1 and 5 years		longer than 5 years/ never		Total
Do you feel competitive?	Yes	No	Yes	No	Yes	No	
I recognise myself in the definition of a smart company	59 (57%)		42 (40%)		3 (3%)		104
	47	11	33	8	1	2	2xNA
I do not recognise myself in the definition of a smart company	15 (16%)		64 (69%)		14 (15%)		93
	13	2	37	27	7	5	2xNA

Tab. 3: Interconnections between self-estimations of smartness, competitiveness, and timeframes for implementing smart solutions.

THE MAIN FINDINGS FROM TABLE 3 ARE:

- The higher the respondents' self-estimation of being smart and competitive, the sooner they plan to fully integrate smart technologies.
- Companies who already identify themselves with smart industry expect to fully implement smart solutions either within one year (57%) or within the next five years (40%). Only 3% of these respondents believe they need more than 5 years to move forward with becoming smart.
- 69% of companies who do not identify themselves with smart industry expect to become smart within the next 5 years. The percentage of those who need more than five years to implement smart solutions amounts to 15%.

From the statements about the timeframe for becoming smart it was interesting to learn more about in which areas of companies smart solutions would bring the most benefits. As Figure 16 shows, Quality Control (121 answers), Machines (117 answers) and Development of new products (115 answers) are the most desired departments for implementing smart solutions.

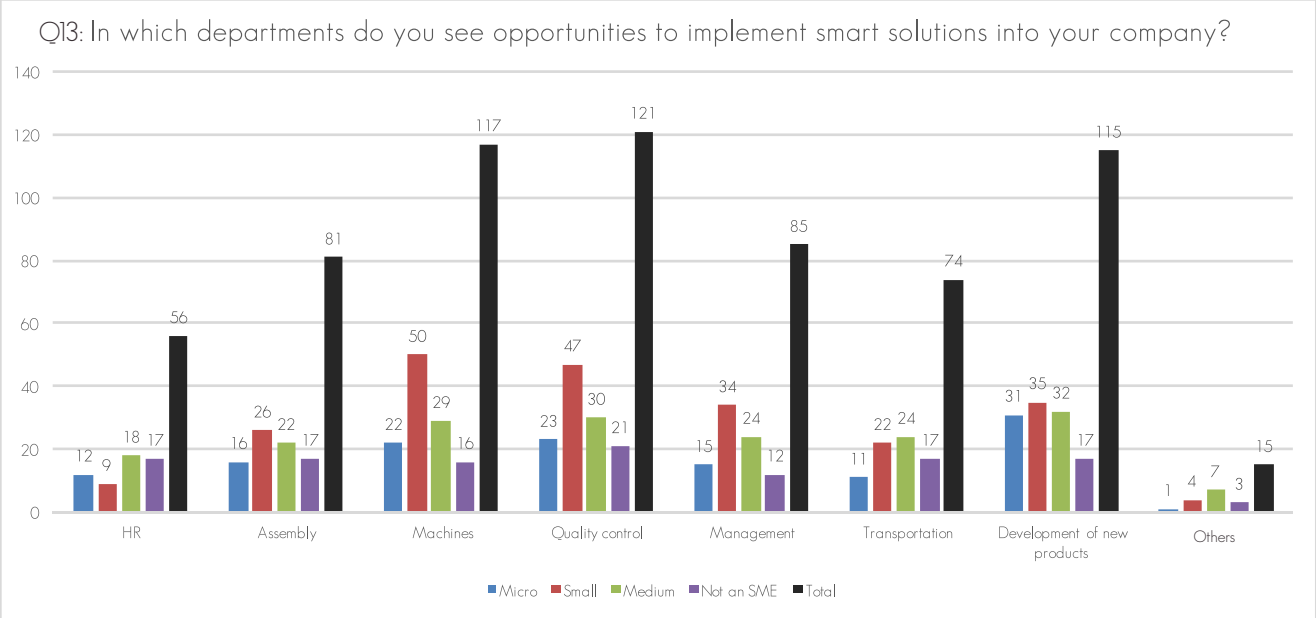


Fig. 16: Vision of implementing smart technologies within companies' departments (n = 212, in absolute figures, many answers possible)

Companies already engaged with being smart were additionally asked to indicate their level of involvement with smart industry (see Figure 17):

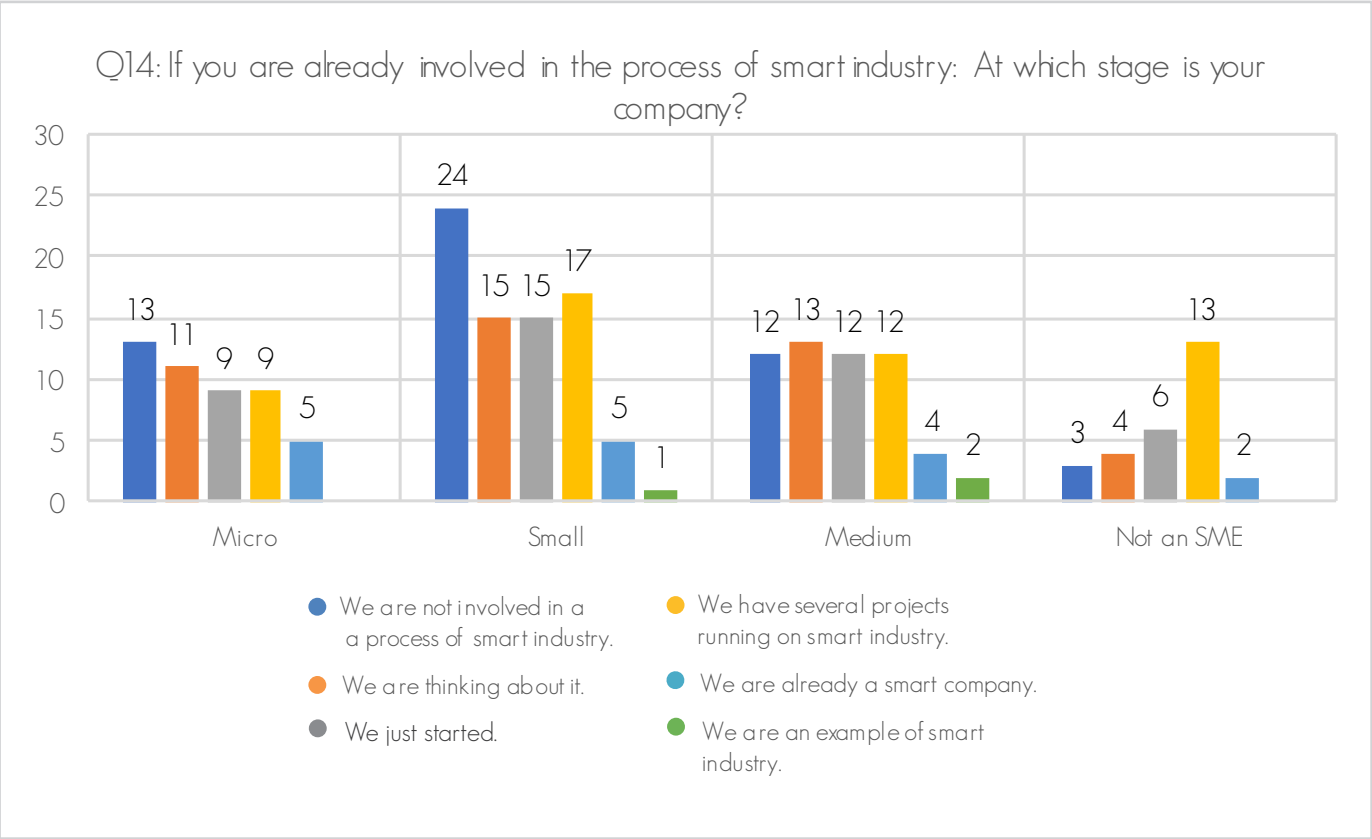


Fig. 17: Level of involvement with smart industry (in absolute figures, n = 207)

Here there are some contradictions with previous answers, which is illustrated by a higher level of self-identification with smart industry (compared to the findings in Figure 15): only a few small and medium-sized companies regard themselves as an example of smart industry. Most companies are either at the initial stages or only thinking about possible alternatives for introducing smart solutions.

2.3. Business-Research cooperation in relation to Smart Engineering

At this stage, the data about possible cooperation between companies and research or higher education institutions (HEIs) for knowledge input in relation to introducing smart industry projects was asked for (see Figure 18).

The results are quite sobering: whilst, on average, 24% of respondents maintain contacts with HEIs, knowledge centres, research institutions or other organisations, 39% of respondents do not cooperate with any researchers at all. This might be a relevant factor hampering the penetration of smart industry into companies.

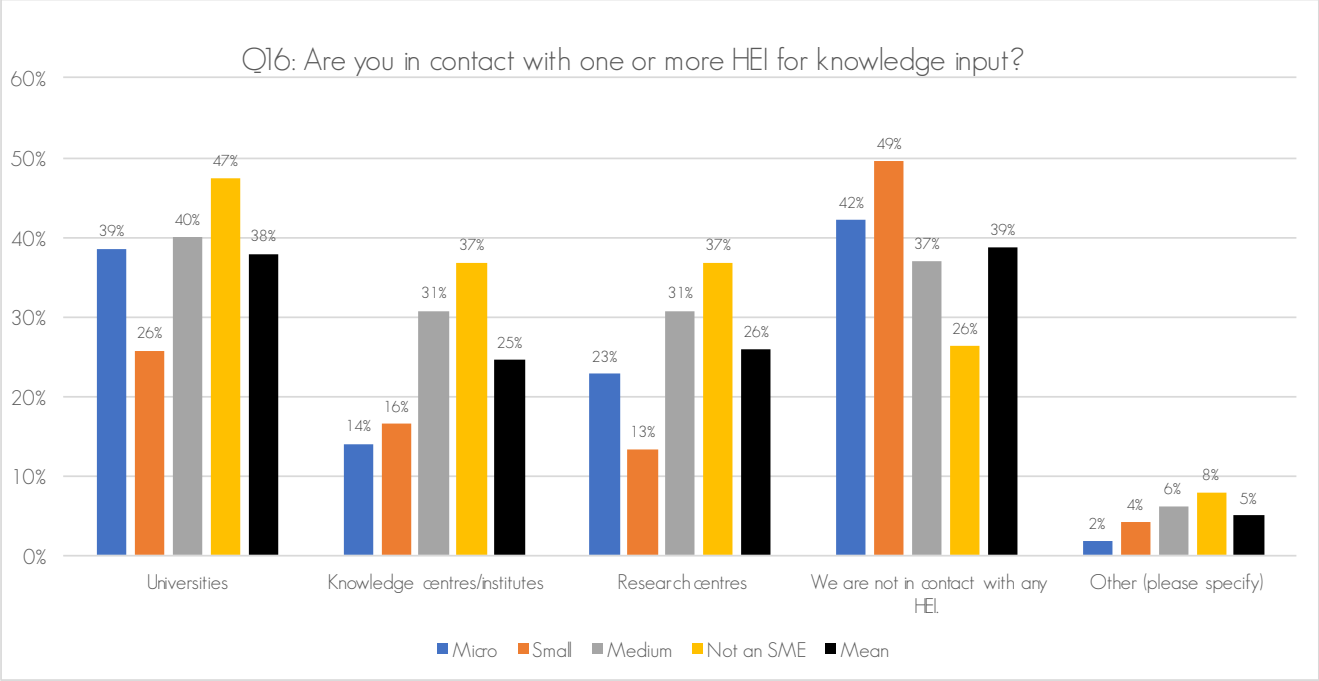


Fig. 18: Cooperation with research institutions (in %, n = 223)

Respondents provided the following explanations regarding "Others" in Tab. 4:

Original language	English translation
Aktuell nur durch Austausch mit Studenten	Currently only through exchange with students
Bedrijven , toeleveranciers	Companies, suppliers
Consultorías Externas	External Consulting Firms
euskalit	Euskalit Basque foundation for the promotion of quality
fachliche & regionale Netzwerke	Professional & regional networks
IT Unternehmen, Firmen für Automatisierung & Softwareentwicklung, Freelancer	IT companies, companies for automation & software development, freelancers
lastno raziskovanje in sledenje smernicam	Own research and following trends
Mit anderen Industrieunternehmen.	With other manufacturing enterprises
otras industrias industriales, proveedores informáticos	Other industries, ICT providers
start up bedrijven	Start-up companies
toeleveranciers van elektrische componenten	Suppliers of electronic components
Unabhängige Berater	External advisors

Tab. 4: Other partners for knowledge input.

In addition, 91 answers were received in response to the open question Q17 related to the concrete indication of input expected or already gained from the research sector. This data is crucial to improve understanding about companies' expectations of researchers, their real educational needs and their views on the barriers preventing the establishment of effective cooperation with HEIs.

These detailed comments from enterprises concerning cooperation with HEIs can be allocated into the six categories, which represent the possible areas of support that the HEI and research sector can provide, as follows:

TESTING • NOTHING YET • INNOVATION • KNOWLEDGE • CONSULTING • NETWORK • (FUTURE) EMPLOYEES

KNOWLEDGE
Algorithms
Competence in the field of production planning
Courses
Design and construction of machines
Development of operational technology systems, which allow autonomous driving of powerful mining machines as well as implementation of expert systems
Expert to-the-point knowhow
Fundamental research, implementation of projects
How to start, which tools to use for efficient implementation
Implementation in the production process
Implementing mathematical models in designs and development of new equipment
Input of technological nature
IT competence, management, accounting, process optimization
IT development trends
Knowledge
Knowledge in their specific domain
Management of technological processes, automatisation of production and logistics
Mass data analysis
Mostly cooperation in specific research projects or for conducting a specific task (example: measurements)
New knowledge
Practical forms of implementation
Process engineering
Professional expertise
Programming
Programming technical designers
Results of research and a plan of approach
Software development
Standards concerning ICT communication, experiences and pitfalls
Statistical approaches, Mathematics
Technological know-how
Technological support
Various calculations (statics, fatigue of materials ...)

NETWORK
Collaboration on development projects, support with grant requests
Collaboration in research & development
Inspiration, examples, network of contacts
Joint projects
Knowledge transfer
Knowledge, project cooperation
Mainly as a client
Research and support for sales
Correct contact person
Sharing
Transfer of know-how
We are not interested in listening to long lectures about abstract research theories but need concrete solutions for our routine work situations. Would be great if researchers walk through our plant and say what kind of improvements are needed.
We have contacts with HEI - as lecturers we are transferring our practical knowledge

TESTING
Analysis of our production
Expertise/test results of new principles
From the economic point of view, enough to amortise the investments and, on the other hand, to achieve a better position in the market.
Material and process support
Measurement, testing
Scientific analysis of the predefined processes
Testing of material
Testing of products and participation in study groups

FUTURE EMPLOYEES
IT engineers
Engineers

CONSULTING
Advice about the existing offer
Advice and practical support
Conducting potential analysis concerning possible applications of smart solutions
Consultation by professors, support to universities : i.e. supervision of projects and final papers, lectures
Consultation, research
On the subject of smart industries, we do not have contact with the organisations mentioned above. Contacts we have are about the technical part of our company, and operational processes as engineering and quality management.
ICT-related topics (Security, Interoperability, etc.)
We tried many times to obtain support from researchers. But they are mostly focused only on their theoretical knowledge.
To explain simple conditions for starting to be „smart". To show the most relevant benefits and standards, that have already been established in this field.
We are not in contact. Quick and easy solutions to implementation problems (conceptual and physical installation)
Support with food hygienic issues
Support in the area of Lean Man, QRM and company-specific issues
In what way can we be helped to implement the smart industry

INNOVATION
Bringing up ideas on possible smart connections that can be implemented in our organization
Development of new technologies
Developments, trends, new raw materials
Innovation
Know-how
Know-how
Looking for new possibilities
Mechanical Engineering, Electronics, Development, State of the Art Research, Trends
New products and services
Our contacts relate mostly to the technical innovation of products or processes
Product development
Research & Development
Research & Development
Research & Development, internationally-funded projects
Research and new applications
Researcher activity to implement within our company
Technological developments
Technology Centres
Technology input

NOTHING YET
We experience little added value. We may not ask the right questions.
Not clear
None
Low at this moment

Tab. 5: The views of companies about enterprise-research cooperation.

IN OTHER WORDS, COMPANIES CAN BENEFIT FROM COOPERATION WITH THE HEI AND RESEARCH SECTOR THROUGH:

- direct selection and recruitment of future employees
- testing of new products and services
- design and development of innovative products and services
- obtaining new knowledge
- receiving professional consultation
- establishing close cooperation and networks.

The frequency that the six defined categories are mentioned is presented in Figure 19:

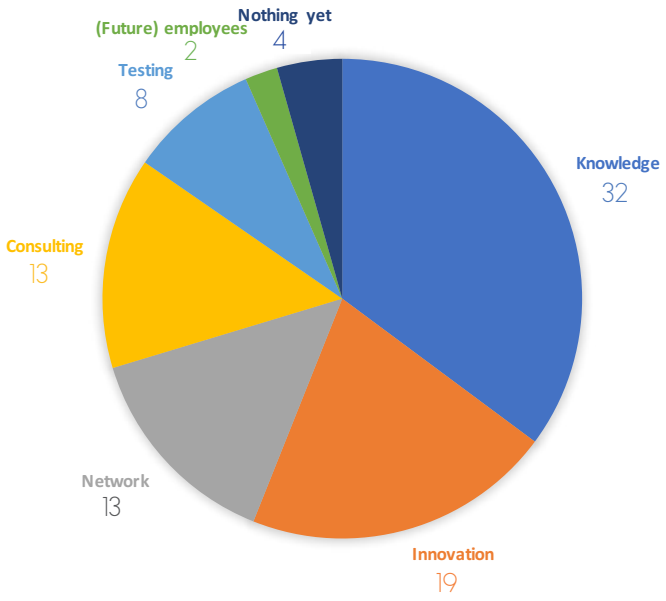


Fig. 19: The desired areas that the research sector can support companies with (in absolute figures, n = 91)

Thus, companies are mostly interested in adapting specific knowledge offered by the research and HEI sector, particularly in relation to (new) technologies.

One of the main factors jeopardising HEI-business cooperation is, according to the research results, a strong theoretical approach by the research sector and their lack of practical orientation.

2.4. Awareness of smart industry within companies

A set of questions was asked to identify which terms and concepts in the field of smart industry are known to the respondents. Figure 20 demonstrates the level of respondents' familiarity with the relevant terms:

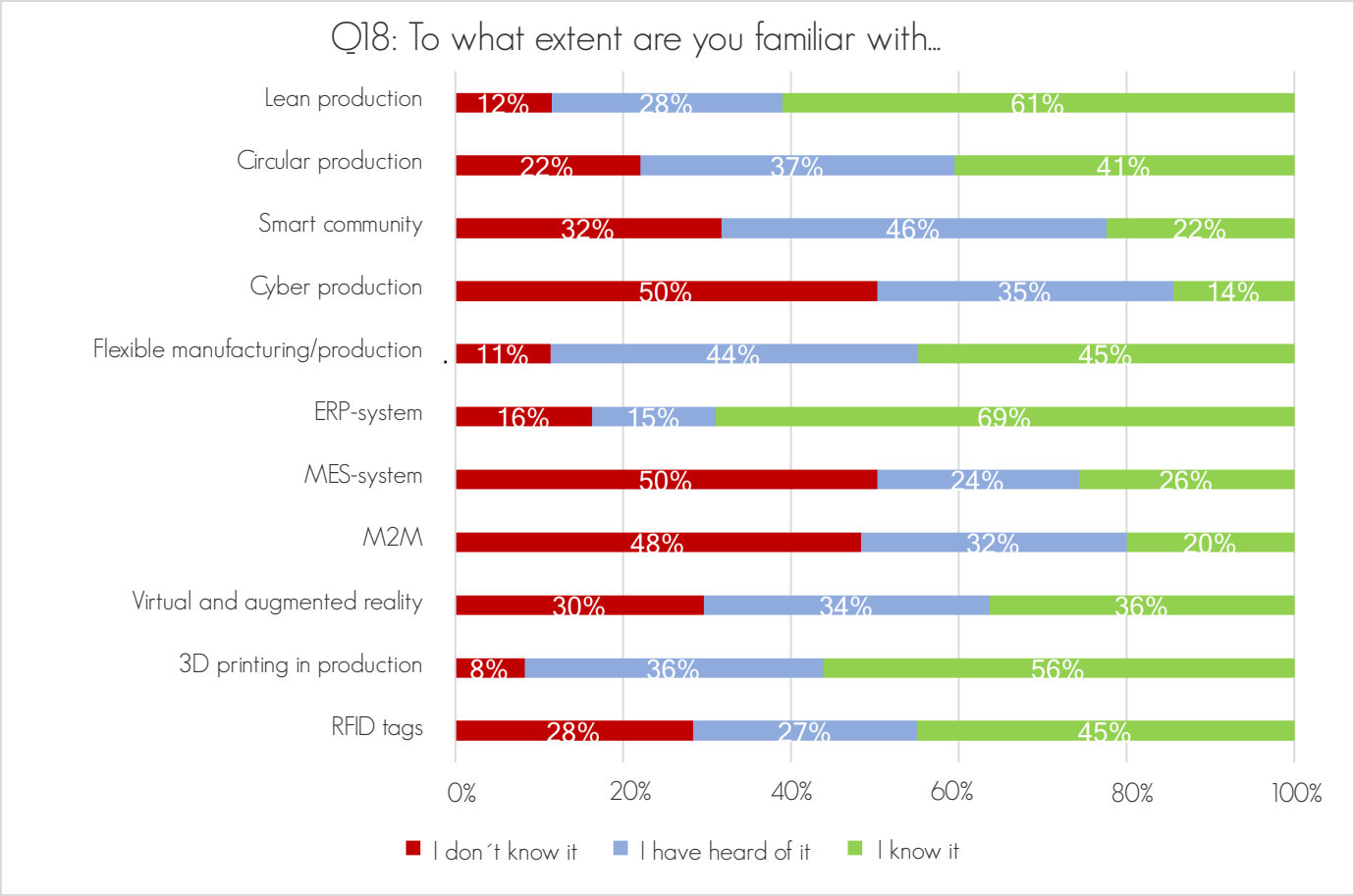


Fig. 20: Level of awareness of smart industry-related terms (in %, n = 203)

Whilst ERP-System with 69%, Lean Production with 61%, and 3D printing in production with 56% positive answers seem to be quite well known, MES-System and Cyber production with 50% and M2M with 48% are still relatively new to many respondents.

However, the level of awareness concerning new terms and technologies may significantly depend upon the function of the respondents. Therefore, the graphs below represent separate results of the technological awareness according to the different job profiles of the respondents.

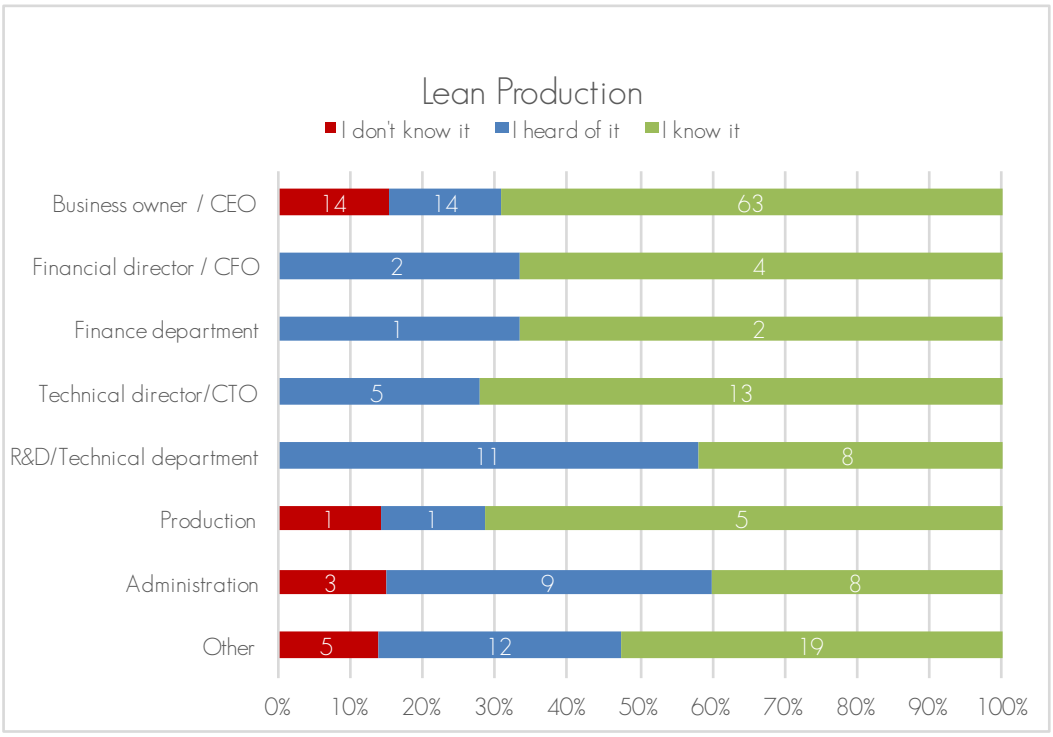


Fig. 21: Awareness of Lean Production (in absolute figures, n = 203)

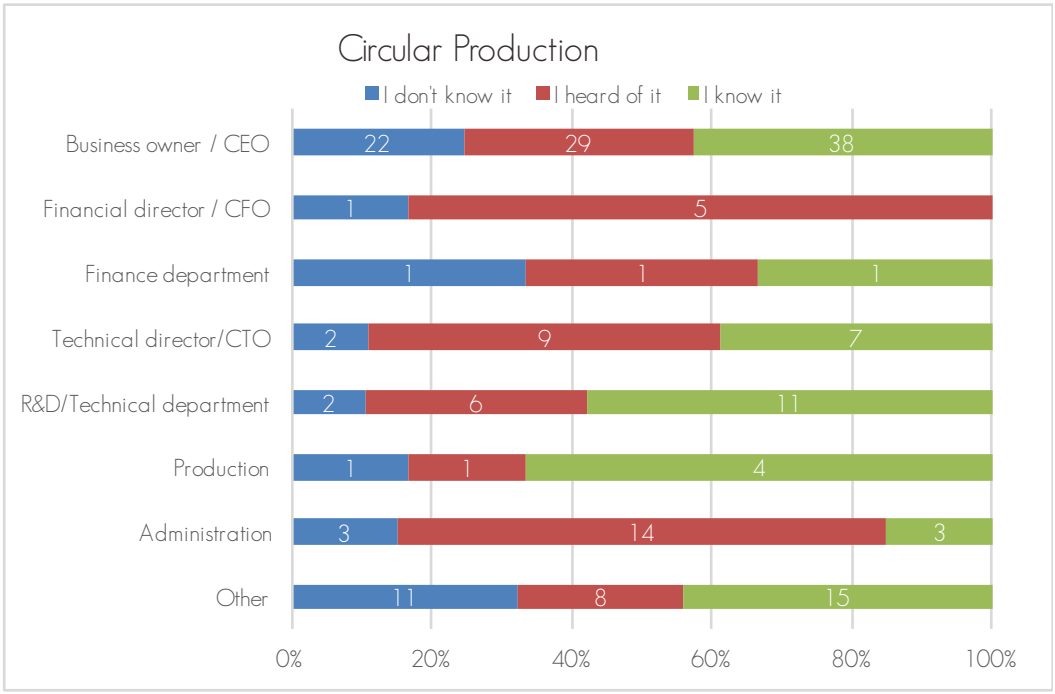


Fig. 22: Awareness of Circular Production (in absolute figures, n = 203)

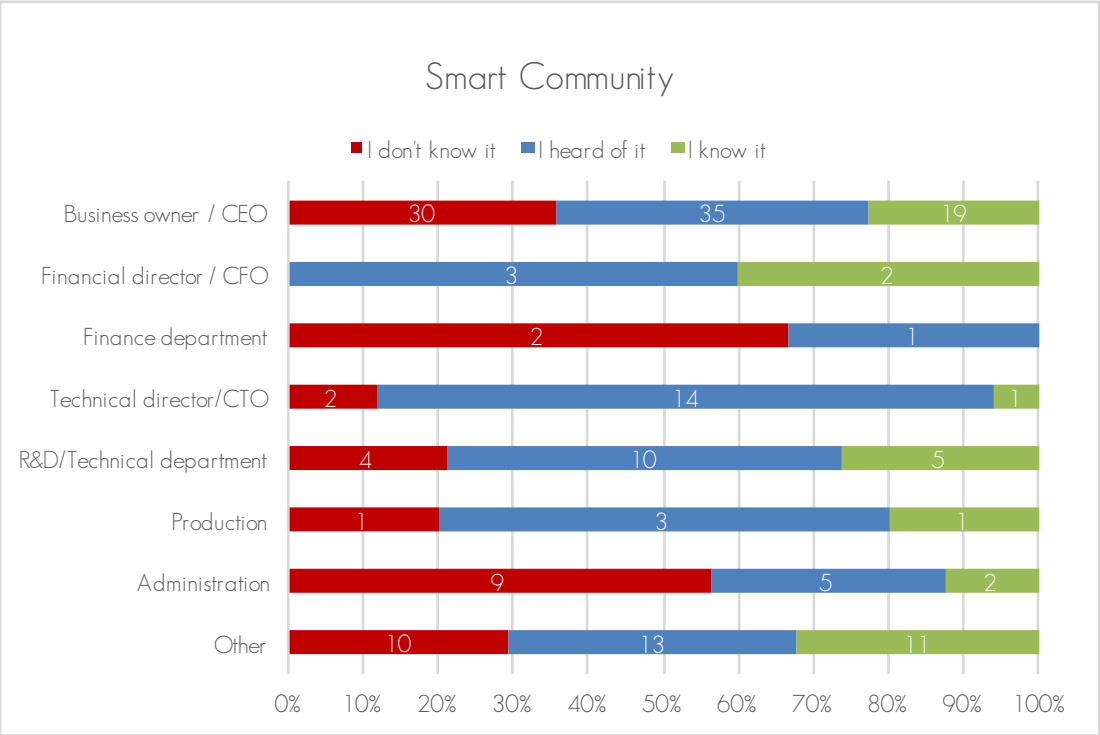


Fig. 23: Awareness of Smart Community (in absolute figures, n = 203)

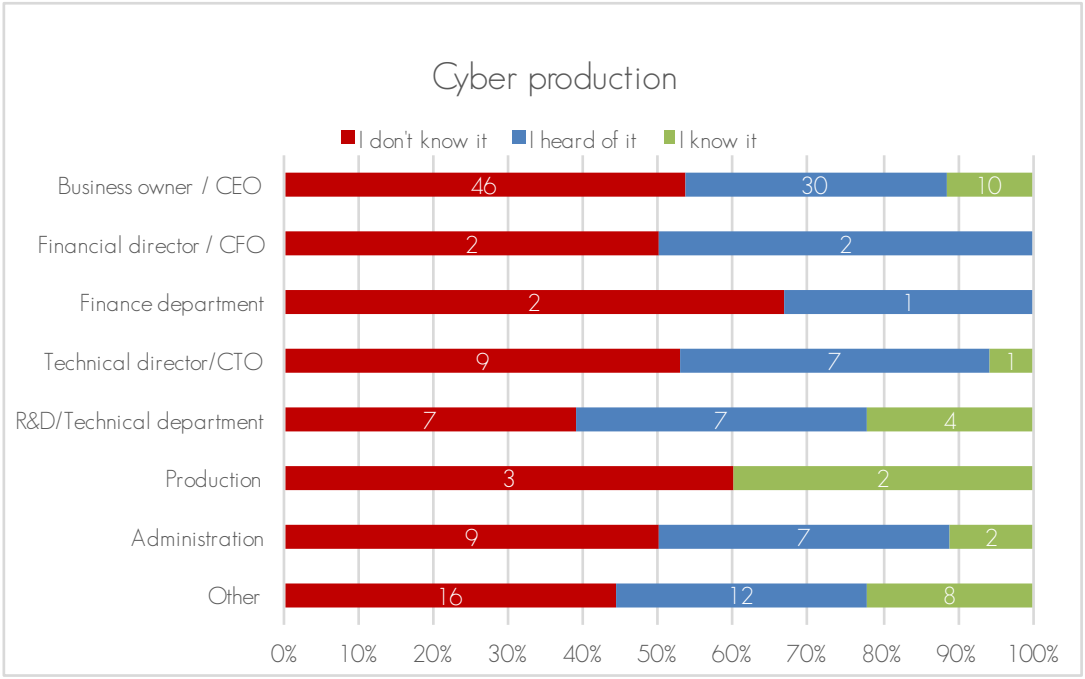


Fig. 24: Awareness of Cyber production (in absolute figures, n = 203)

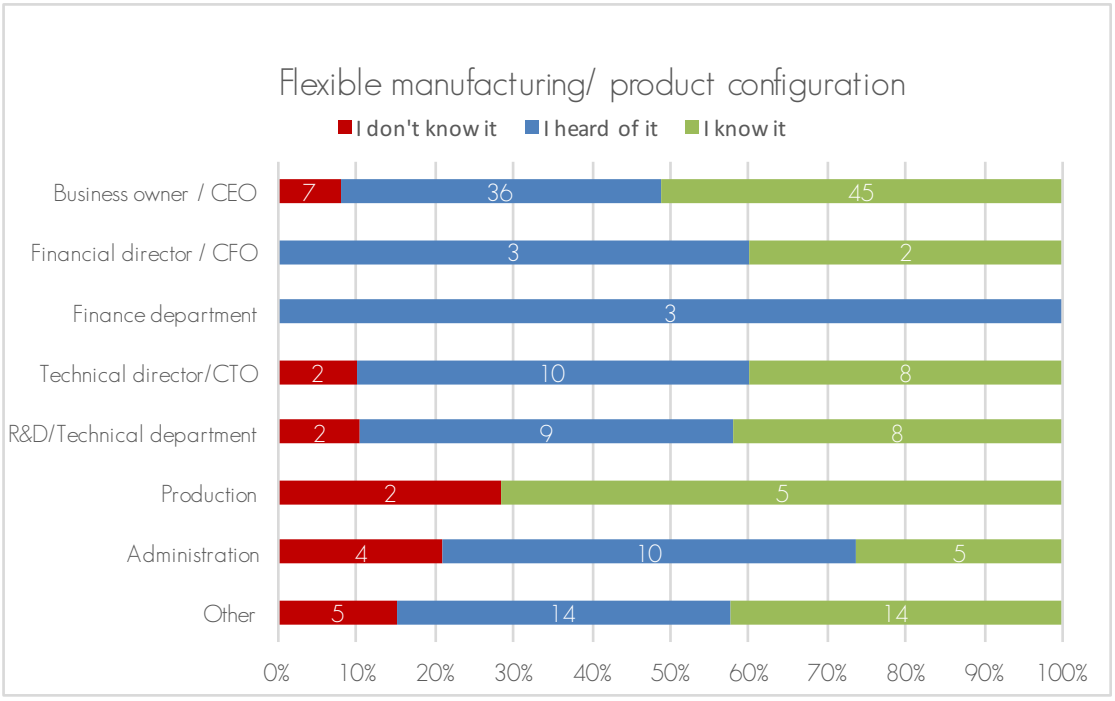


Fig. 25: Awareness of Flexible Manufacturing (in absolute figures, n = 203)

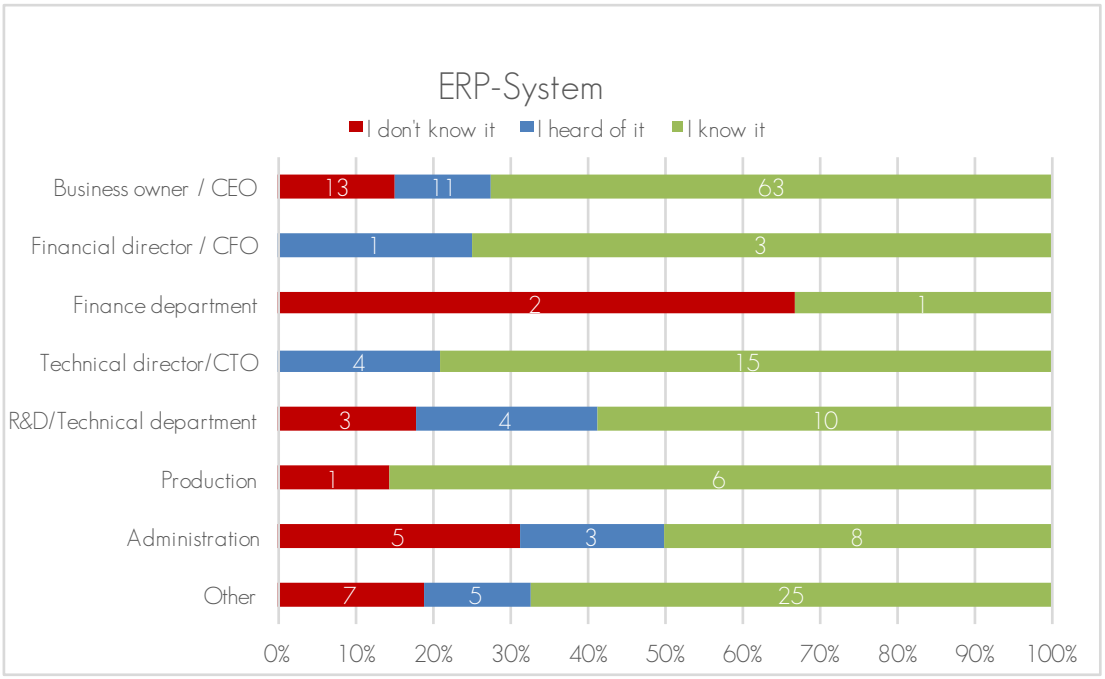


Fig. 26: Awareness of ERP-System (in absolute figures, n = 203)

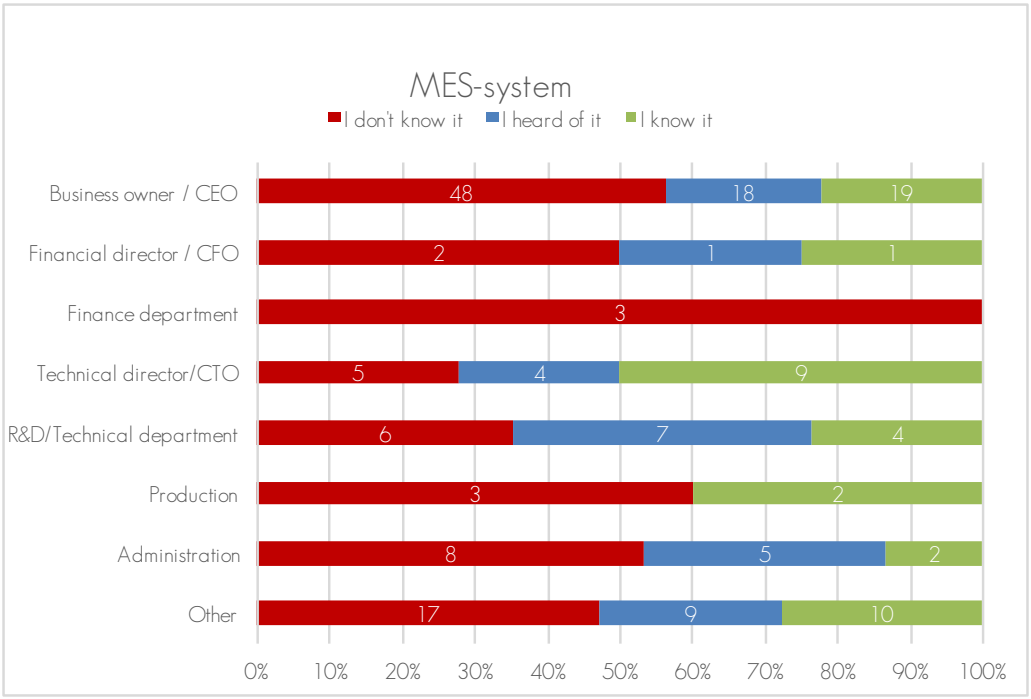


Fig. 27: Awareness of MES-System (in absolute figures, n = 203)

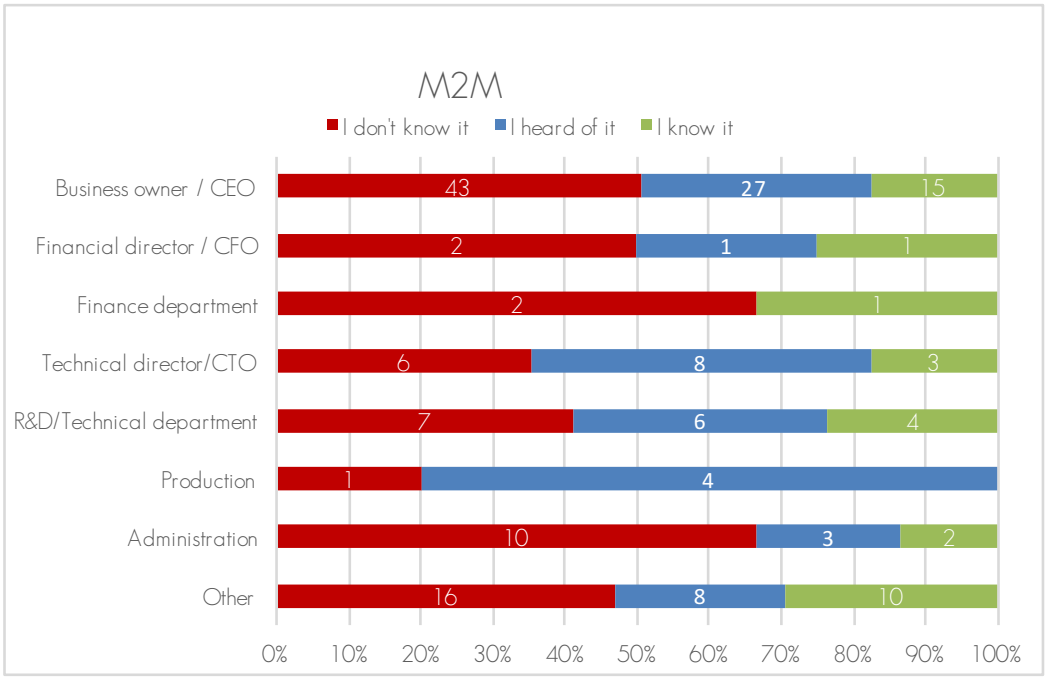


Fig. 28: Awareness of M2M (in absolute figures, n = 203)

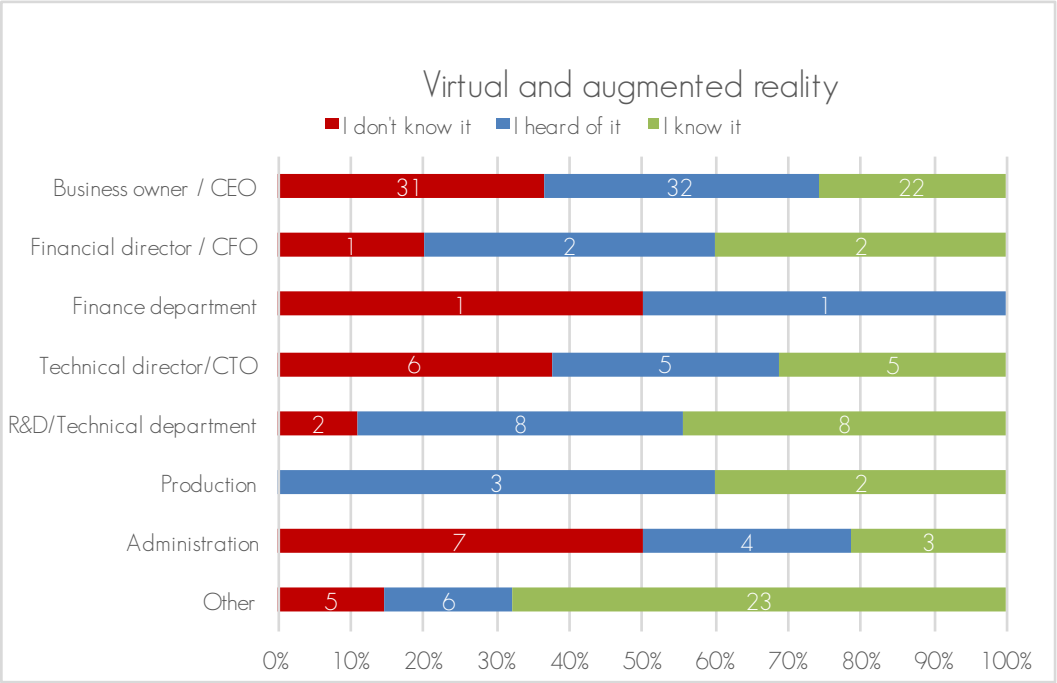


Fig. 29: Awareness of Virtual & Augmented Reality (in absolute figures, n = 203)

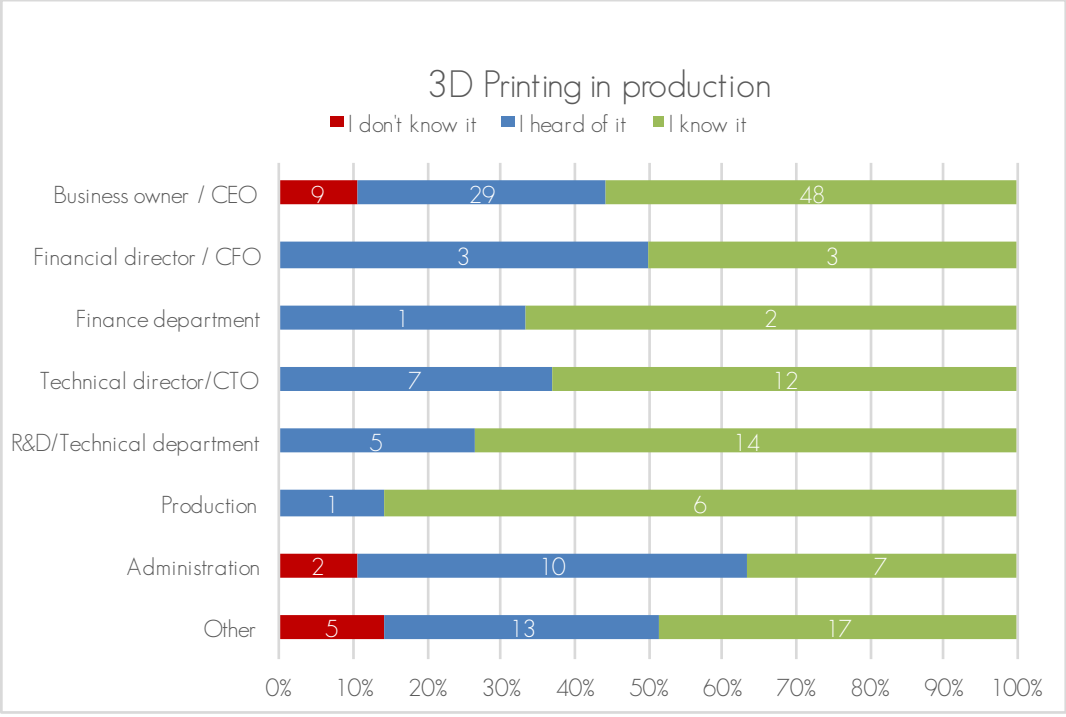


Fig. 30: Awareness of 3D printing in production (in absolute figures, n = 203)

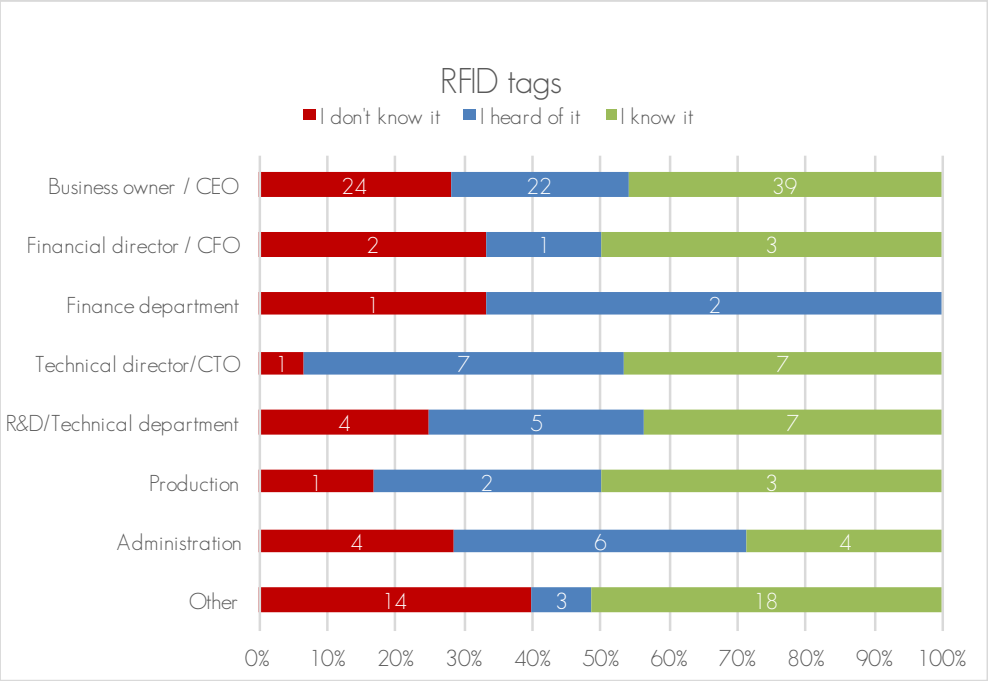


Fig. 31: Awareness of RFID tags (in absolute figures, n = 203)

As could be expected, respondents with technical working backgrounds (CTO, R&D) demonstrated a higher level of familiriaty with smart industry-related terms. However, even this respondent group had some difficulties with the terms Cyber Production and M2M.

Respondents employed within financial departments or administration showed less awareness of new technologies.

Finally, the awareness of smart industry-related terms at the strategic company level, by CEOs, could be positively highlighted. This is a relevant success factor towards the integration of new technologies within entire companies.

2.5. Smart Industry-related difficulties, needs, and challenges

The level of familiriaty with smart industry-related terms is closely linked to the difficulties faced by companies when dealing with digitalisation. Figure 32 highlights the most relevant obstacles stated by respondents:

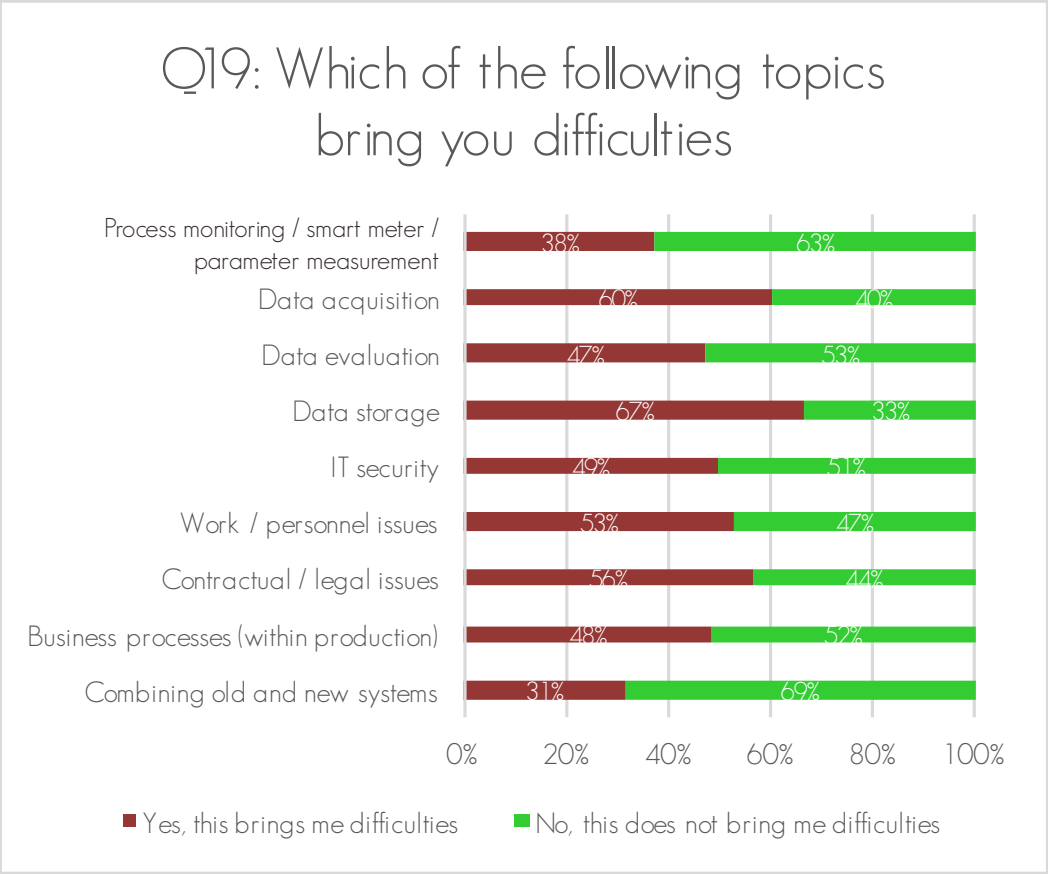


Fig. 32: Smart industry-related difficulties (in %, n = 203)

Figure 32 demonstrates quite high rates of difficulties for almost all topics that were questioned. In particular, coping with data storage (67%), data acquisition (60%), and contractual and legal issues cause significant difficulties for respondents. These findings confirm the global efforts worldwide towards ensuring the security of personal data.

Additionally, the question about the interdependencies between the company size and the difficulties to be tackled might be of interest. Thus, the figures 33 – 41 represent the views of different companies regarding this issue.

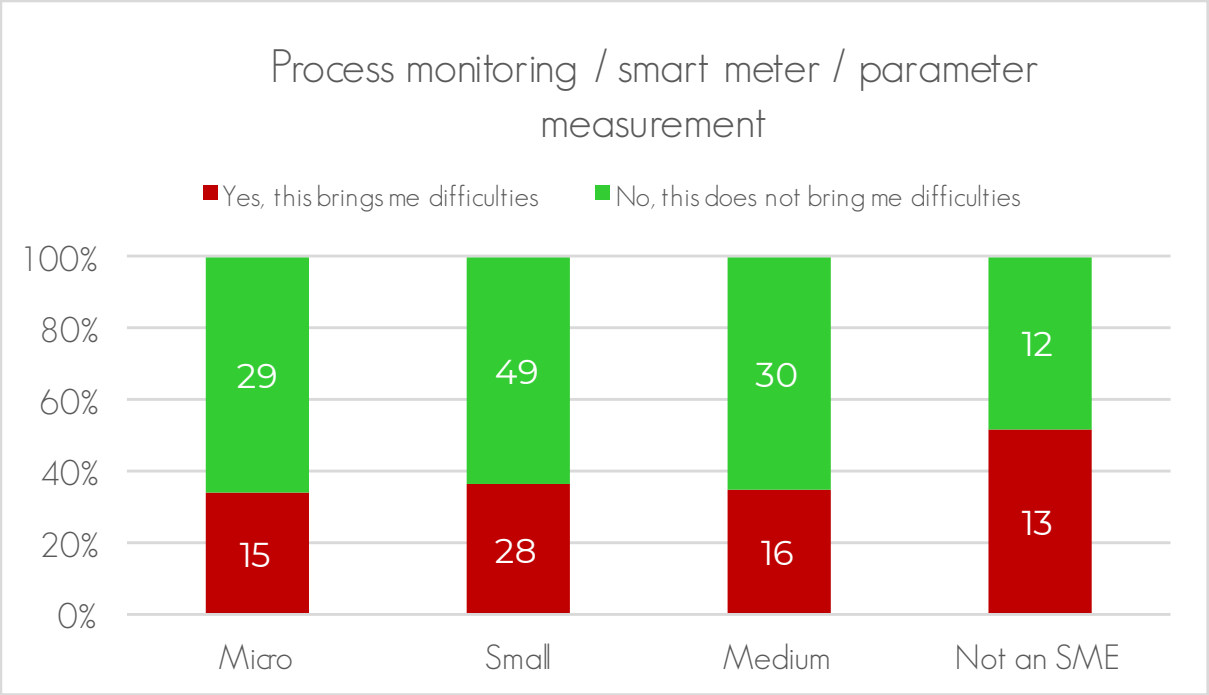


Fig. 33: Difficulties with process monitoring (in absolute figures, n = 203)

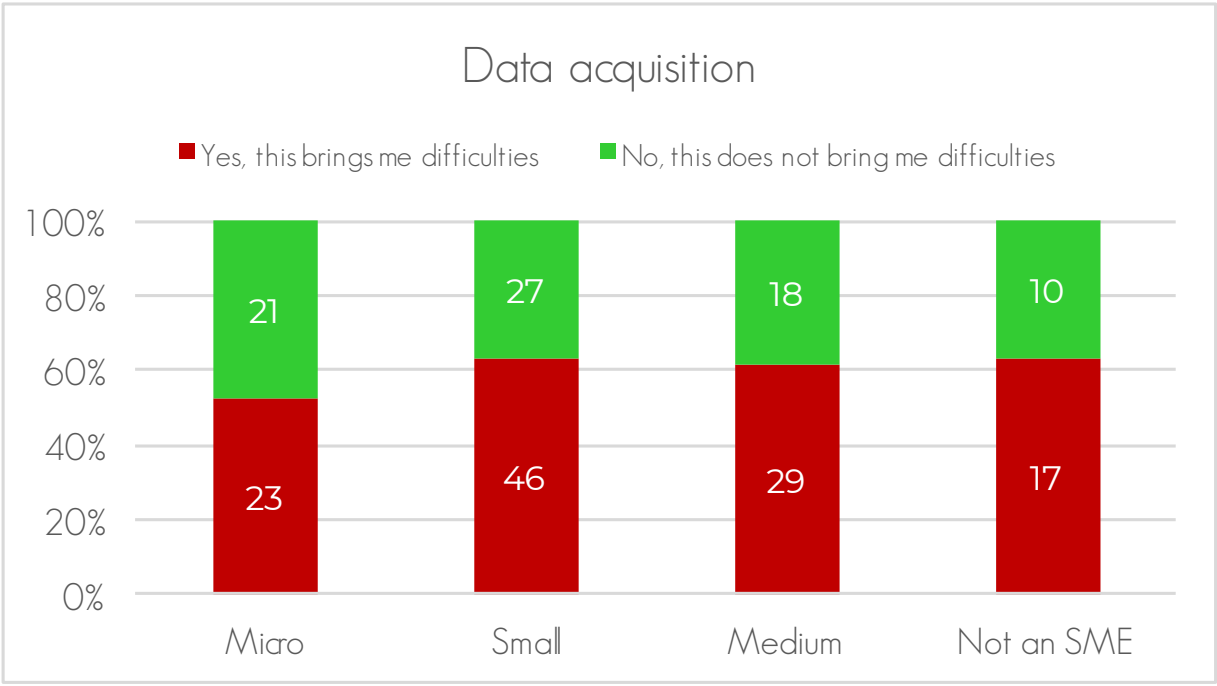


Fig. 34: Difficulties with data acquisition (in absolute figures, n = 203)

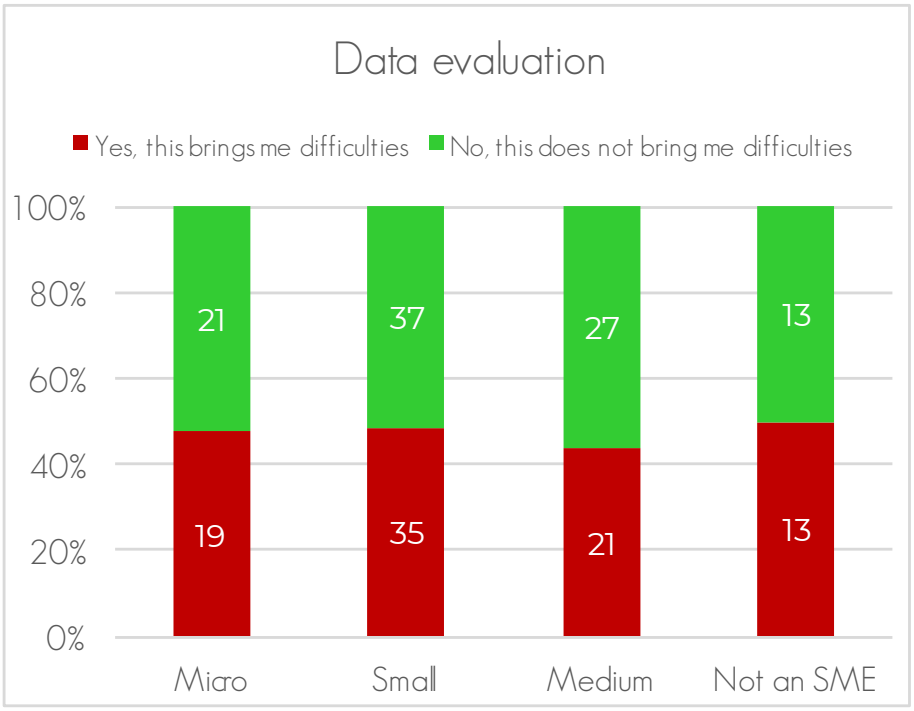


Fig. 35: Difficulties with data evaluation (in absolute figures, n = 203)

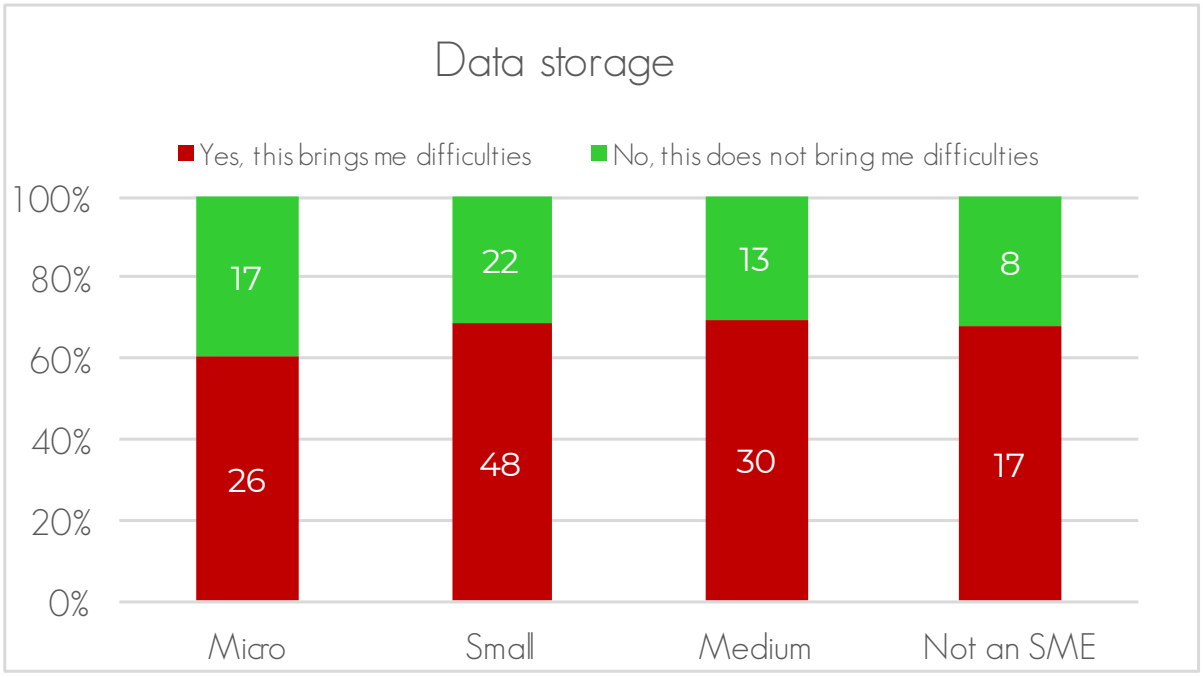


Fig. 36: Difficulties with data storage (in absolute figures, n = 203)

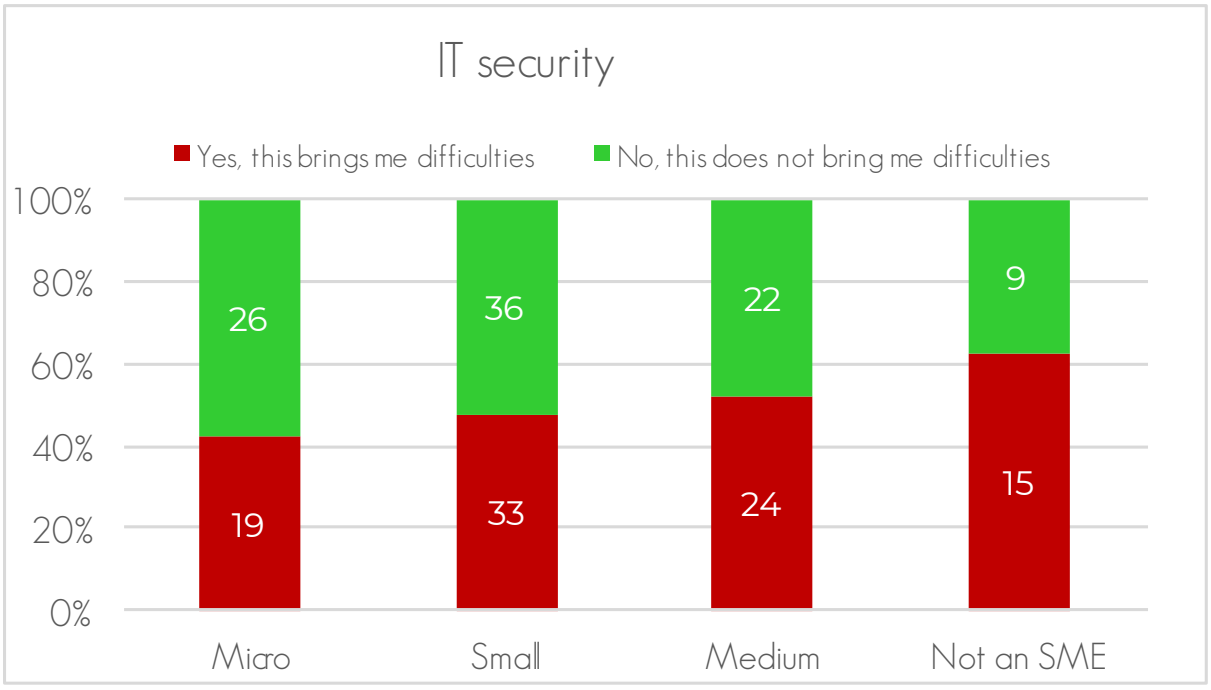


Fig. 37: Difficulties with IT security (in absolute figures, n = 203)

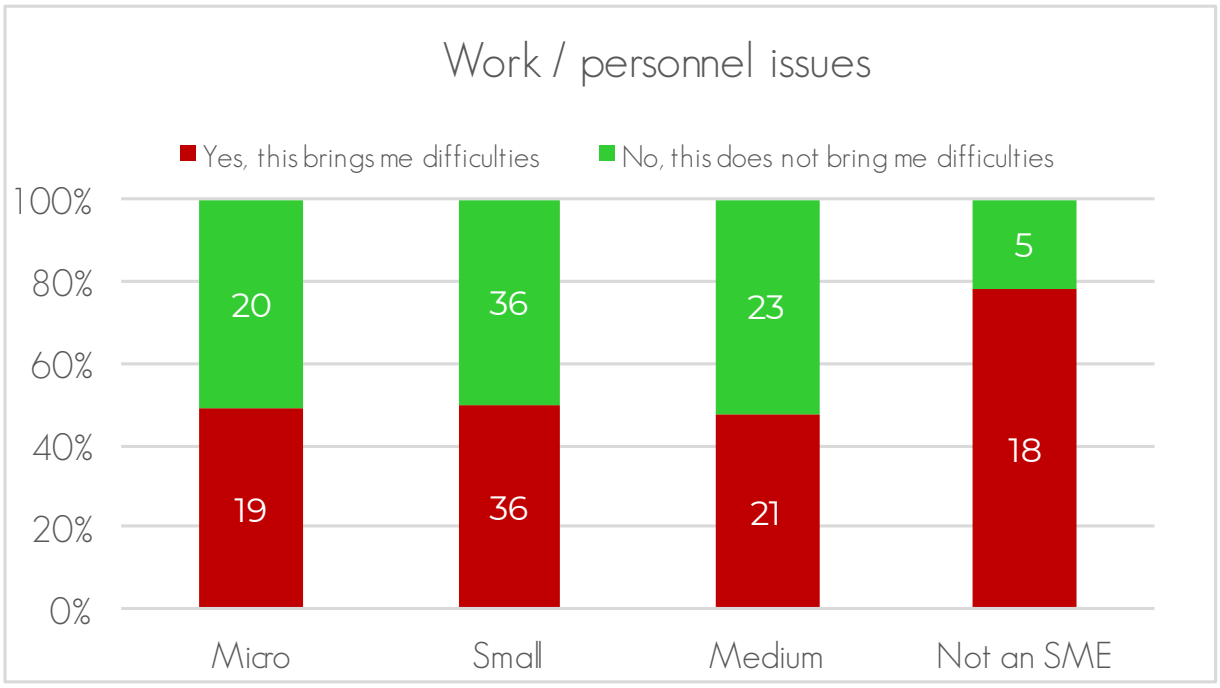


Fig. 38: Difficulties with work/personnel issues (in absolute figures, n = 203)

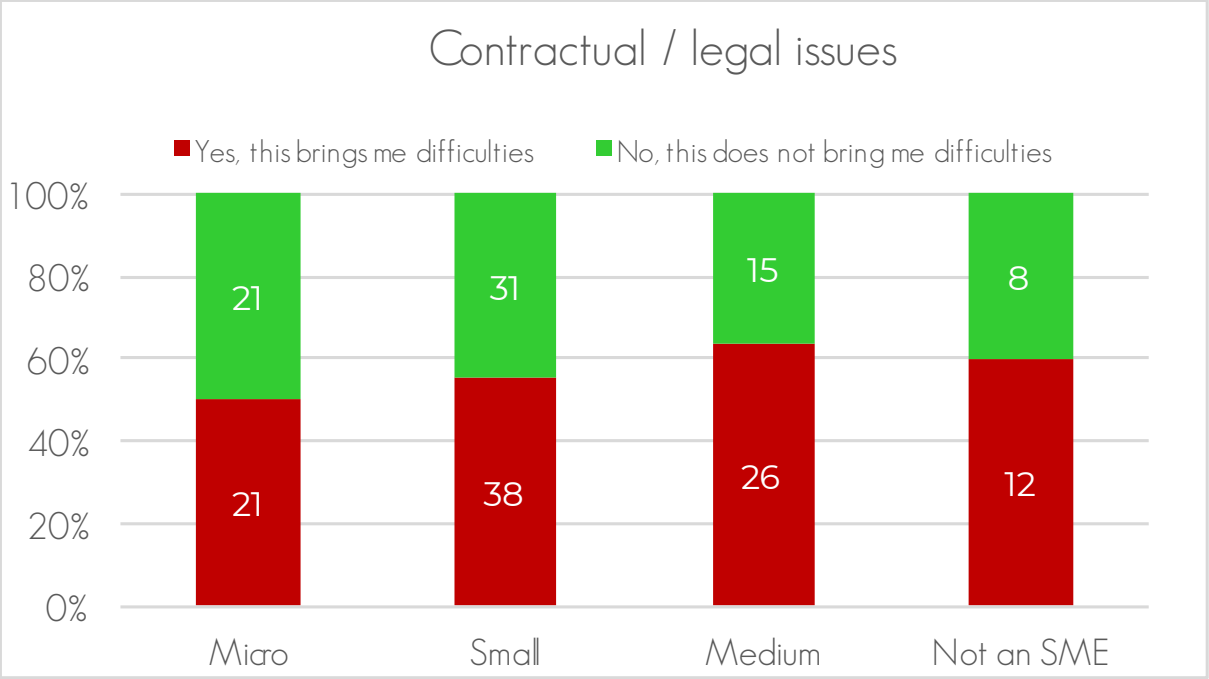


Fig. 39: Difficulties with contractual/legal issues (in absolute figures, n = 203)

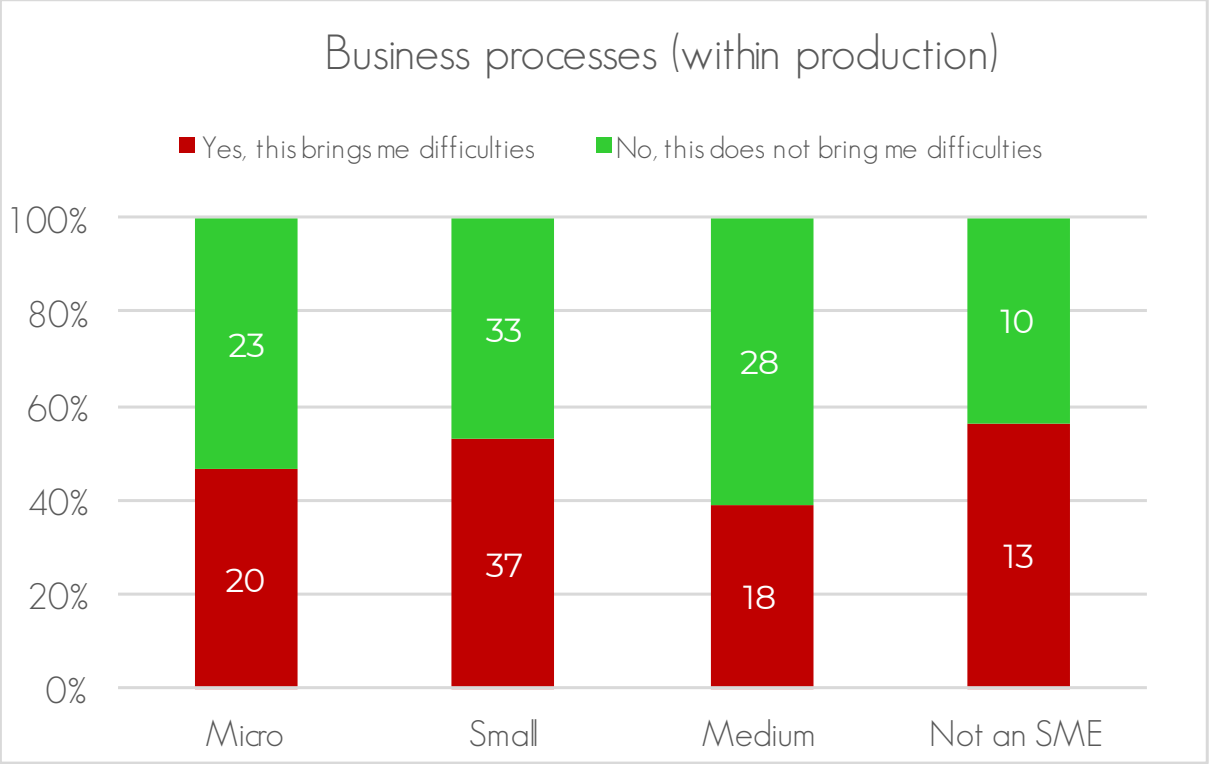


Fig. 40: Difficulties with business processes (in absolute figures, n = 203)

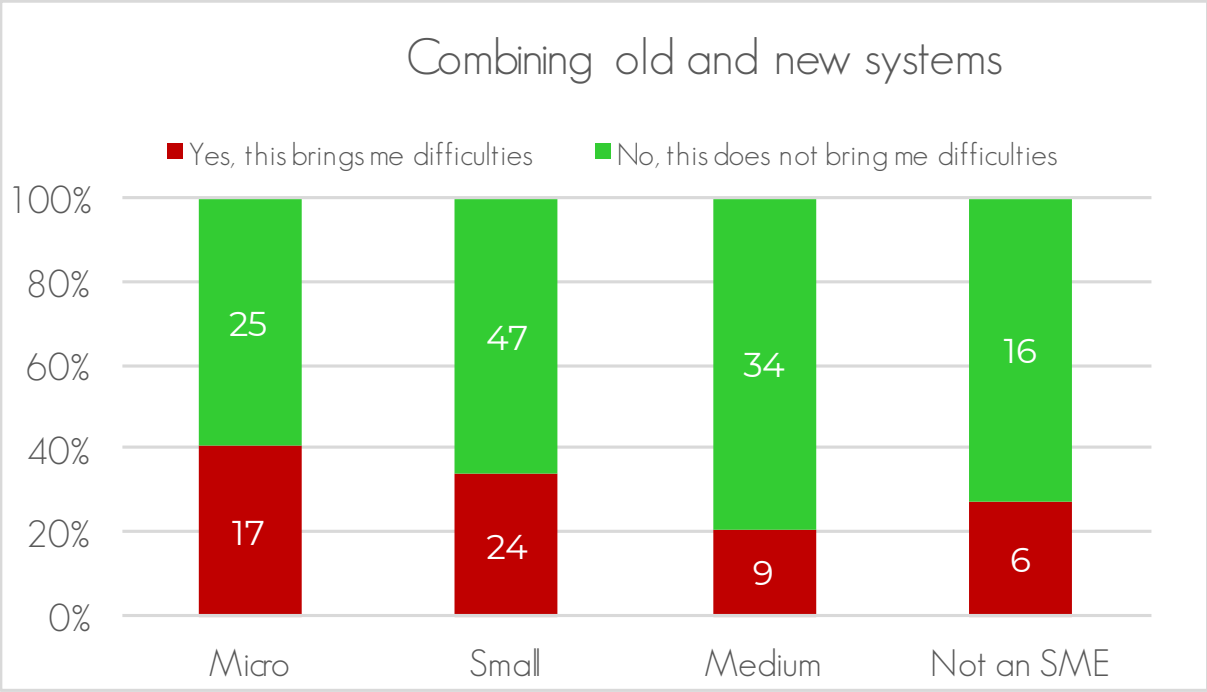


Fig. 41: Difficulties with combining old and new systems (in absolute figures, n = 203)

It seems that SMEs and, in particular, micro-companies are better positioned in dealing with different types of difficulties compared to non-SMEs. This might be explained by a lack of flexibility within companies that operate on larger scales in terms of staff, data or processes. For SMEs, this can create additional competitive advantages in relation to adopting improved digital technologies.

The investigation of the enterprises' cooperation with the research and HEI sector was accompanied by an exploration into the companies' own research and development activities and related investments. Figure 42 aggregates the companies' estimations in this field (on a scale from 0% to 100%):

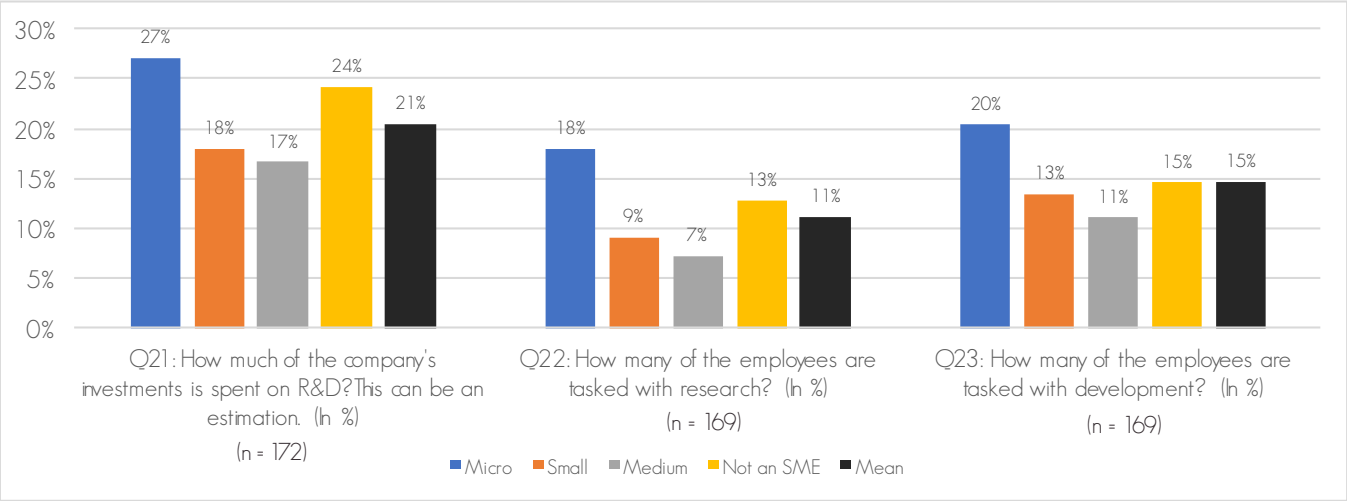


Fig. 42: Companies' estimation of research & development engagement (in %)

According to the respondents' estimations, their companies' investment flow into research and development averaged 21%, representing quite a high index. Approximately 11% of the companies' staff are engaged in research activities and 15% in development projects. In particular, the efforts by micro-companies in the area of R&D need to be stressed.

The self-estimation of companies' own capability to overcome potential challenges along the path to becoming smart was one of the investigation fields. To explore this, 10 challenges were pre-defined, and several options as to their relevance to respondents were suggested. Figure 43 demonstrates the aggregated results of these estimations:

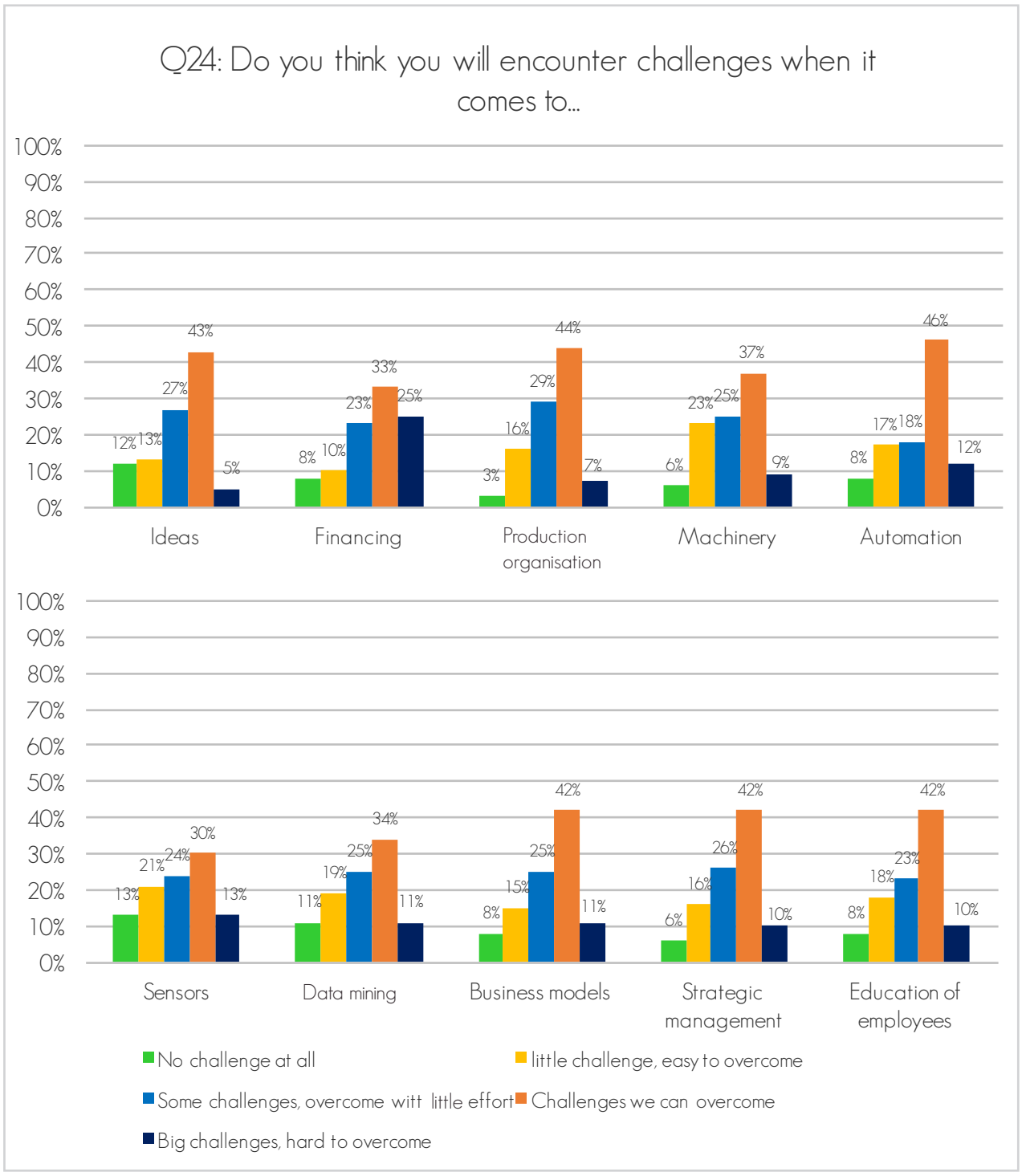


Fig. 43: Smart industry-related challenges and their estimation (in %, n = 182)

According to Figure 43, approximately 40% of companies rate the above-named topics as challenges but believe they can overcome most of them in the end. As "Big challenge, hard to overcome" the topic Finance was chosen by 25% of respondents: this should be considered when planning a smart industry strategy for a company.

However, it must also be considered that small and medium-sized companies do not struggle with the same issues as larger companies. In Table 6 these differences are highlighted.

The following colour code was used:

≤ 5%	5% < x ≤ 10%	11% < x ≤ 20%	21% < x ≤ 30%	> 30%

Q24	Company size	No challenge at all	Little challenge, easy to overcome	Some challenges, overcome with little effort	Challenges we can overcome	Big challenges, hard to overcome
Ideas	Micro	8 (20%)	8 (20%)	7 (18%)	15 (38%)	2 (5%)
	Small	7 (10%)	8 (12%)	22 (32%)	29 (42%)	3 (4%)
	Medium	3 (8%)	2 (5%)	11 (30%)	19 (51%)	2 (5%)
	Not an SME	2 (10%)	4 (19%)	5 (24%)	9 (43%)	1 (5%)
Financing	Micro	4 (10%)	4 (10%)	8 (21%)	14 (36%)	9 (23%)
	Small	5 (7%)	9 (13%)	16 (24%)	20 (29%)	18 (26%)
	Medium	3 (8%)	3 (8%)	10 (27%)	14 (38%)	7 (19%)
	Not an SME	1 (6%)	0 (0%)	4 (22%)	6 (33%)	7 (39%)

Q24	Company size	No challenge at all	Little challenge, easy to overcome	Some challenges, overcome with little effort	Challenges we can overcome	Big challenges, hard to overcome
Production organisation	Micro	1 (3%)	9 (23%)	13 (33%)	15 (38%)	2 (5%)
	Small	3 (4%)	9 (13%)	22 (31%)	34 (47%)	4 (6%)
	Medium	1 (2%)	9 (22%)	11 (27%)	15 (37%)	5 (12%)
	Not an SME	1 (5%)	1 (5%)	4 (21%)	12 (63%)	1 (5%)
Machinery	Micro	4 (11%)	10 (26%)	6 (16%)	15 (39%)	3 (8%)
	Small	3 (4%)	15 (21%)	22 (31%)	22 (31%)	8 (11%)
	Medium	4 (10%)	8 (19%)	13 (31%)	16 (38%)	1 (2%)
	Not an SME	(0%)	6 (29%)	1 (5%)	10 (48%)	4 (19%)

Q24	Company size	No challenge at all	Little challenge, easy to overcome	Some challenges, overcome with little effort	Challenges we can overcome	Big challenges, hard to overcome
Automation	Micro	5 (14%)	9 (24%)	5 (14%)	15 (41%)	3 (8%)
	Small	7 (11%)	8 (12%)	14 (21%)	25 (38%)	12 (18%)
	Medium	1 (3%)	8 (20%)	9 (23%)	21 (53%)	1 (3%)
	Not an SME	0 (0%)	3 (14%)	1 (5%)	15 (68%)	3 (14%)
Sensors	Micro	9 (27%)	3 (9%)	7 (21%)	9 (27%)	5 (15%)
	Small	6 (11%)	15 (27%)	11 (20%)	16 (29%)	8 (14%)
	Medium	3 (8%)	10 (28%)	12 (33%)	10 (28%)	1 (3%)
	Not an SME	0 (0%)	1 (6%)	4 (25%)	7 (44%)	4 (25%)
Data mining	Micro	6 (18%)	11 (33%)	6 (18%)	7 (21%)	3 (9%)
	Small	9 (15%)	10 (16%)	15 (24%)	21 (34%)	7 (11%)
	Medium	1 (3%)	4 (12%)	14 (41%)	11 (32%)	4 (12%)
	Not an SME	0 (0%)	3 (17%)	2 (11%)	11 (61%)	2 (11%)

Q24	Company size	No challenge at all	Little challenge, easy to overcome	Some challenges, overcome with little effort	Challenges we can overcome	Big challenges, hard to overcome
Business models	Micro	4 (12%)	6 (18%)	11 (32%)	11 (32%)	2 (6%)
	Small	6 (10%)	7 (11%)	17 (27%)	24 (39%)	8 (13%)
	Medium	1 (3%)	9 (26%)	8 (24%)	12 (35%)	4 (12%)
	Not an SME	1 (5%)	1 (5%)	1 (5%)	16 (76%)	2 (10%)
Strategic management	Micro	3 (8%)	7 (19%)	10 (28%)	13 (36%)	3 (8%)
	Small	3 (5%)	13 (21%)	14 (22%)	25 (40%)	8 (13%)
	Medium	2 (6%)	3 (9%)	12 (34%)	15 (43%)	3 (9%)
	Not an SME	1 (5%)	1 (5%)	4 (21%)	11 (58%)	2 (11%)
Education of employees	Micro	7 (18%)	10 (26%)	7 (18%)	11 (28%)	4 (10%)
	Small	4 (6%)	12 (17%)	20 (29%)	27 (39%)	6 (9%)
	Medium	0 (0%)	8 (20%)	8 (20%)	18 (45%)	6 (15%)
	Not an SME	2 (10%)	0 (0%)	3 (15%)	14 (70%)	1 (5%)

Tab. 6: Estimation of smart industry-related challenges depending on company size (n = 182, in % and in absolute figures)

It seems that most of these items create challenges, however the companies are generally confident that they will be able to overcome them. The micro-companies indicated greater confidence in managing the challenges.

Thus, these companies can be regarded as agile organisations, able to rapidly adapt to market and environmental changes in productive and cost-effective ways . To become a smart company and to stay on top of the latest technologies, it is vital to be agile.

In our opinion, respondents who ticked the answers options "No challenge at all" and "Little challenge, easy to overcome", are very close to being agile and therefore, to becoming smart.

Following topics (= challenges)
imply being agile:

- Business models
- Strategic management
- Ideas
- Education of employees.

In summing up the answers for both options "No challenge at all"and "Little challenge, easy to overcome" for the above-named agility-related topics, the following results are evident, which demonstrate the highest merits for micro-companies and therefore confirm their agility:

'no to little challenge'	Business models	Strategic management	Ideas	Education of employees
Micro	10 (30%)	10 (27%)	16 (40%)	17 (43,6%)
Small	13 (21%)	16 (26%)	15 (22%)	16 (23,2%)
Medium	10 (29%)	5 (15%)	5 (15%)	8 (20%)
Not an SME	2 (10%)	2 (10%)	6 (29%)	2 (10%)

Tab. 7: Summarised merits for agility-related topics depending on company size (in absolute figures and %)

Furthermore, the respondents were asked to estimate their needs concerning relevant milestones for becoming smart organisations. Figure 44 represents the needs stated by companies, as follows:

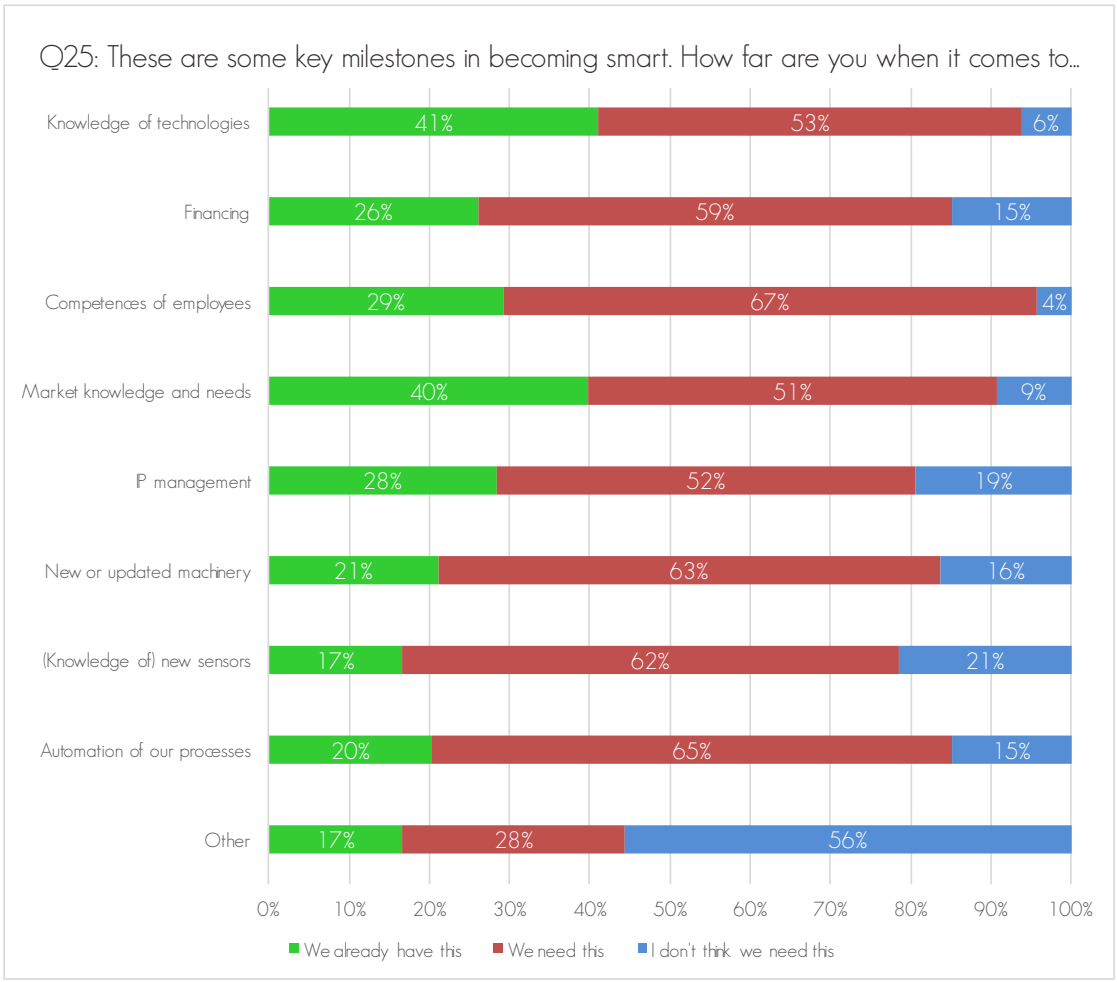


Fig. 44: Needs of companies become smart industry enablers (in %, n = 182)

One of the most interesting observations here is that the second highest relevant item in becoming smart is the competence of employees (67%). Only 4% of the respondents believe they do not need qualified staff.

When analysing the importance of competent staff in relation to company size, the following results emerge:

	We have this	We need this	I don't think we need this
Micro	13 (32,5%)	22 (55%)	5 (12,5%)
Small	10 (14%)	58 (82%)	3 (4%)
Medium	8 (19%)	31 (74%)	3 (7%)
Not an SME	7 (29%)	16 (67%)	1 (4%)

Tab. 8: Companies' needs in competent staff

Here it is clear that most of the respondents (especially from small companies) are at least aware that they need to have competent employees. Again, the micro-companies are the group with the greatest confidence that they already have achieved this aim.

Besides agility and staff, knowledge is also an important criterion in becoming smart. This is reflected in two topics 'Knowledge of technologies' and '(knowledge of) sensors'.

Topic	Company size	We have this	We need this	I don't think we need this
Knowledge of technologies	Micro	19 (45%)	19 (45%)	4 (10%)
	Small	28 (38%)	39 (53%)	6 (8%)
	Medium	18 (43%)	23 (55%)	1 (2%)
	Not an SME	9 (39%)	14 (61%)	0 (0%)
	Total	74 (41%)	95 (53%)	11 (6%)
Knowledge of sensors	Micro	9 (26%)	17 (50%)	8 (24%)
	Small	9 (15%)	37 (63%)	13 (22%)
	Medium	5 (14%)	24 (65%)	8 (22%)
	Not an SME	1 (7%)	12 (80%)	2 (13%)
	Total	24 (17%)	90 (62%)	31 (21%)

Tab. 9: Needs of companies concerning knowledge of technologies and of sensors

It is remarkable to observe that on the one hand micro-companies again indicate more than the other company types that they already have what is needed, however on the other hand they also indicate more than the others that they do not think they need it.

Most respondents state that they do need this, but do not have it (sufficiently). Small companies with 63% of the responses are the largest group amongst those who indicate needing this knowledge. Together with the medium-sized companies, this is the most relevant target group to be supported by the SMeART tools.

2.6. Production

In this chapter, survey findings relating to the specifics of production processes within companies are presented. This chapter is divided into three sub-chapters: Pre-production, Production, and Post-production.

The findings represented in the sections Pre-production and Post-production are based on the optional answers of respondents who decided to fill in these non-obligatory parts of the survey.

2.6.1. PRE-PRODUCTION

The first warm-up question under Pre-production addressed the strategy applied when designing new products. Figure 45 represents the means for the indicated technologies depending on the company size:

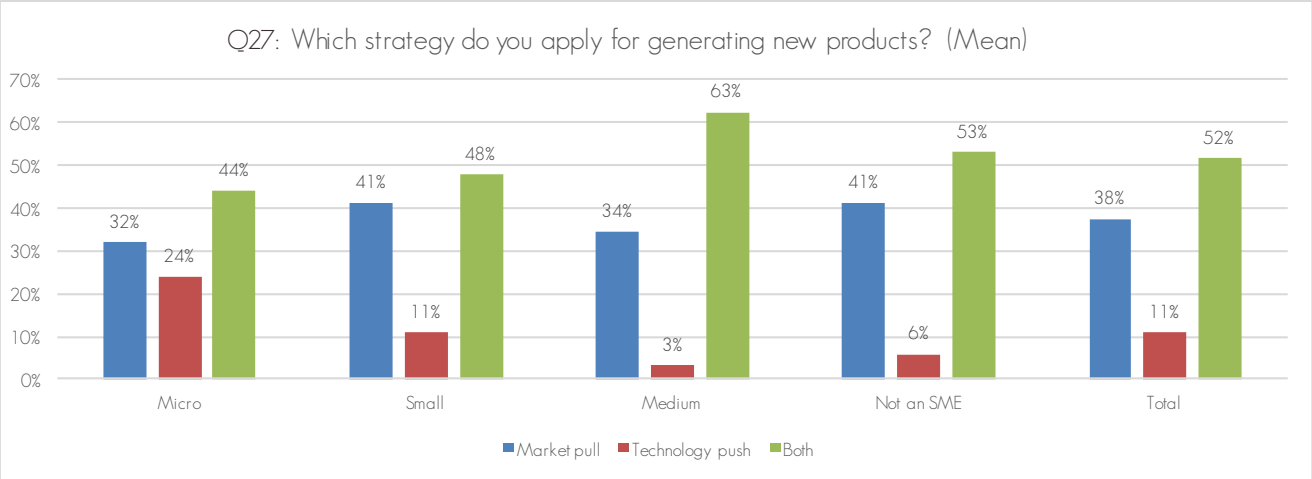


Fig. 45: Strategies for product design (in %, n = 120)

Only 11% of the respondents (in total) stated the application of technology push. The percentage of respondents utilising technology push reduces proportionally as the company size increases: micro – 24% (again, the highest index), small – 11%, medium-sized – 3%, and a slight increase amongst larger companies (6%). However, most of the companies (53% in total) use both strategies for product design. The larger the company is the more it is influenced by both the market pull as the technology push.

Further questions were aimed at exploring the usage of several smart technologies such as Big Data analysis, design application, Computer-Aided Design planning etc. in the area of pre-production. The figures 46 – 51 represent these findings according to company size:

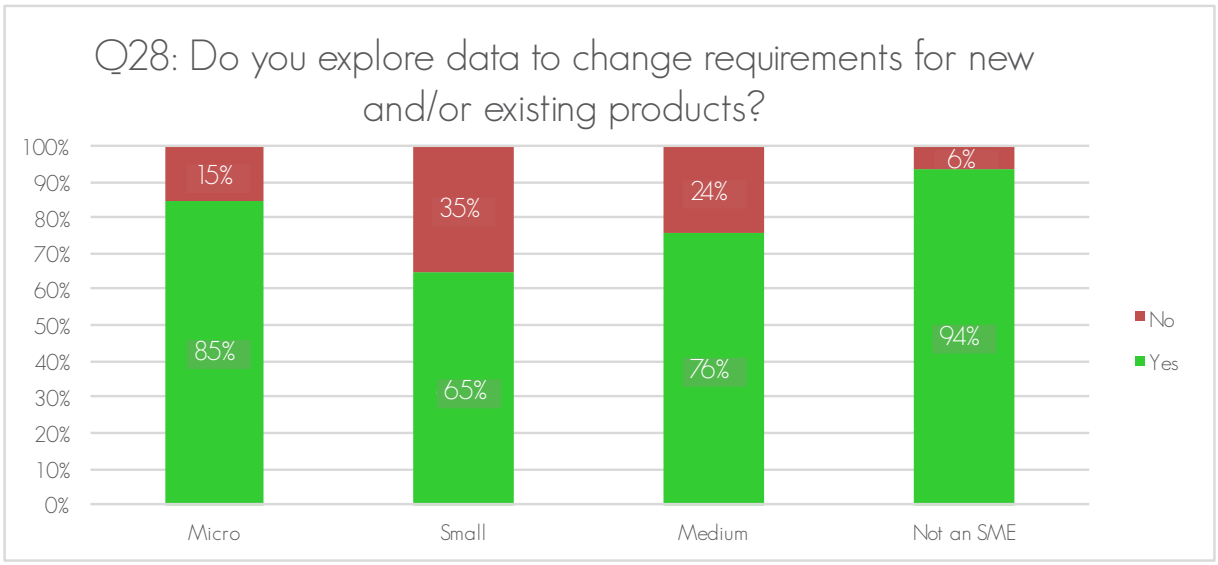


Fig. 46: Data collection for new product development (in %, n = 123)

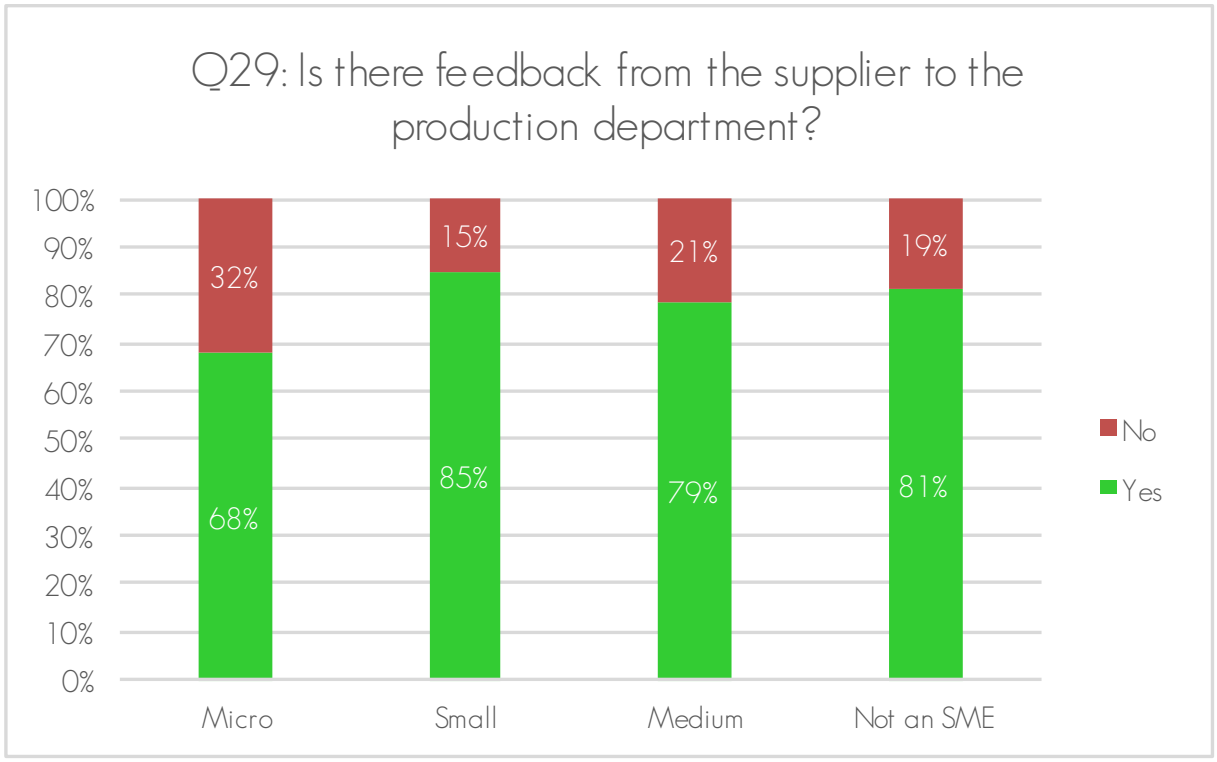


Fig. 47: Feedback between supplier and production (in %, n = 121)

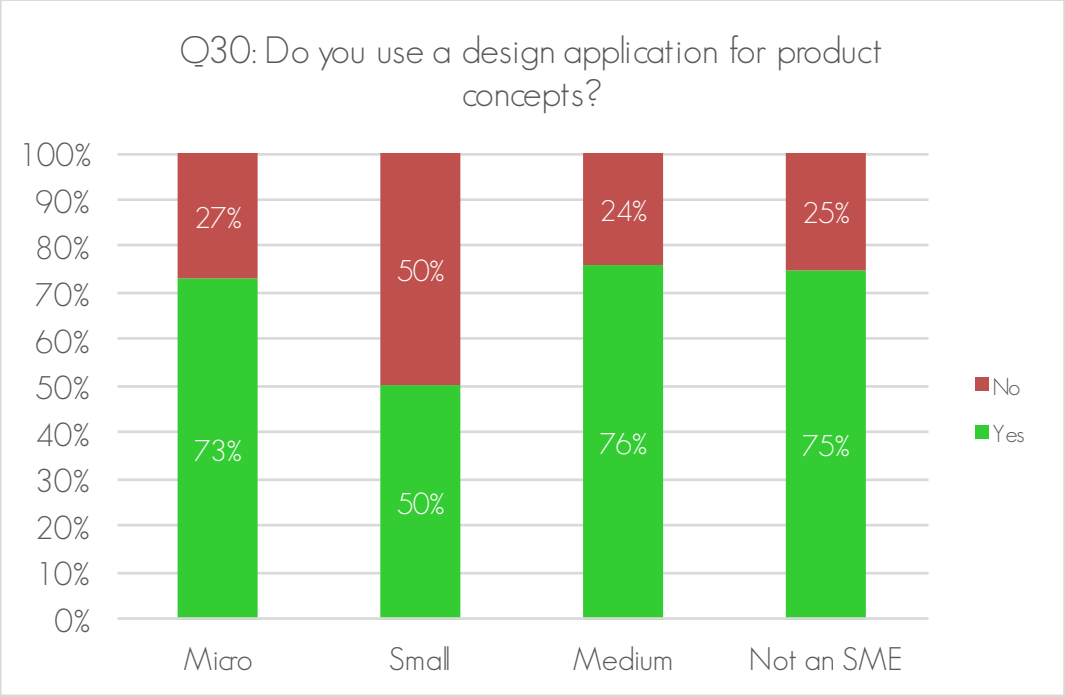


Fig. 48: Use of design application (in %, n = 123)

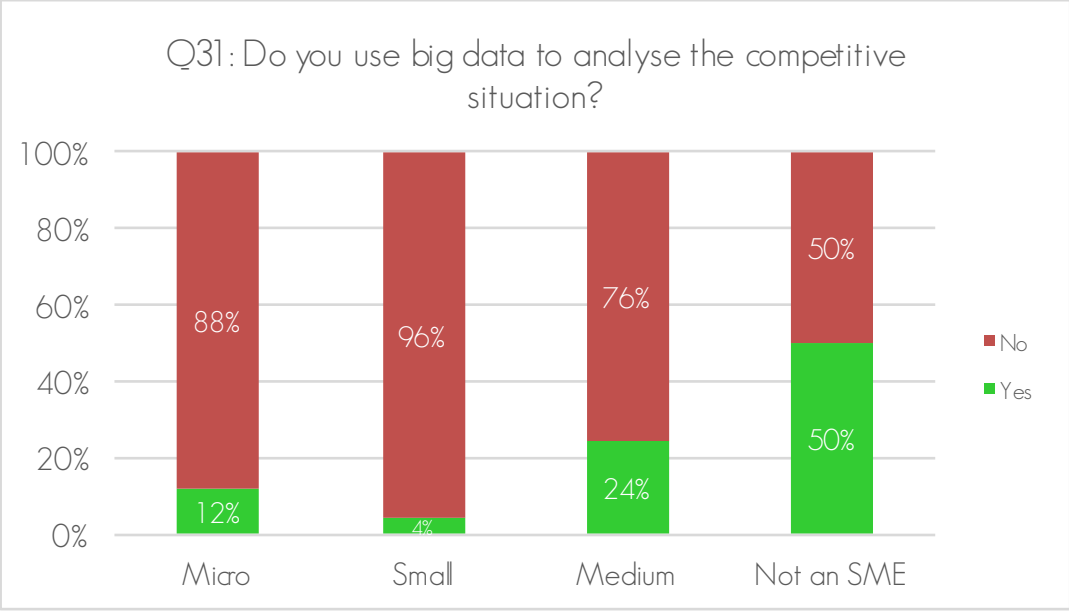


Fig. 49: Use of big data for competitive analysis (in %, n = 122)

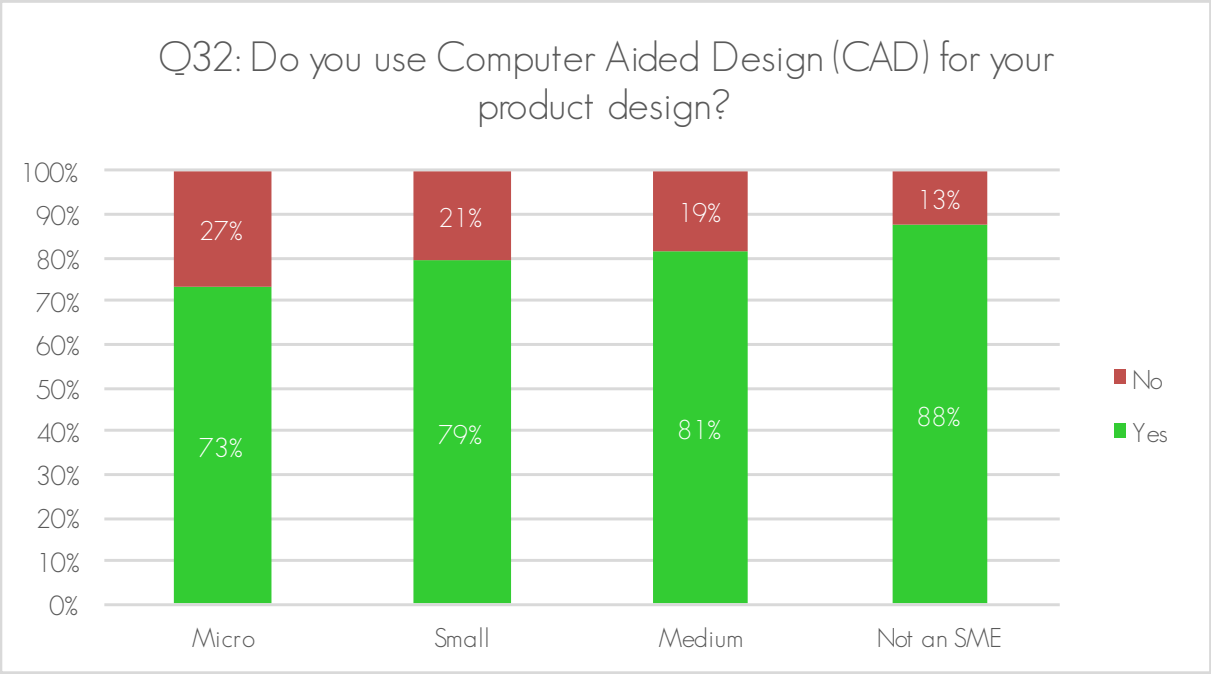


Fig. 50: Usage of CAD technology (in %, n = 122)

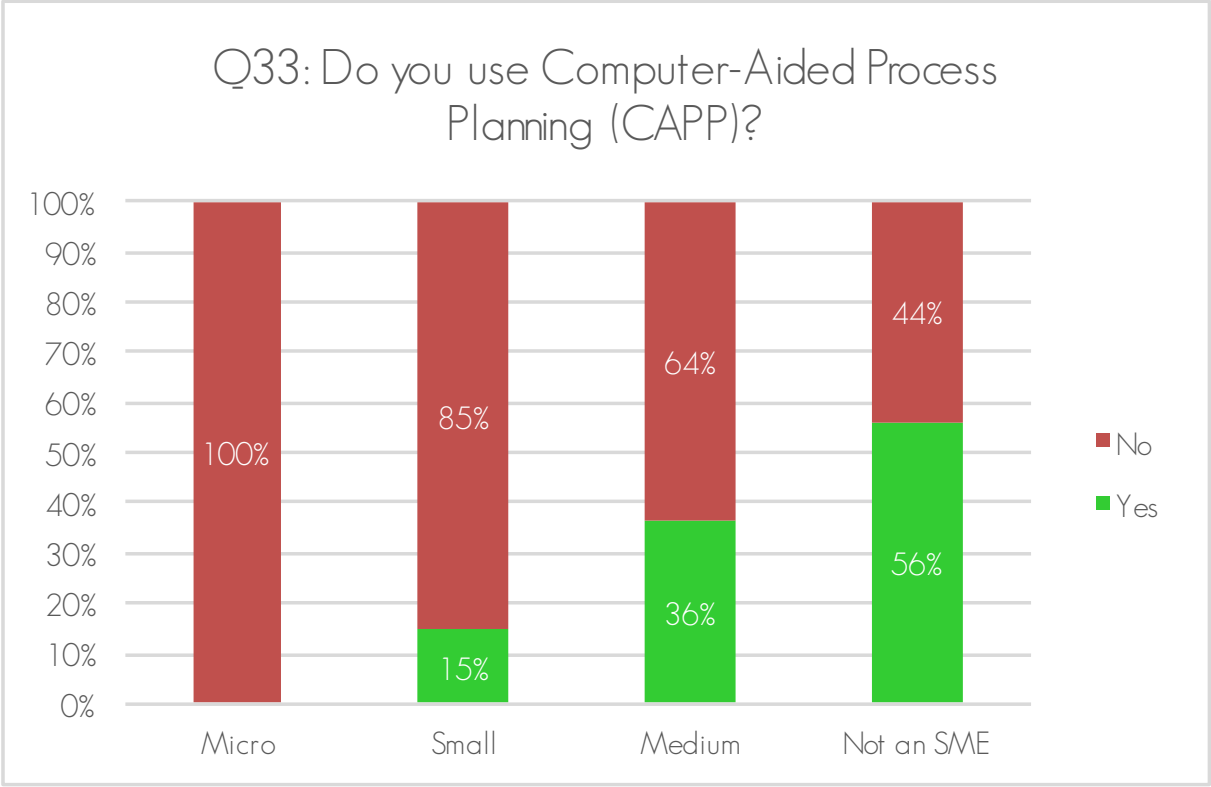


Fig. 51: Usage of CAPP technology (in %, n = 122)

RELEVANT FINDINGS IN THE FIELD OF PRE-PRODUCTION:

- Data collection for designing new or optimising existing products seems to be an integral part of the pre-production processes prevailingly within large companies (93.8%). Admittedly, small and medium-sized companies collect data too, however, to a lesser extent (64.6% and 75.8% respectively).

- Even if data is being collected, voluminous and various data sets (big data) are rarely used (here for competitive analysis purposes, as Figure 49 shows), especially by small companies (4%). This index significantly differs from that of large companies (50%). This might be predictable as large companies deal with large data due to their scale and need to collect and analyse it.

- Design applications and CAD seem to be used equally by all company types when designing products (between 73–79%), whilst CAPP technology is a quite new phenomenon for SMEs and is being applied to a lesser extent (15% of small and 36% of medium-sized companies).

2.6.2. PRODUCTION

The sub-section Production demonstrates the level of companies' digitalisation when developing products. The related set of questions was obligatory for all respondents, and they reached them either directly after filling in the previous questions related to Pre-production (in this case, respondents were moved on to Q34) or after Q26 without having filled in the part Pre-production part (in this case respondents were moved on to Q56). Therefore, question sets Q34 – Q50 and Q56 – Q72 are identical (i.e. Q34 is equal Q56 etc.). The related diagrams represent aggregated values obtained from these two question sets (i.e. Fig. 52 shows summarized merits from Q34 plus Q56). The flow of the questions is also made clear in Fig. 2 on page 14.

Production: Production planning

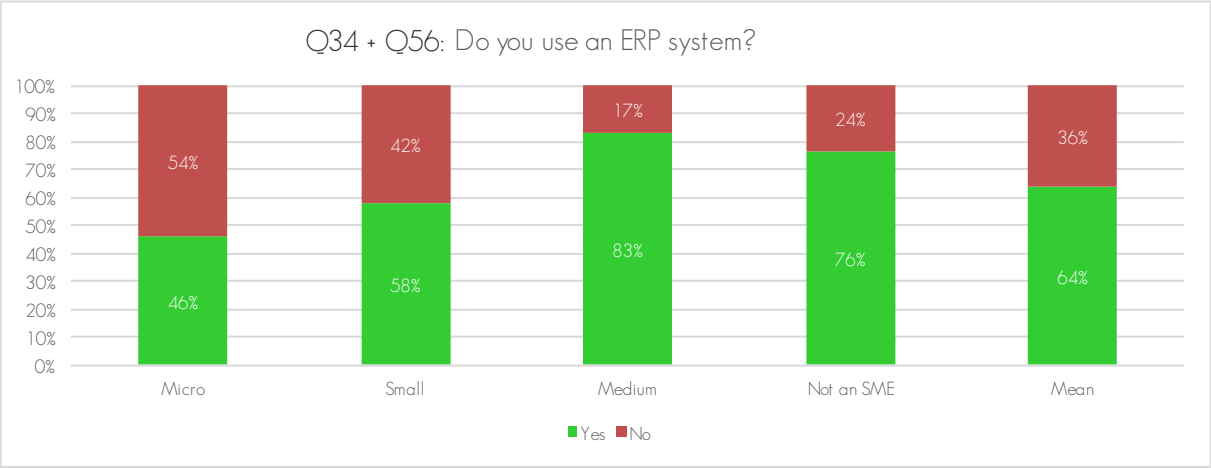


Fig. 52: Usage of enterprise resource planning (ERP) system (in %, n = 165)

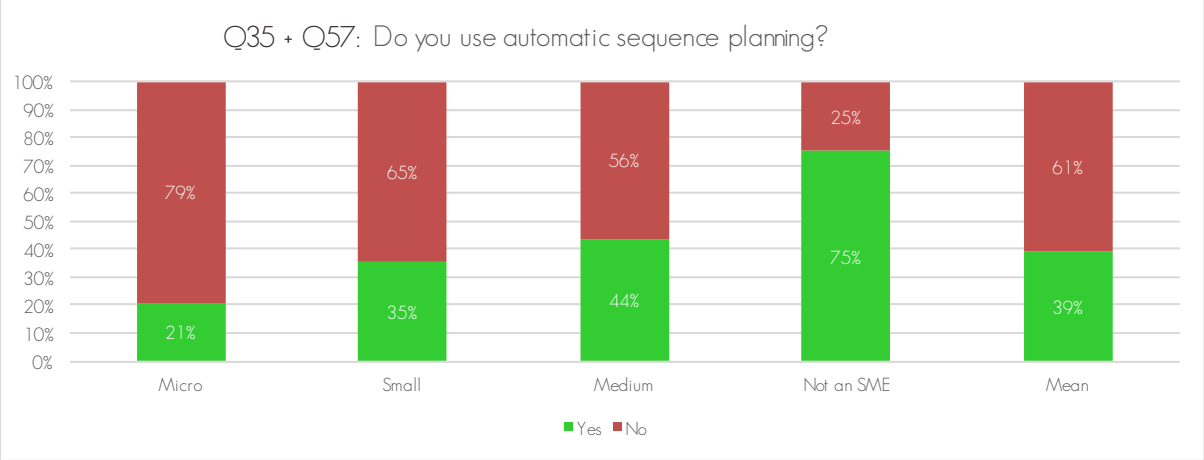


Fig. 53: Usage of automatic sequence planning (in %, n = 164)

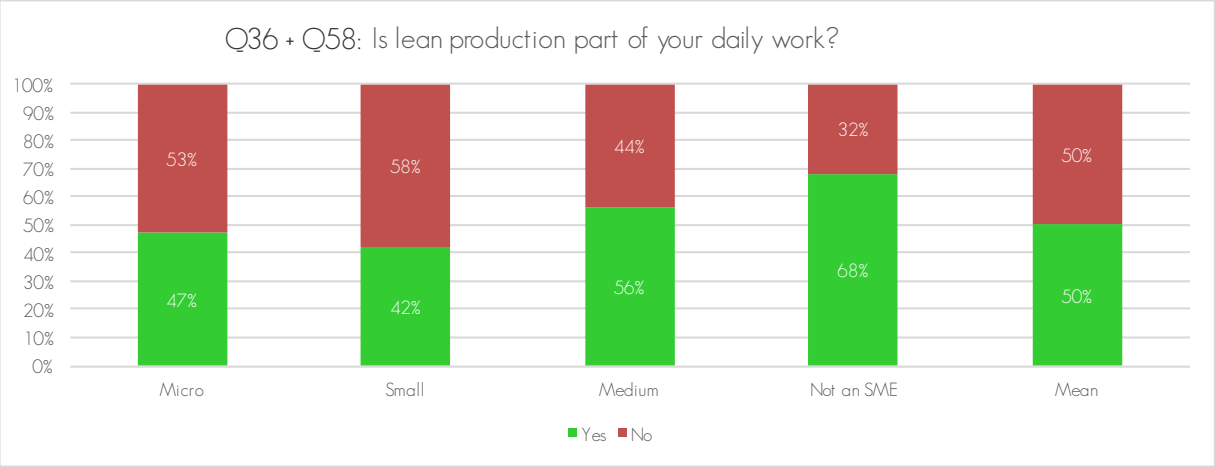


Fig. 54: Usage of lean production (in %, n = 167)

- Figure 52 (ERP application) partly verifies the truth that in today's business landscape, no business is too small for an ERP solution, which allows small businesses to appear, act and operate like a large-scale business. Whilst medium-sized companies stated 83%, it is 58% for small businesses.
- Even lower is the integration of automatic sequence planning as indicated by SMEs (35% and 44% respectively).
- Lean production is, on average, appreciated by half of all respondents.

Production: Production control

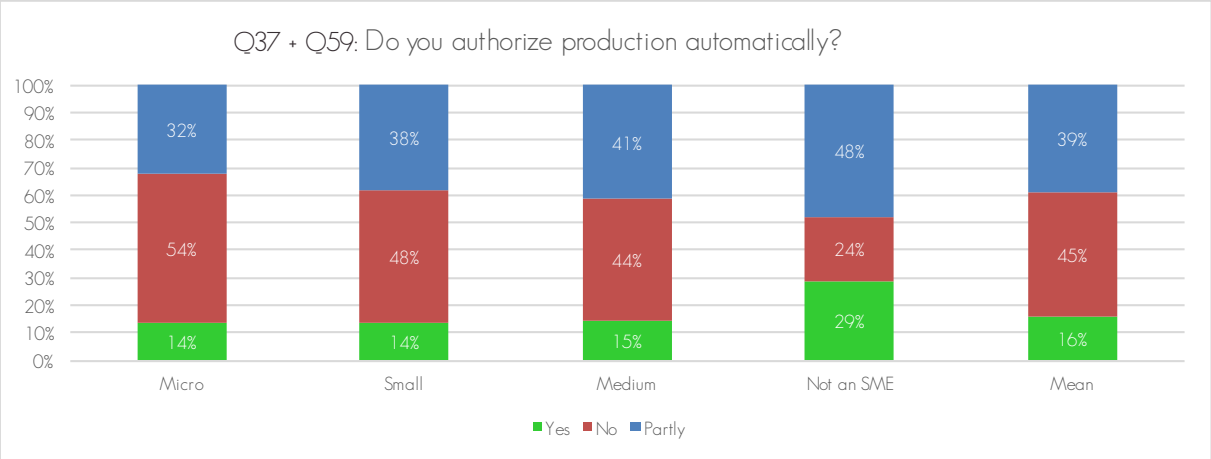


Fig. 55: Usage of automatic authorisation of production (in %, n = 165)

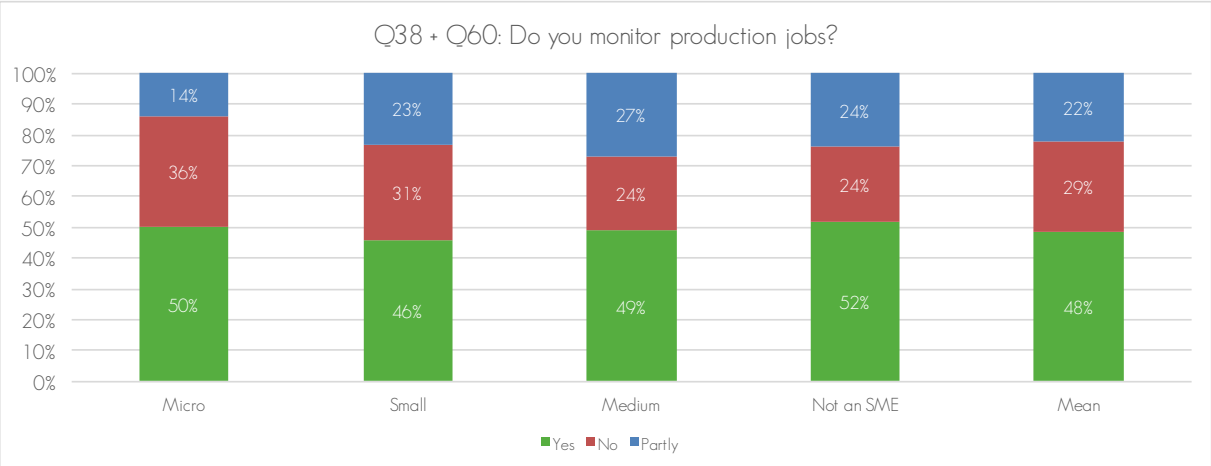


Fig. 56: Monitoring of production jobs (in %, n = 163)

- Products are being only partly automatically authorised (39% of all respondents), with a tendency towards non-usage of automated technologies for product authorisation.

- Monitoring of prevailingly product development activities takes place according to approximately 50% of all respondents.

Production: Material supply

Two survey questions addressed the topic of material supply regarding the automatisation of related processes. Figures 57 and 58 display the related findings:

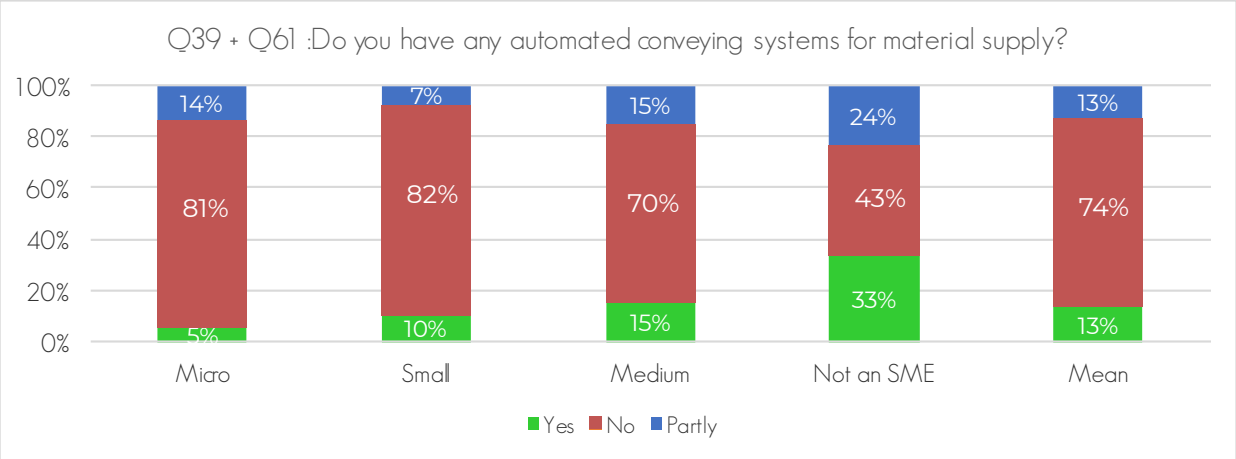


Fig. 57: Usage of automated conveying systems for material supply (in %, n = 165)

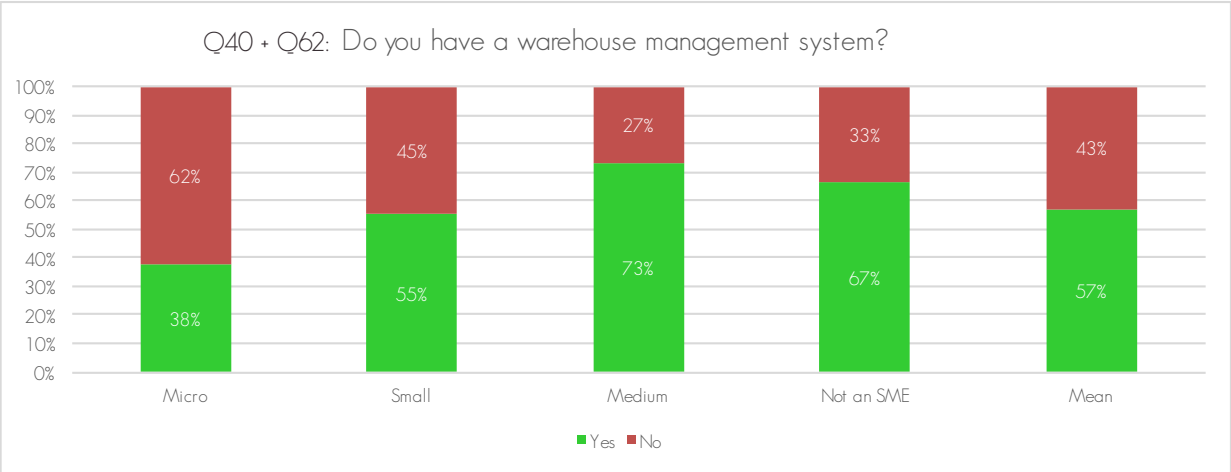


Fig. 58: Availability of warehouse management system WMS (in %, n = 166)

- Automated conveyor systems seem to be not a popular solution especially amongst smaller companies. The larger the company the higher the usage of conveyors (5% in micro-companies but 33% in non-SMEs).

- WMS is better integrated into the production processes within most companies than hardware solutions (conveyor systems): 55% of small and 73% of medium-sized businesses use this software application for optimising warehouse management.

Production: Manufacturing

Digitalisation of companies' manufacturing processes was one of the topics that respondents were also asked to estimate within their business. These results are presented in the figures 59 – 64.

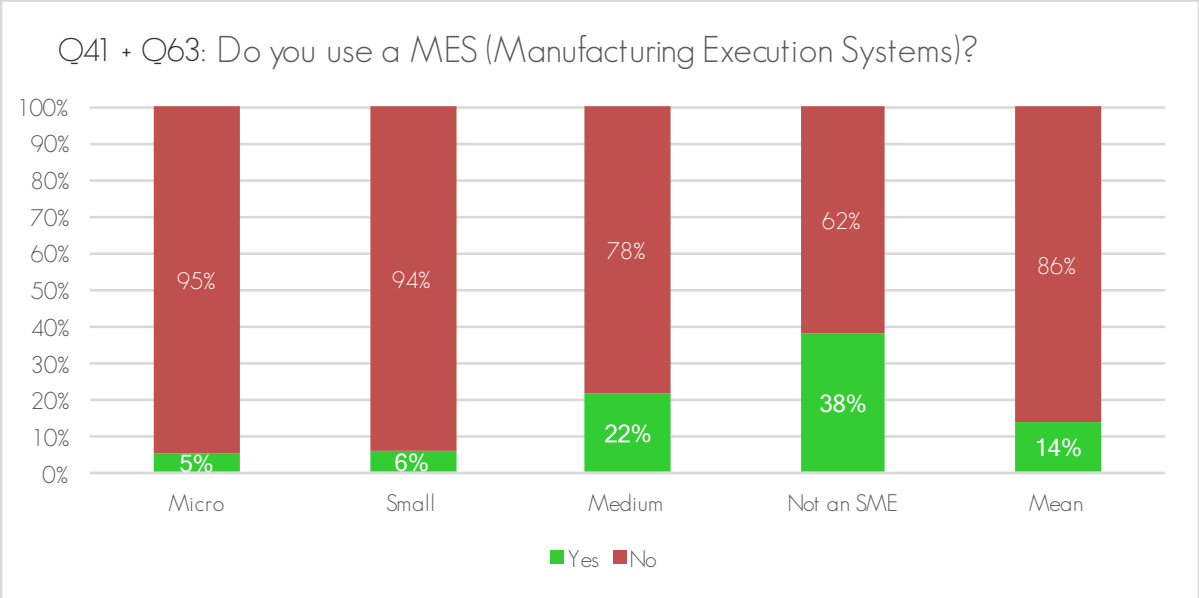


Fig. 59: Usage of Manufacturing Execution System MES (in %, n = 165)

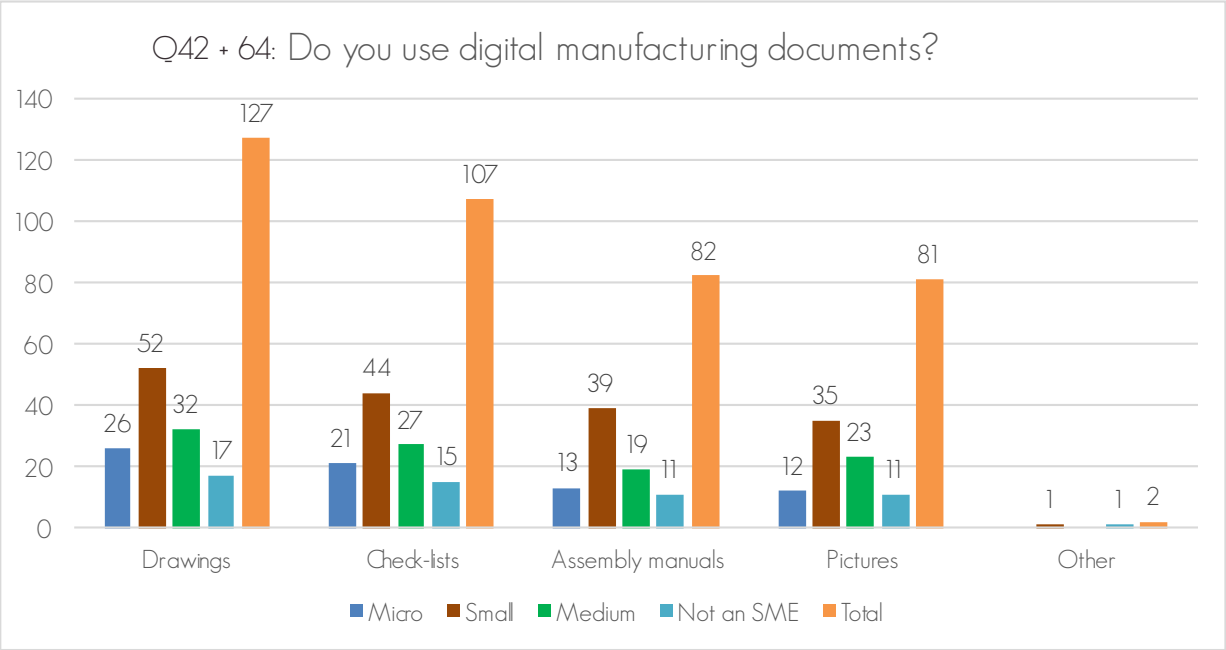


Fig. 60: Usage of digital manufacturing documents (in absolute figures, n = 150, multiple answers possible)

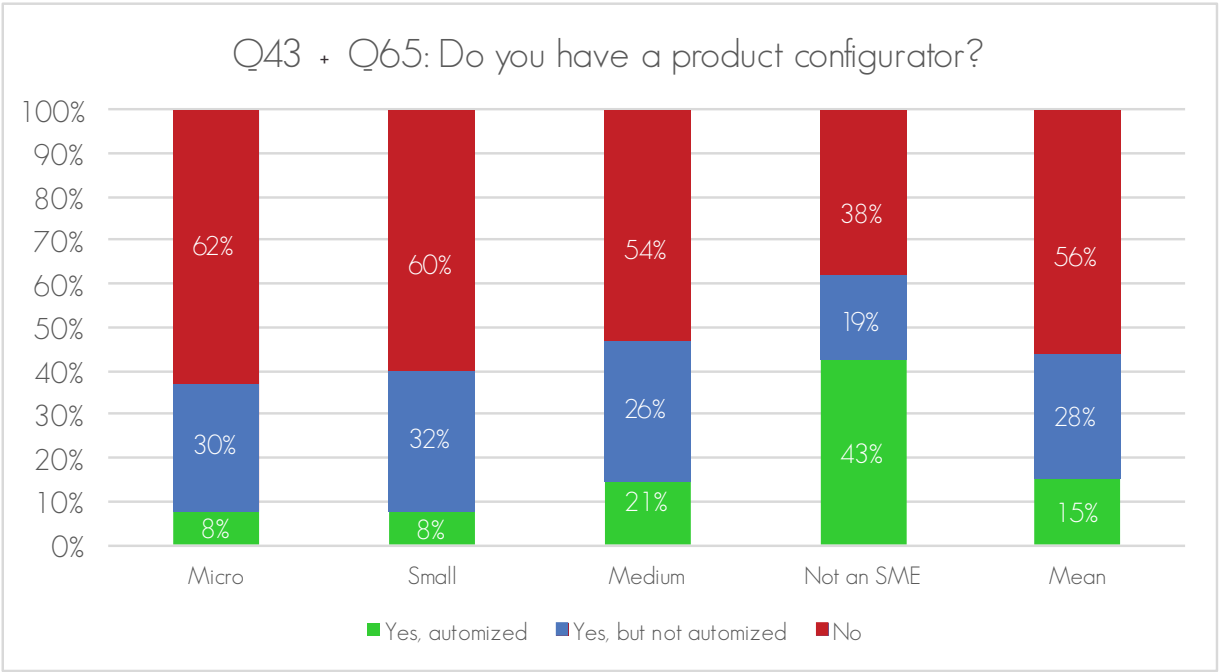


Fig. 61: Usage of product configurator (in %, n = 162)

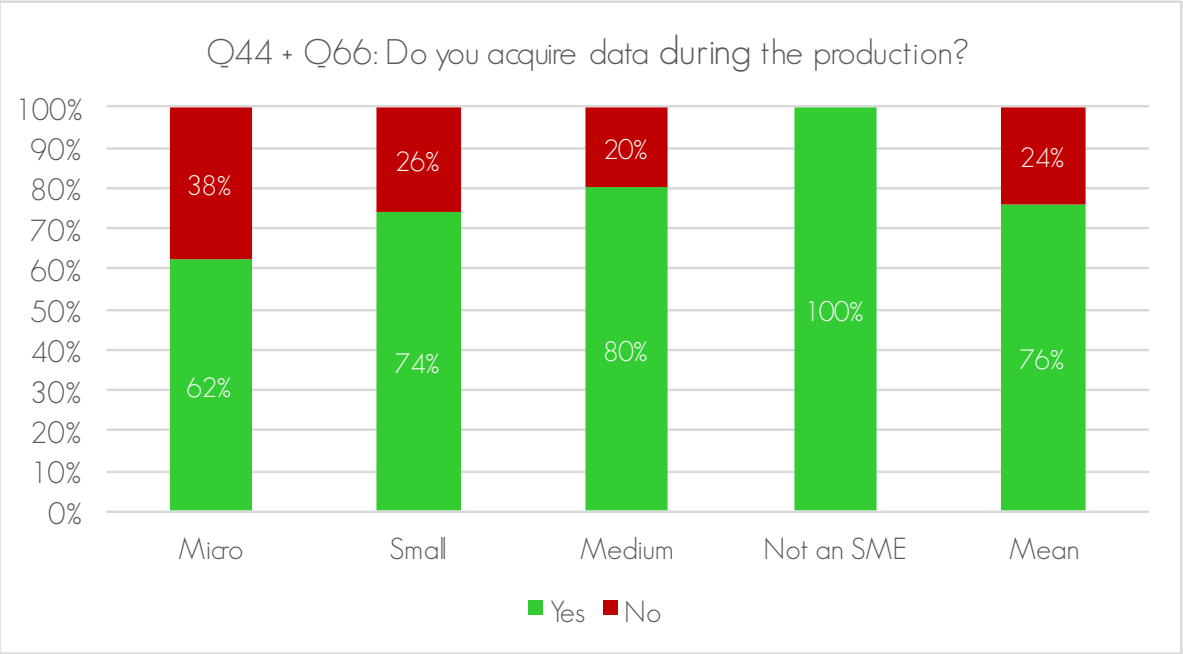


Fig. 62: Data acquisition during production (in %, n = 164)

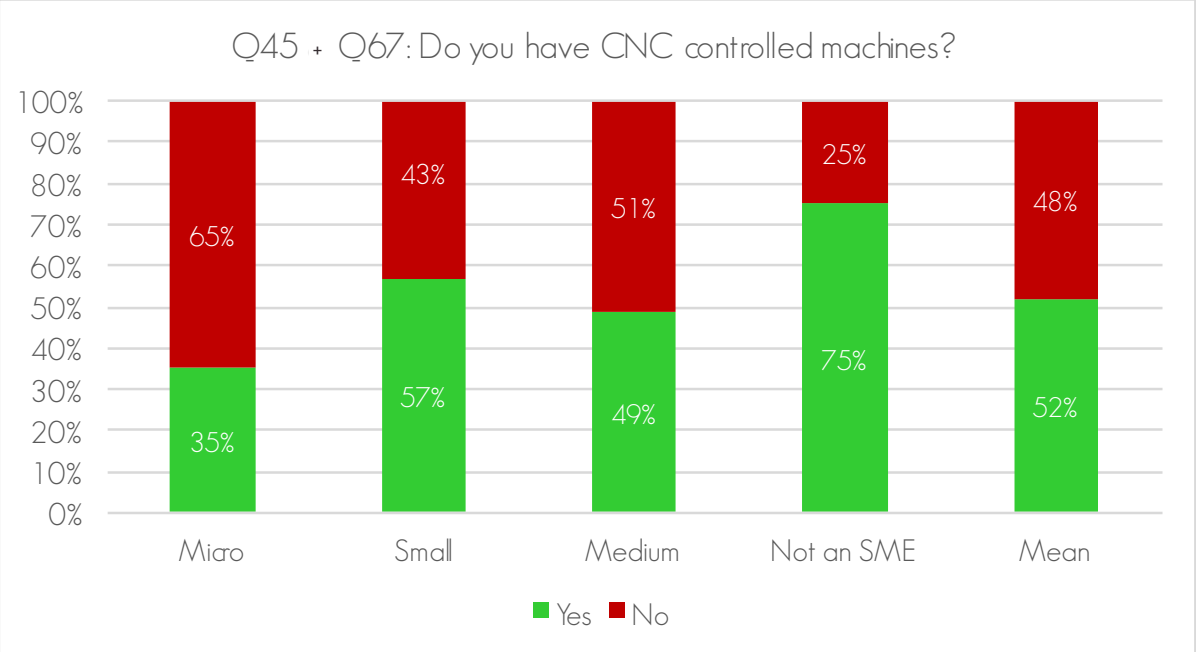


Fig. 63: Usage of CNC (in %, n = 163)

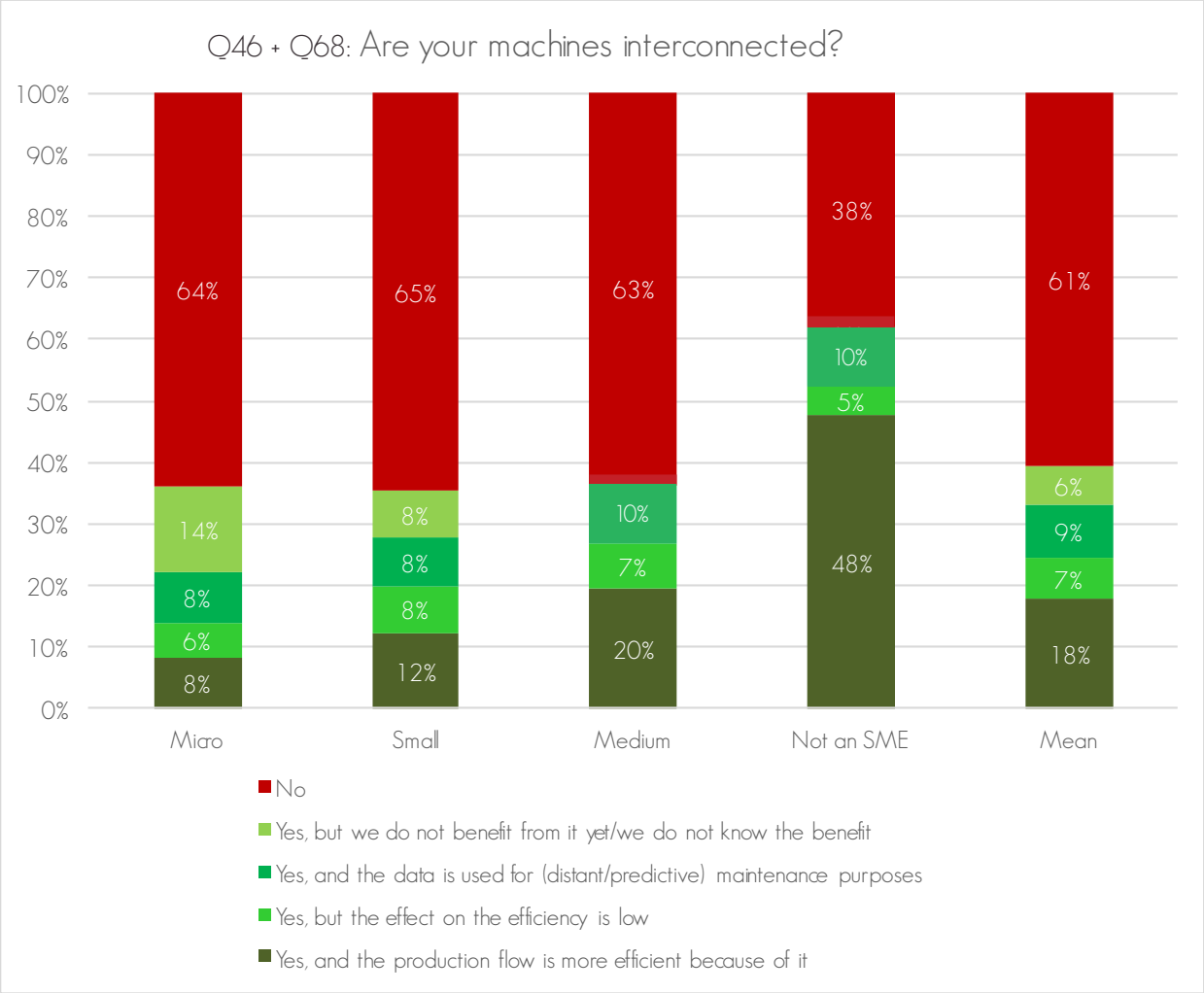


Fig. 64: Machine interconnection and estimation of their efficiency (in %, n = 163)

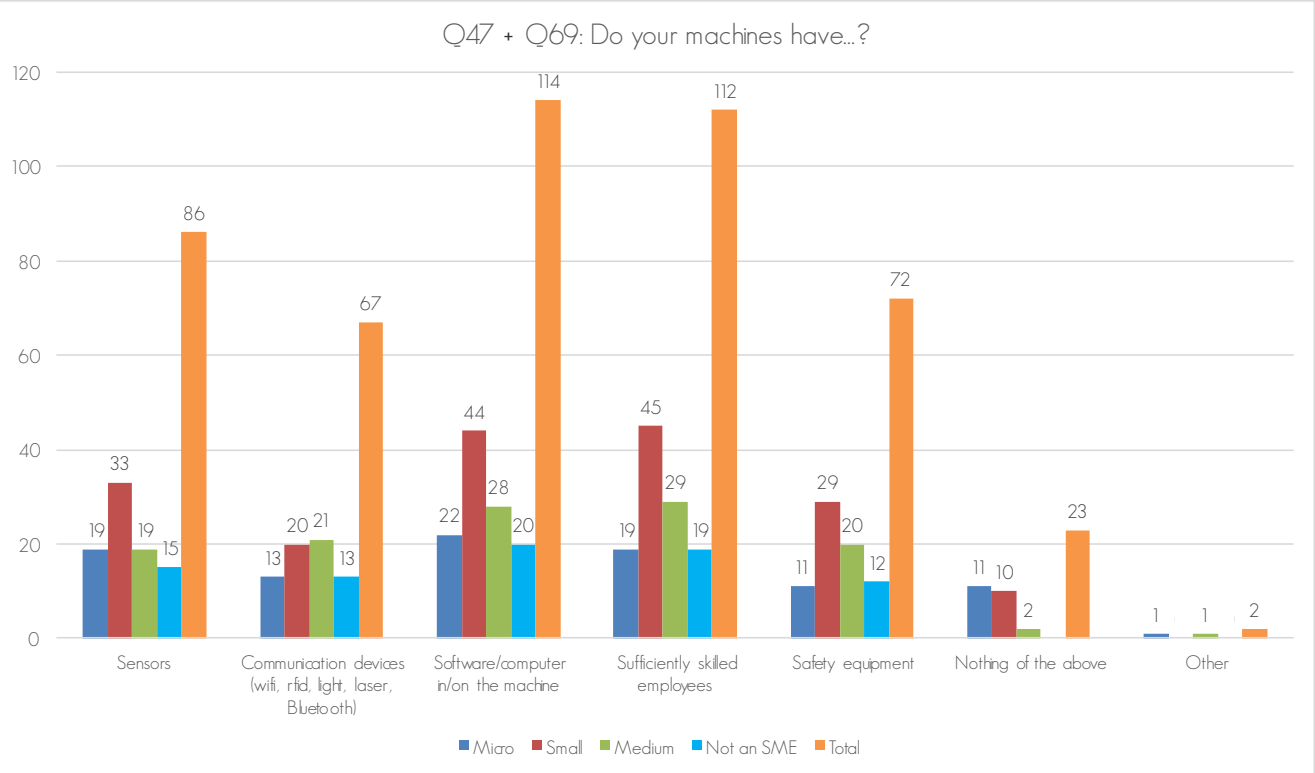


Fig. 65: Characteristics of the technical environment within companies (in absolute figures, n = 176)

RELATED FINDINGS ARE:

- MES is used, according to Figure 59, by micro and small businesses to a very small extent (5% and 6% respectively). It makes however a significant difference to large companies (38%).
- Less complex digital solutions like drawings, checklists, assembly manuals (Figure 60) are more popular particularly among small companies (on average 40% of answers in total).
- Usage of automated product configurators (Figure 61) is rather moderate among SMEs (8% for both micro and small companies and 21% for medium-sized businesses) and it slightly increases for non-automated solutions (on average, approx. 30%). Larger companies, in turn, seem to be more confident with automated configurators (43%) and use non-automated solutions rarely (19%). In general, approximately 60% of respondents from micro and SMEs do not use this solution although it might help them when creating customized products.
- Data acquisition during manufacturing (Figure 62) seems to be a must for large companies (100%) and it also takes place at micro and SMEs with 62%, 74%, and 80% of answers respectively. Here the tendency is quite clear: the larger the company is the more intensive the acquisition of data is.
- CNC machines (Figure 63) are used equally in SMEs with approximately 50% and increasingly at large companies (75%). Since most respondents produce metal products, this index might be seen as being quite predictable.
- Machine interconnection (Figure 64) seems to be used by micro and SMEs with, on average, 35% of answers for each company size (if we add up the different "yes" options for each company size). Of the 35%, 20% of medium-sized companies and 10% of small businesses attest, for example, to increasing their efficiency. Approximately 10% of these 35% use the data for maintenance purposes. Approximately 7% from the 35% do not observe any advantages.
- A typical technical environment within companies (Figure 65) includes computer-based machines equipped with software and sensors, which are operated by sufficiently skilled employees.

Production: Assembly & Quality Control

The next set of questions aimed at learning more about the use of smart technologies within the areas of Assembly and Quality Control. Figures 66 – 68 visualise the answers received.

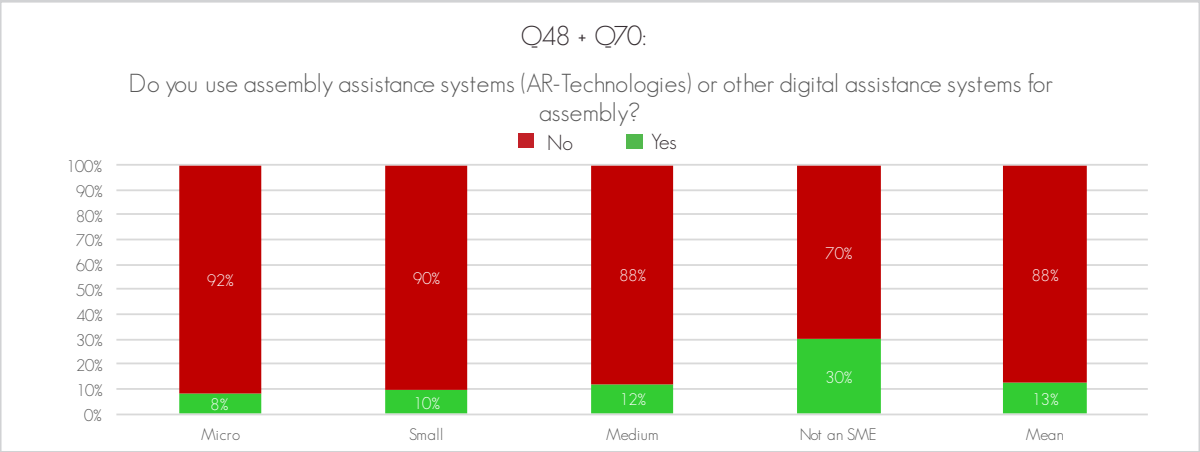


Fig. 66: Usage of digital assembly assistance systems (in %, n = 160)

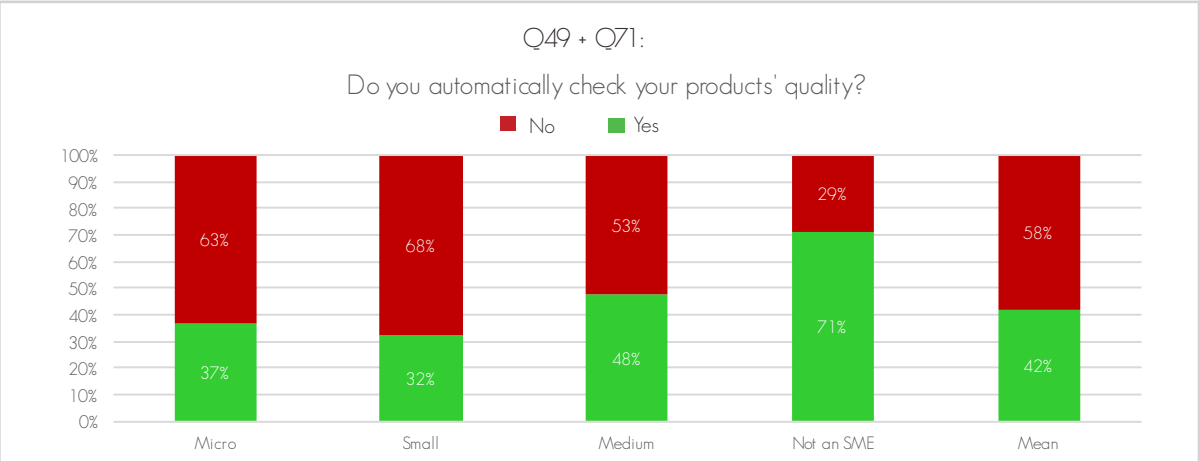


Fig. 67: Automated quality control of products (in %, n = 164)

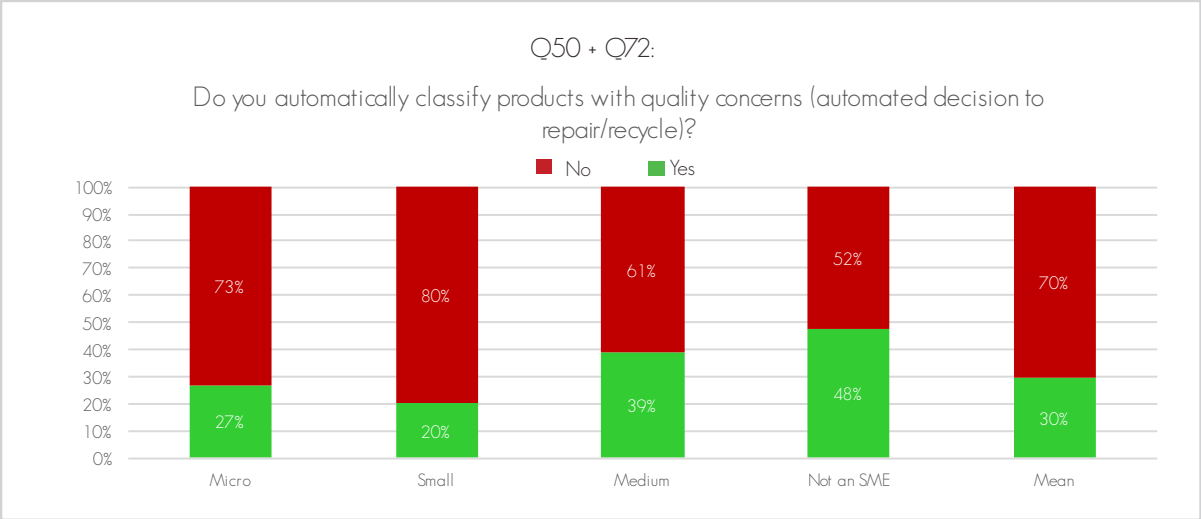


Fig. 68: Usage of solutions for automated product classification with quality concerns (in %, n = 164))

FINDINGS:

- Integration of digital assembly assistance systems into SMEs is, according to Figure 66, quite low (between 10 - 12%).
- Automated quality loops are undertaken at 32% of small business and at 48% of medium-sized companies (see Figure 67).
- Smart technologies for classifying products of inferior quality are introduced at 39% of medium-sized enterprises (see Figure 68). This index is twice as large as at small business (20%).

2.6.3. POST-PRODUCTION

The section Post Production focused on identifying the various approaches by companies to the issue of after sales, recycling and data evaluation. These questions were again answered by only part of the respondents, namely those who also filled in the part Pre-Production.

POST-PRODUCTION: AFTER SALES

Figures 69 – 71 present company activities in the field of product and data tracing:

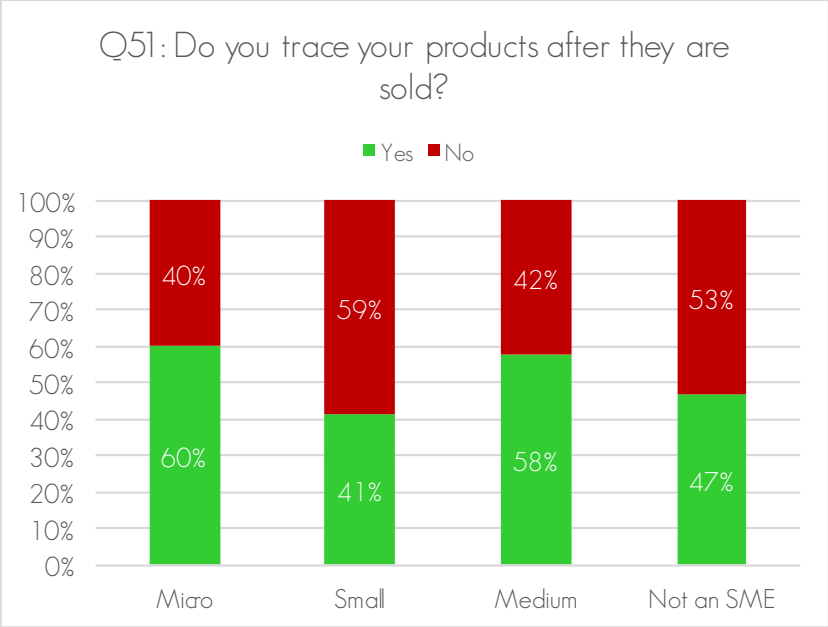


Fig. 69: Product tracing (in %, n = 119)

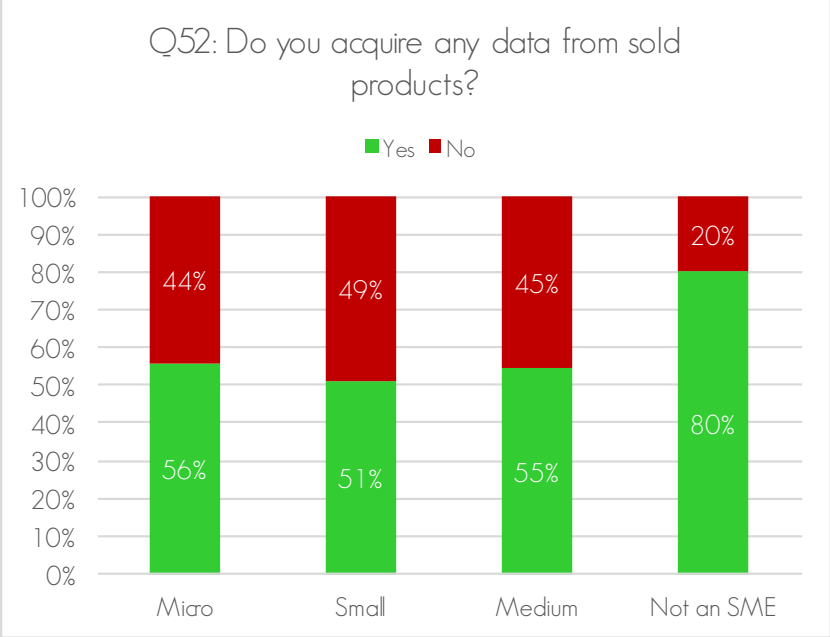


Fig. 70: Data acquisition after sales (in %, n = 118)

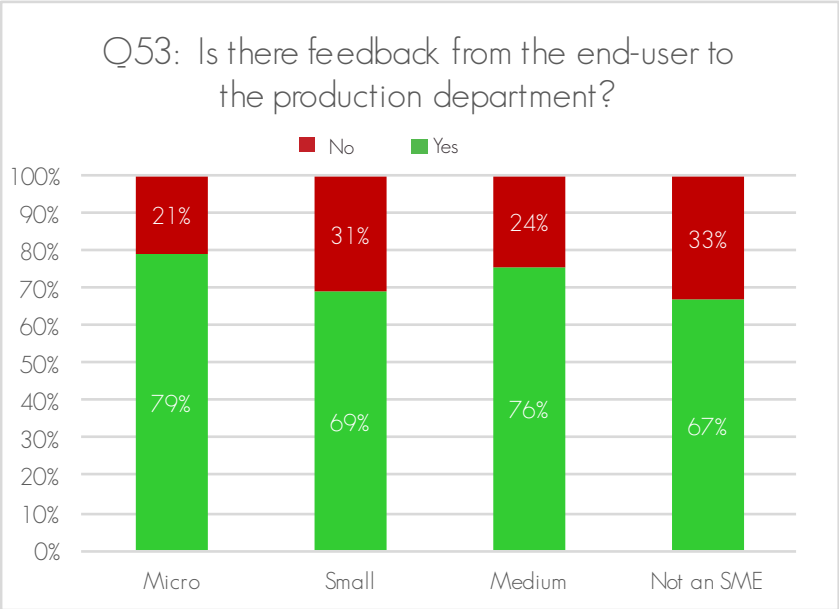


Fig. 71: Data exchange between customers and production departments (in %, n = 117)

FINDINGS:

- Product tracing (Figure 69) was scored well by medium-sized (58%) and micro-companies (60%). Small businesses demonstrated a lower outcome of 41%.
- Micro, small and medium-sized businesses display fairly equal rates (on average 50%) for data acquisition concerning products sold (Figure 70), whilst large companies compensate for their lower activity in relation to product tracing (41%) through higher activity in terms of data acquisition (80%).
- Feedback from customers to production departments seems to be more or less equal for all company types (Figure 71): on average 70% of all companies stated this.

POST-PRODUCTION: RECYCLING

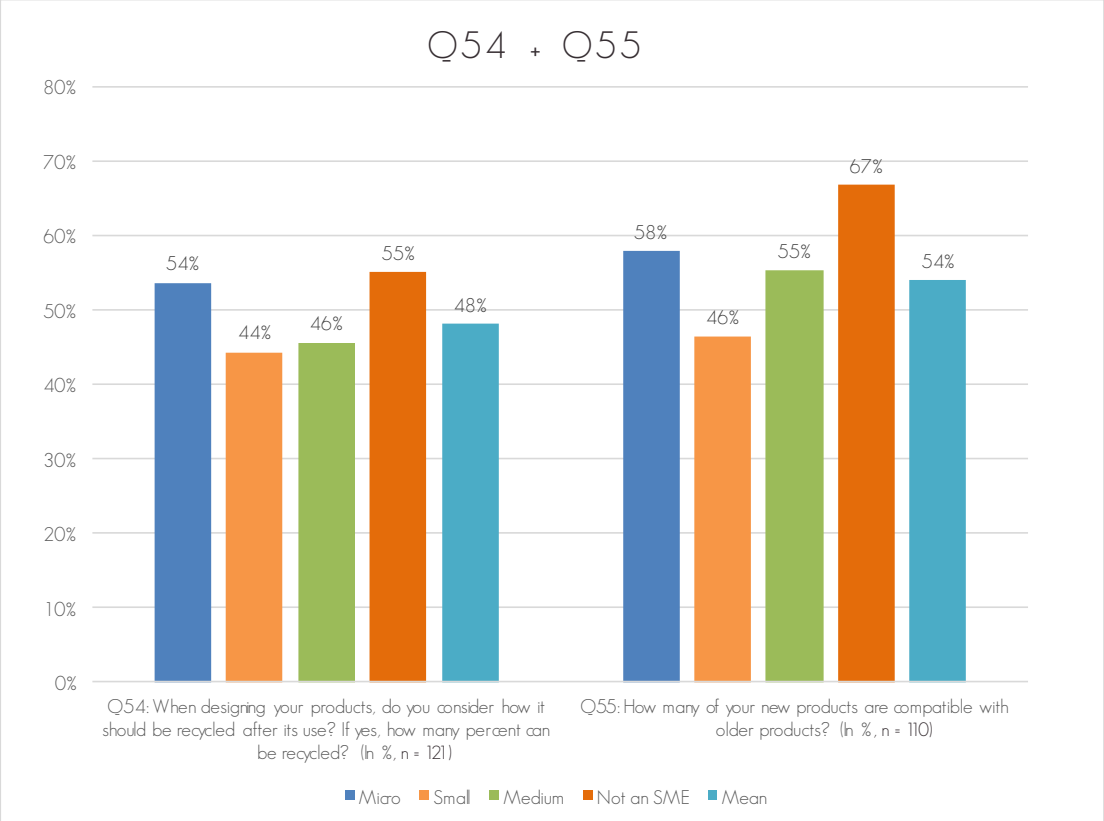


Fig. 72: Recycling behaviour by companies plus new and old product compatibility (in %)

- Small and medium-sized companies demonstrate a rate of 44% - 46% when estimating the recycling potential of their products.
- More than half of all respondents stated that their new products are compatible with older ones. This does not seem to correspond however to real-life experience. Possibly the term "compatible" was interpreted here in different ways.

2.7. Data management

Data collection and mining is becoming more and more a relevant part of modern business life. Therefore, the survey also aimed at identifying trends and technologies for data collection and evaluation processes within manufacturing companies.

Since not every respondent was able to provide answers about the data handling within their company, this set of questions was made optional. 83 answers were received but the number of potential respondents for the questions was 126, which corresponds to 66%. This is lower than the 76% of respondents who provided data for the questions Q44 - Q66 ‚Do you acquire data during the production?' and who were therefore expected to move forward through the survey.

The respondents who ticked the option "Yes" were forwarded the set of questions aimed at exploring aims and objects concerning data collection. Those who selected the option "No" continued with the question 78.

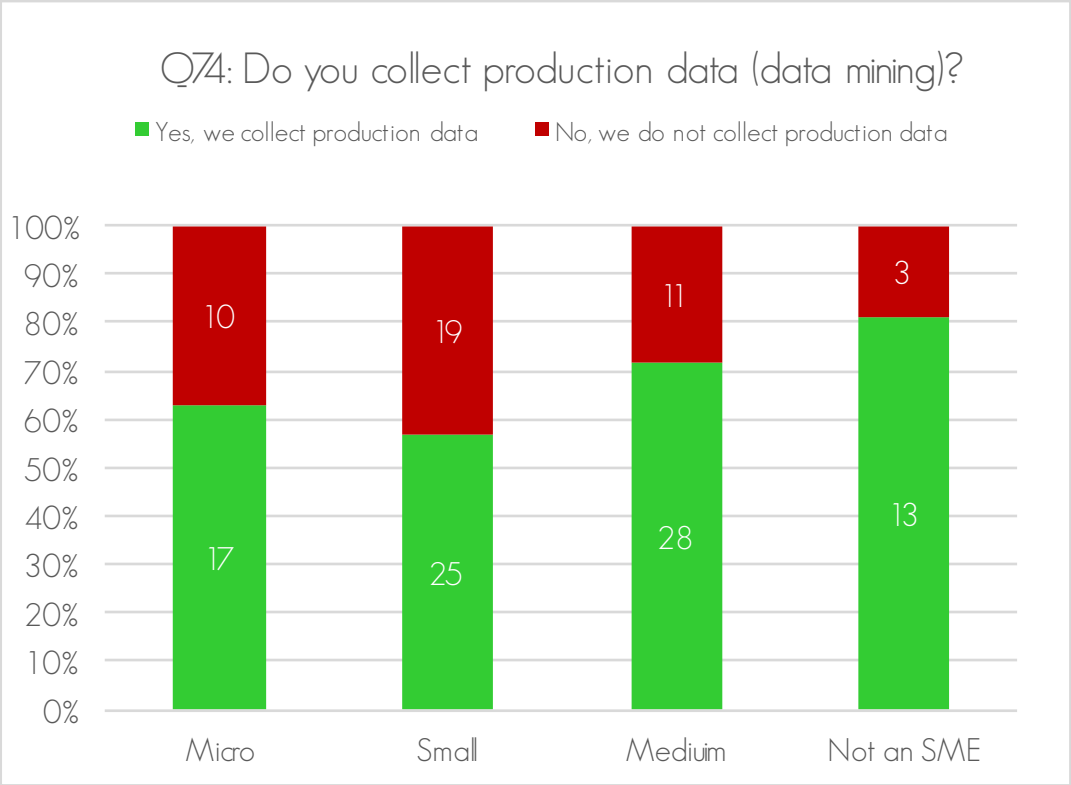


Fig. 73: Data mining (production) (in absolute figures, n = 126)

All company types seem to achieve the threshold of 50% in collecting production data.

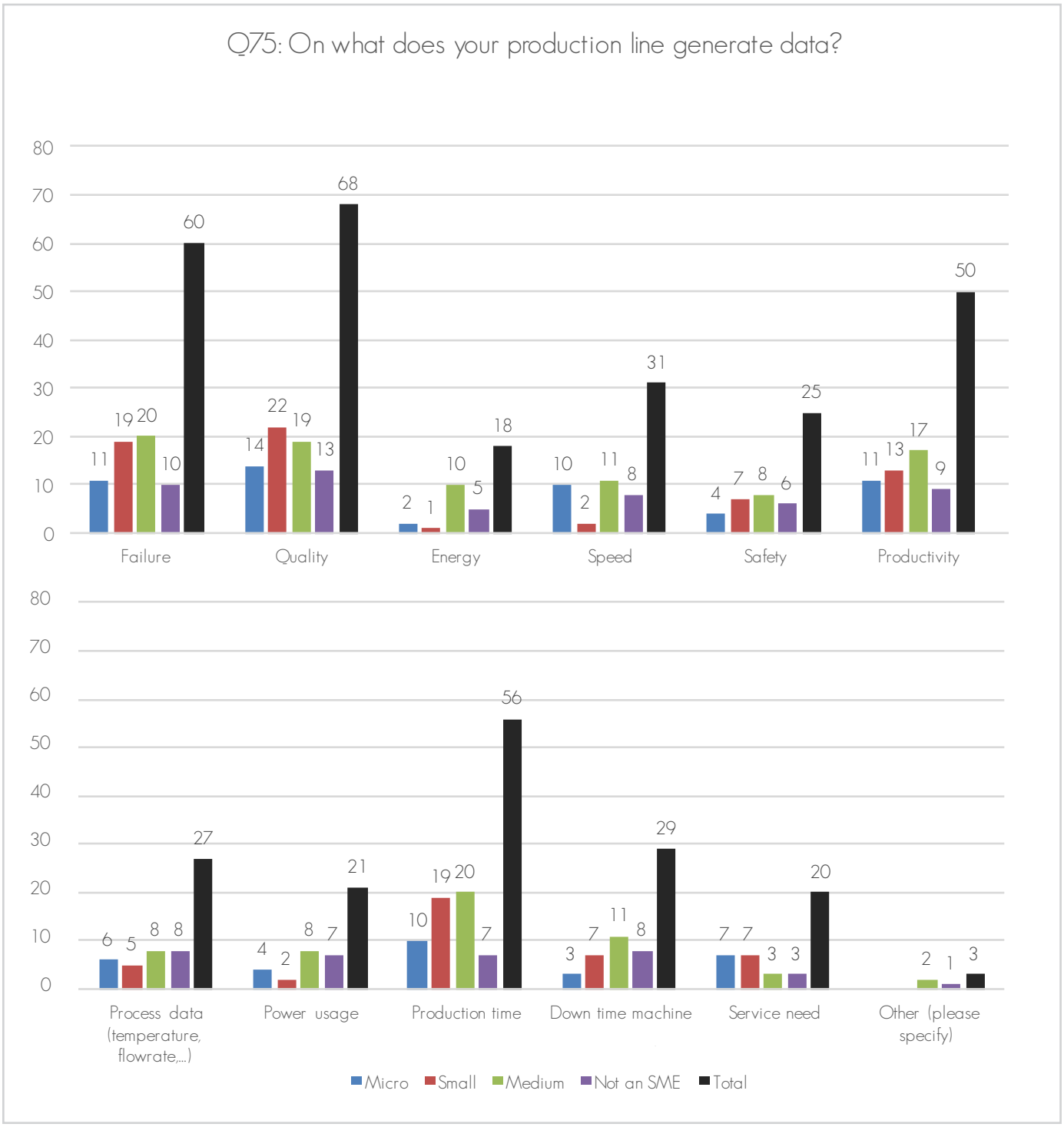


Fig. 74: Objects of data mining (in absolute figures, n = 82, many answers possible)

Quality, failure, and production time with 68, 60, and 56 responses respectively are the top 3 items for which companies of all types generate data.
For small and medium-sized companies, this is exactly their top 3 concerning data collection objectives. For micro-businesses and large companies, their top 3 is slightly different: Quality – Failure – Productivity.
These findings might be connected to the relevancy of the related processes within the companies.
The production fields Energy, Service needs and Power usage have, in turn, the least indexes for collecting data (18, 20, and 21 answers for all company types).

The next figure 75 demonstrates the purposes of data collection:

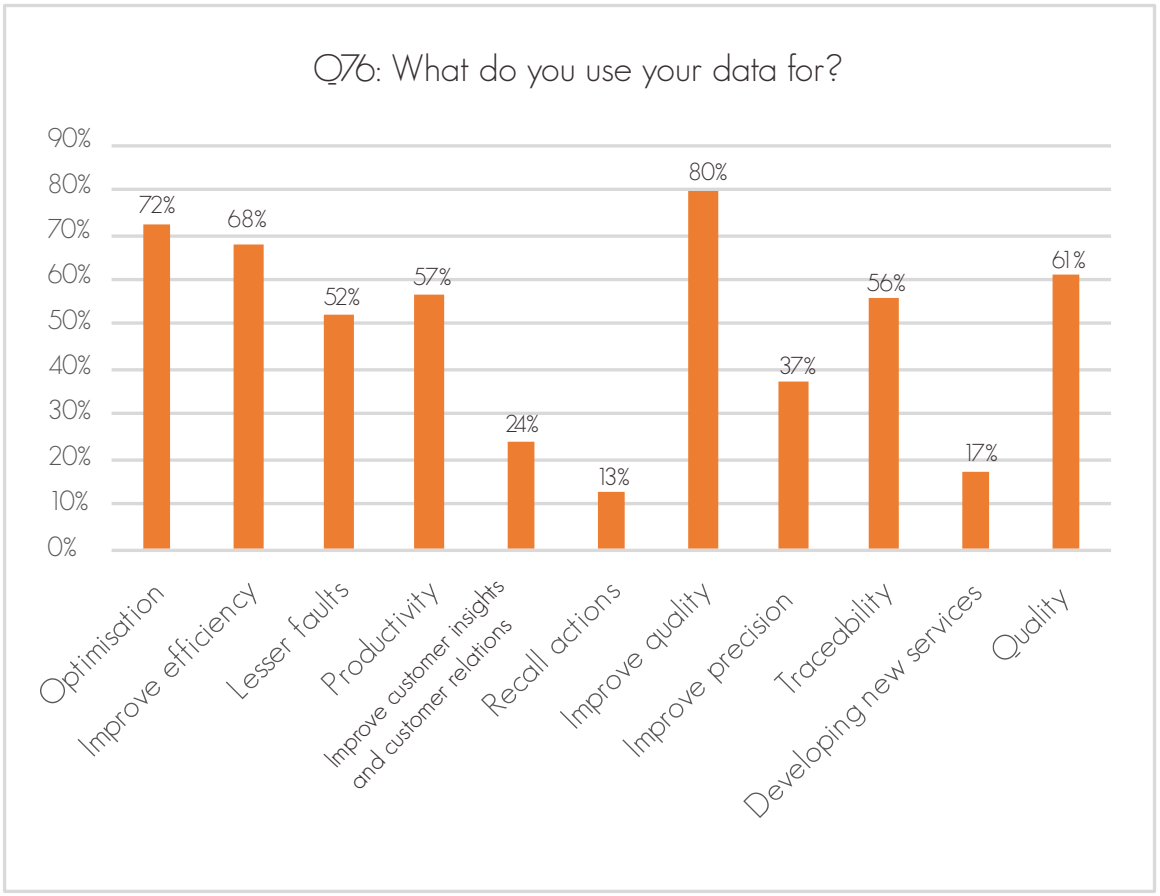
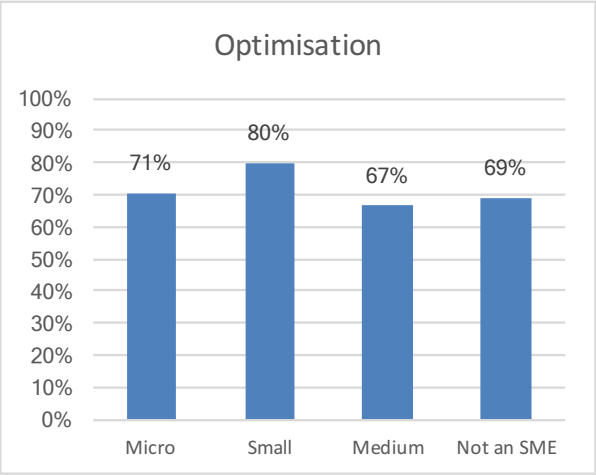
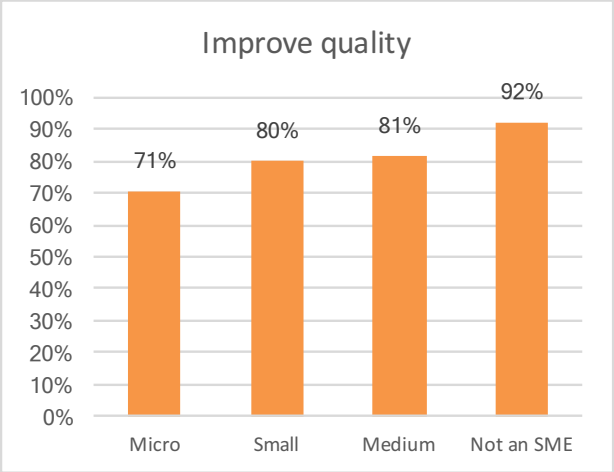


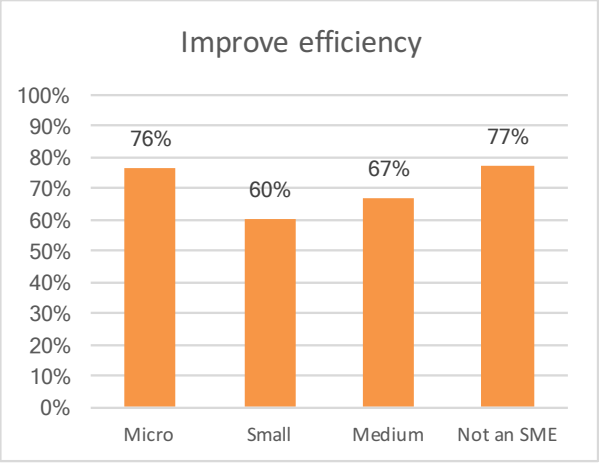
Fig. 75: Purpose of data collection (in %, n = 82, for all company types)

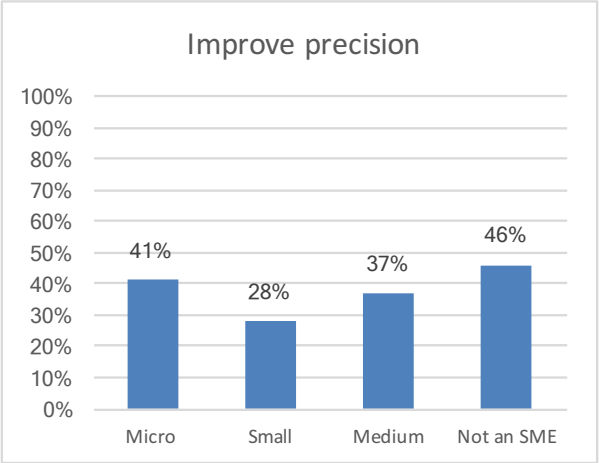
The most stated objectives for data collection are Quality improvement (80%), Optimisation (72%), and Efficiency improvement (68%).
Data collection for Recall actions (13%), Developing new services (17%), and Customer relations improvement (24%) received the fewest answers.

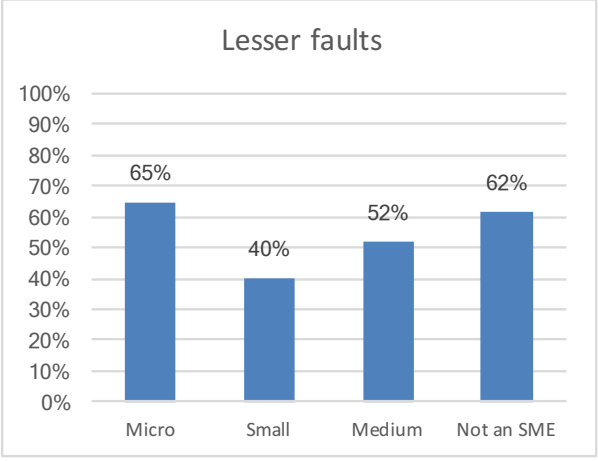
Again, the question arose whether the purposes of data collection vary depending upon company size. The related findings are represented below in the aggregated Figure 76.

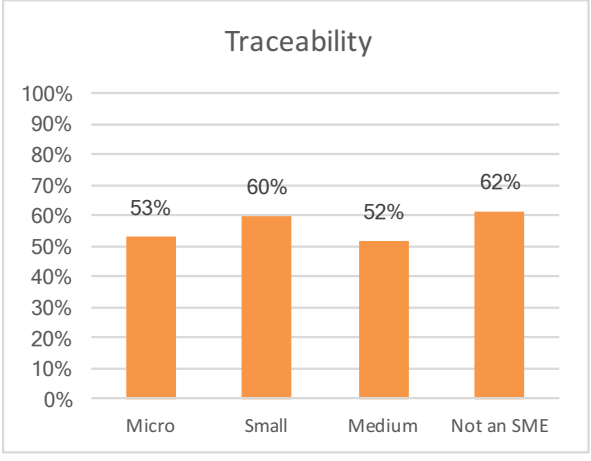

Optimisation
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
71%
80%
67%
69%
Micro
Small
Medium
Not an SME

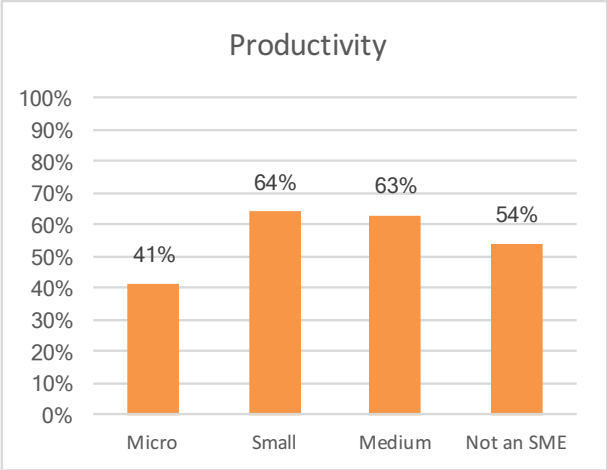

Improve quality
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
71%
80%
81%
92%
Micro
Small
Medium
Not an SME

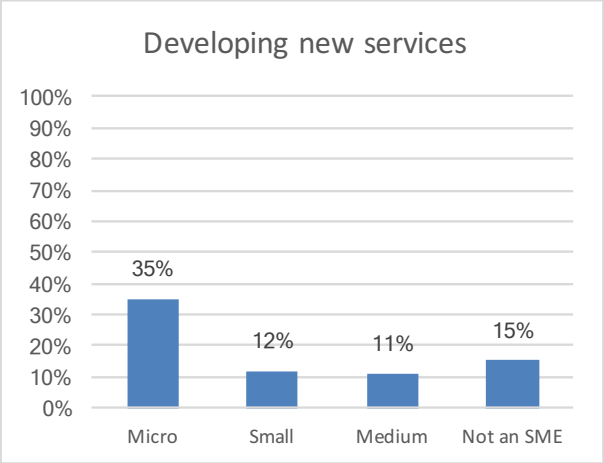

Improve efficiency
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
76%
60%
67%
77%
Micro
Small
Medium
Not an SME

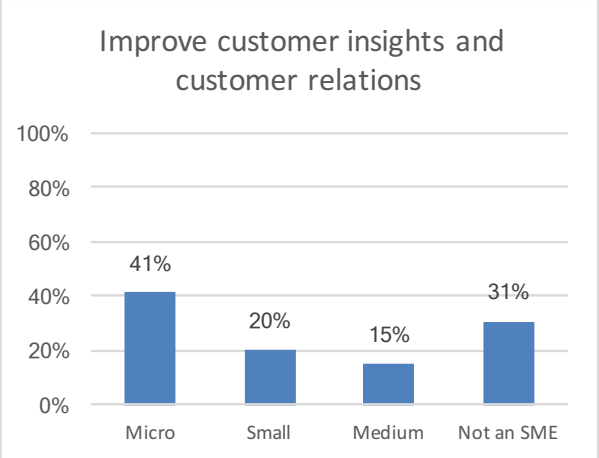

Improve precision
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
41%
28%
37%
46%
Micro
Small
Medium
Not an SME

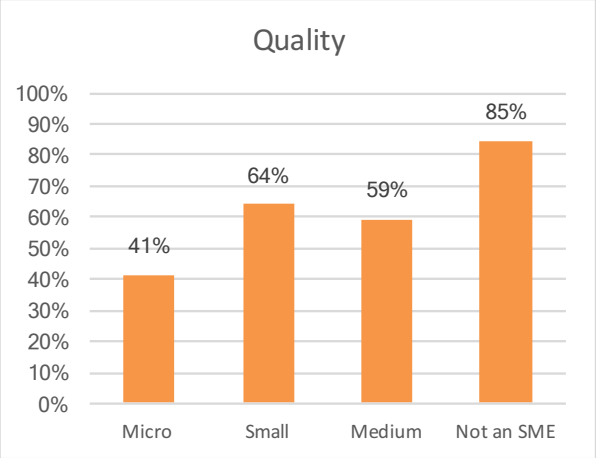

Lesser faults
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
65%
40%
52%
62%
Micro
Small
Medium
Not an SME


Traceability
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
53%
60%
52%
62%
Micro
Small
Medium
Not an SME









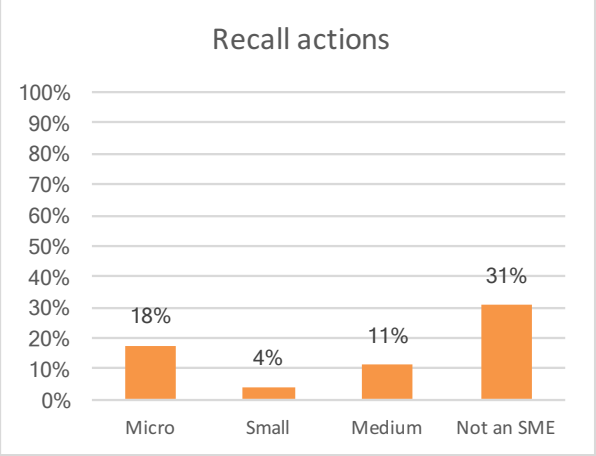


Fig. 76: Purposes of data collection depending upon company size (in %, n = 82)

FINDINGS:

- Micro-companies still highlight the same objectives when collecting data as stated in the findings for Figure 75. However, they are rated in a different way, namely: Efficiency improvement (76%), Quality improvement (71%) and Optimisation (71%).
- Small companies rate even higher the relevance of Quality improvement and Optimisation (both with 80%) with Quality and Productivity in second place (both with 64%).
- Medium-sized businesses, like micro-companies, collect data mostly for Quality improvement (81%), Efficiency improvement and Optimisation (both with 67%).
- Large companies stress Improving Quality (92%), Quality (85%) and Efficiency improvement (77%) as the most relevant objectives of data collection.
- The largest differences can be seen for the item Developing new services, for which micro-companies use their data significantly more than the others (35% compared to 11% stated by medium-sized businesses).

The last question in the data collection set aimed, as Figure 77 shows, at learning about the use of intelligent sensor technology in companies:

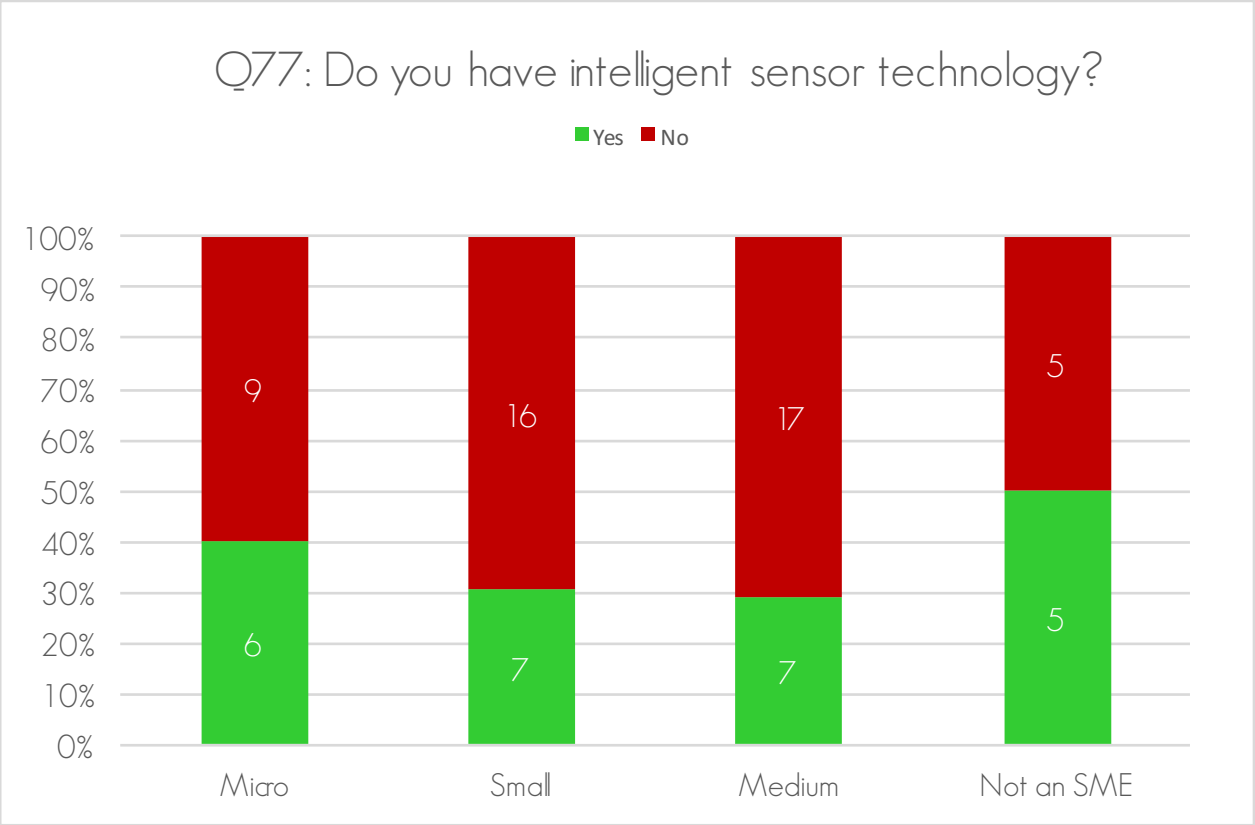


Fig. 77: Usage of intelligent sensor technology (in absolute figures, n = 72)

- SMEs with 30% of answers seem to lag behind micro (40%) and large companies (50%) in using intelligent sensor technology.

The respondents who selected the option "No" for Q74 related to data collection, were asked about their vision of potential data use. The findings are represented below by the figures 78 - 81.

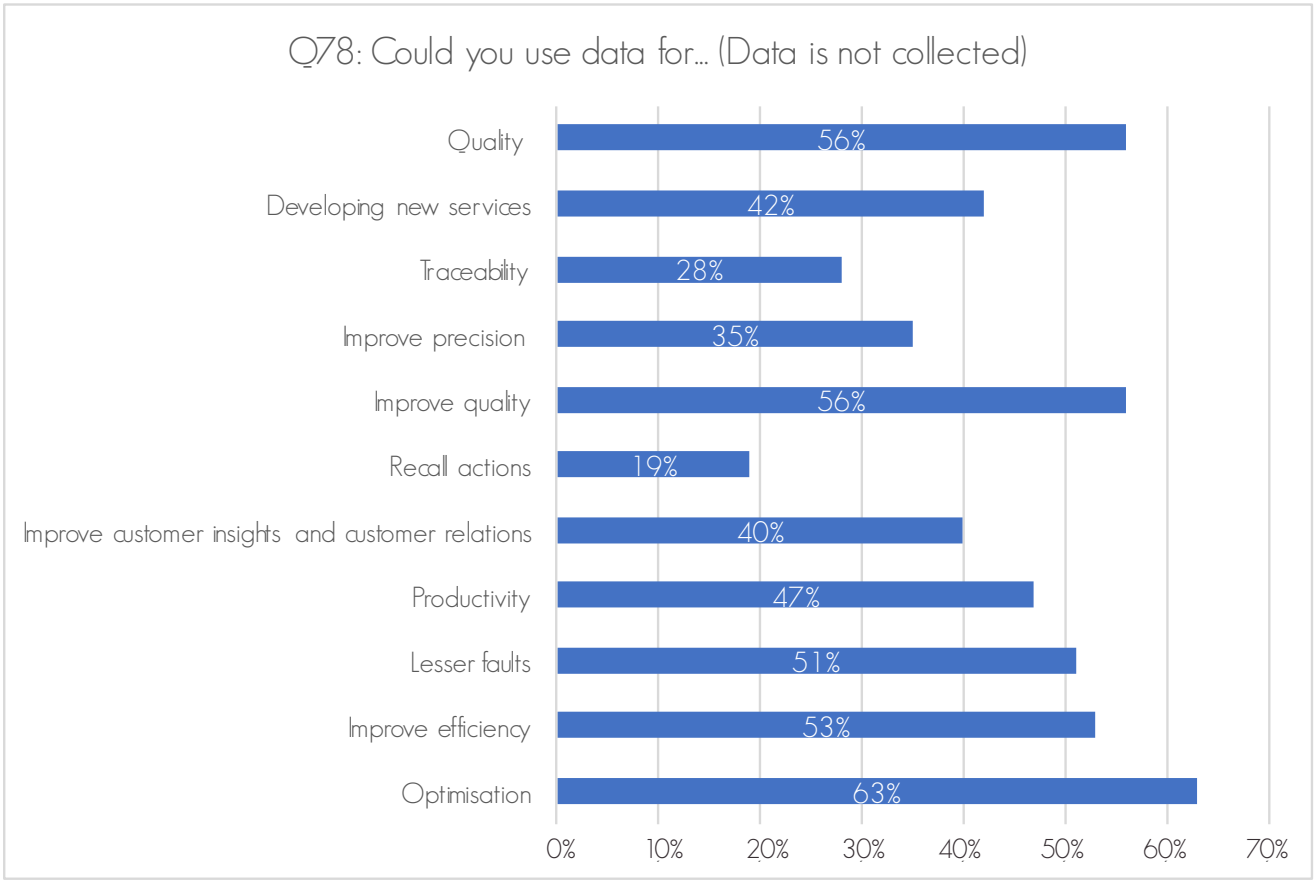
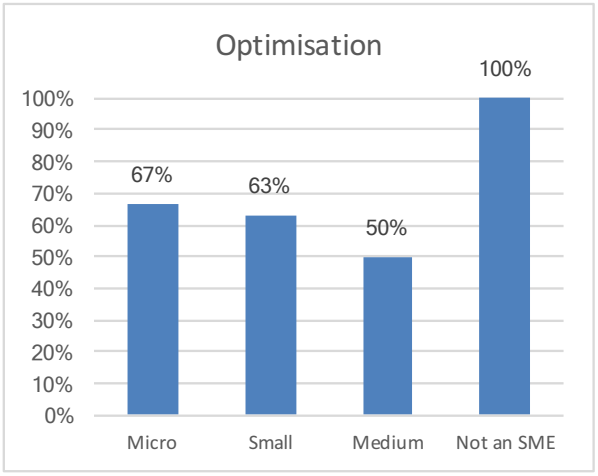
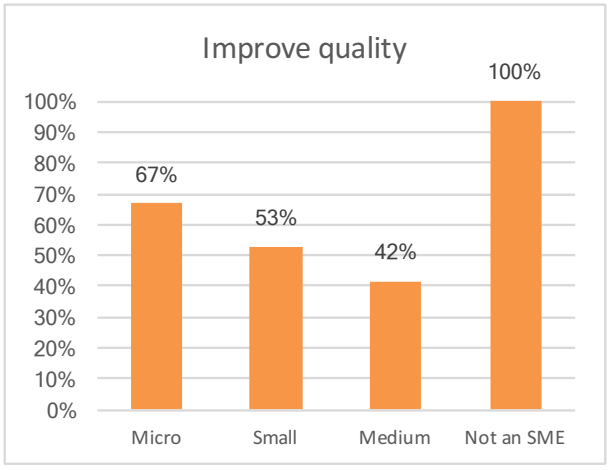


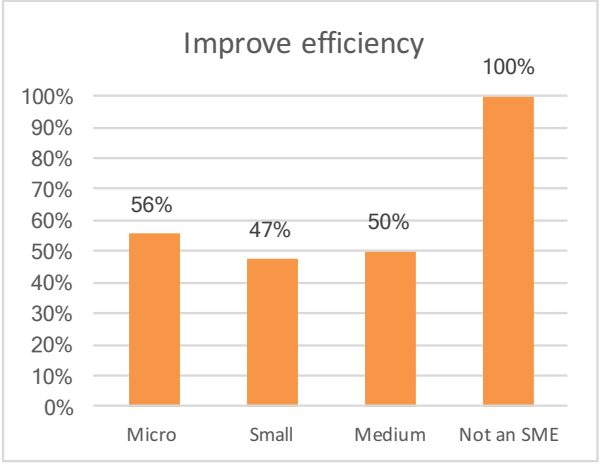
Fig. 78: Companies' vision of the potential use of collected data (in %, n = 43)

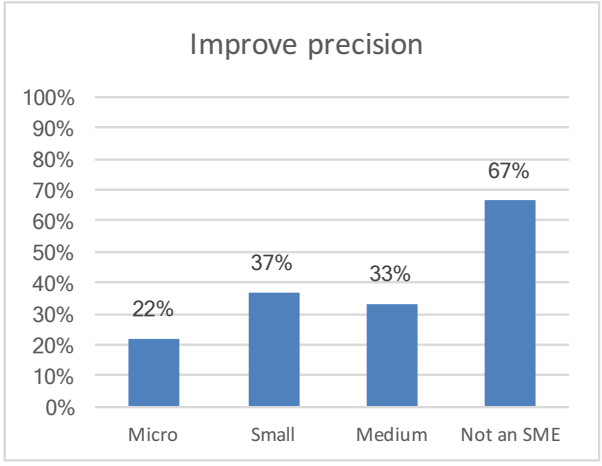
- Respondents who did not collect data indicated the same fields for the potential use of collected data, which were stated by respondents who already do it, namely Optimisation (63%), Quality improvement and Quality (both with 56%) and Efficiency improvement (53%).
- The less-rated fields for the potential use of data are Recall actions (19%), Traceability (28%) and Precision improvement (35%).
- However, many potential fields for the use of data are rated rather equally so that many estimations range, for example, between 40% - 47% or 51% - 56%. This might be explained by a lack of practical experience in this field and therefore, by estimating as many options as are relevant.

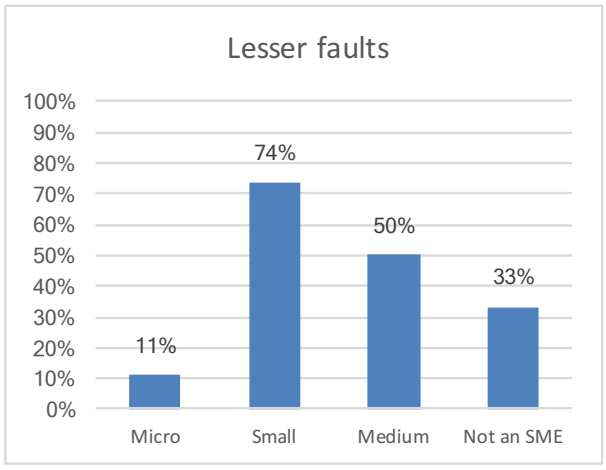
The question of company size being relevant to rating dimensions for potential data use is demonstrated in the next figure, 79.

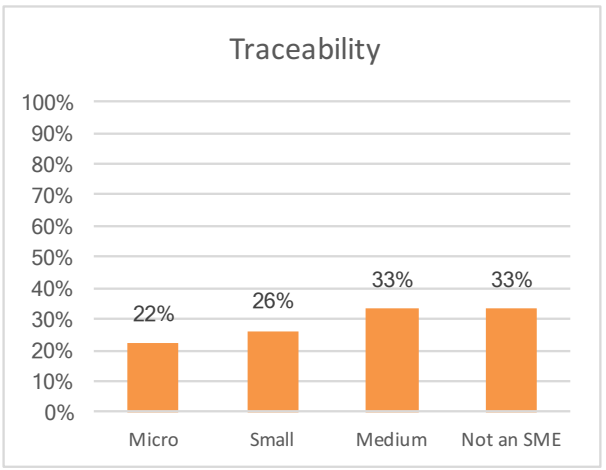


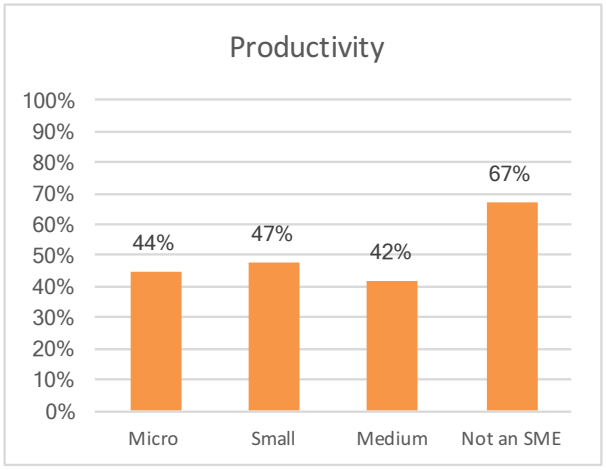


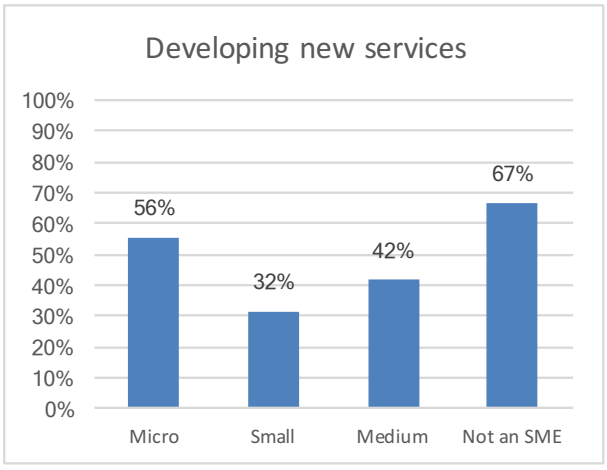


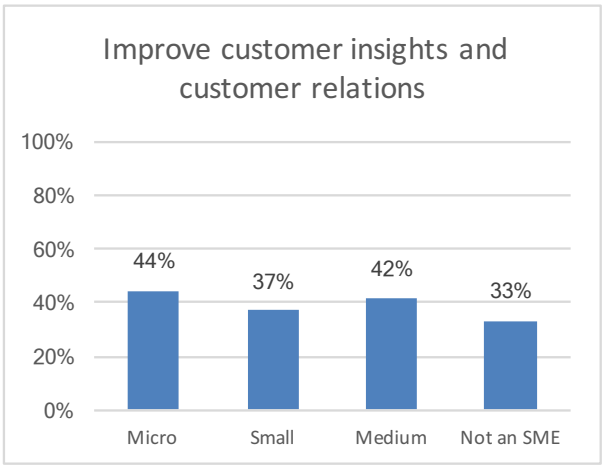


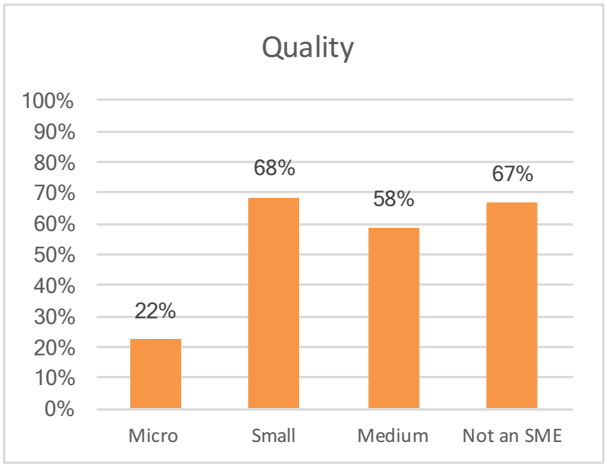

Lesser faults
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
11%
74%
50%
33%
Micro
Small
Medium
Not an SME


Traceability
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
22%
26%
33%
33%
Micro
Small
Medium
Not an SME


Productivity
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
44%
47%
42%
67%
Micro
Small
Medium
Not an SME


Developing new services
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
56%
32%
42%
67%
Micro
Small
Medium
Not an SME


Improve customer insights and customer relations
100%
80%
60%
40%
20%
0%
44%
37%
42%
33%
Micro
Small
Medium
Not an SME


Quality
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
22%
68%
58%
67%
Micro
Small
Medium
Not an SME

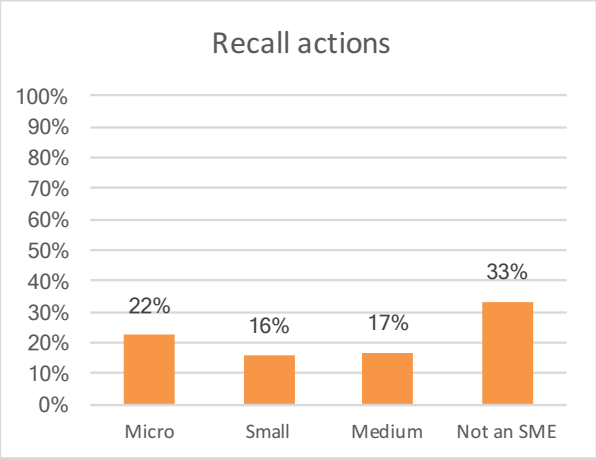


Fig. 79: Purposes of data collection depending upon company size (in %, n = 43)

- Micro-companies define their preferences for data collection quite clearly and rate highest the fields Quality improvement and Optimisation (both with 67%) and Efficiency improvement and Development of new services (both with 56%).
- Small companies see the greatest advantages of data collection in the fields Decrease of faults (74%), Quality (68%), and Optimisation (63%).
- Medium-sized businesses would mostly collect data related to Quality (58%). The fields Efficiency improvement, Optimisation, and Decrease of faults are in second place with 50%.
- Large companies stress the fields Quality improvement, Efficiency improvement, and Optimisation as being absolutely relevant to the use of collected data and rate these with 100%.

In general, these estimations show a wide range of variety and individuality regardless of company size.

The next set of questions were aimed at the further learning potential needs of companies in the field of smart data collection. The results are visualised in figures 80 and 81.

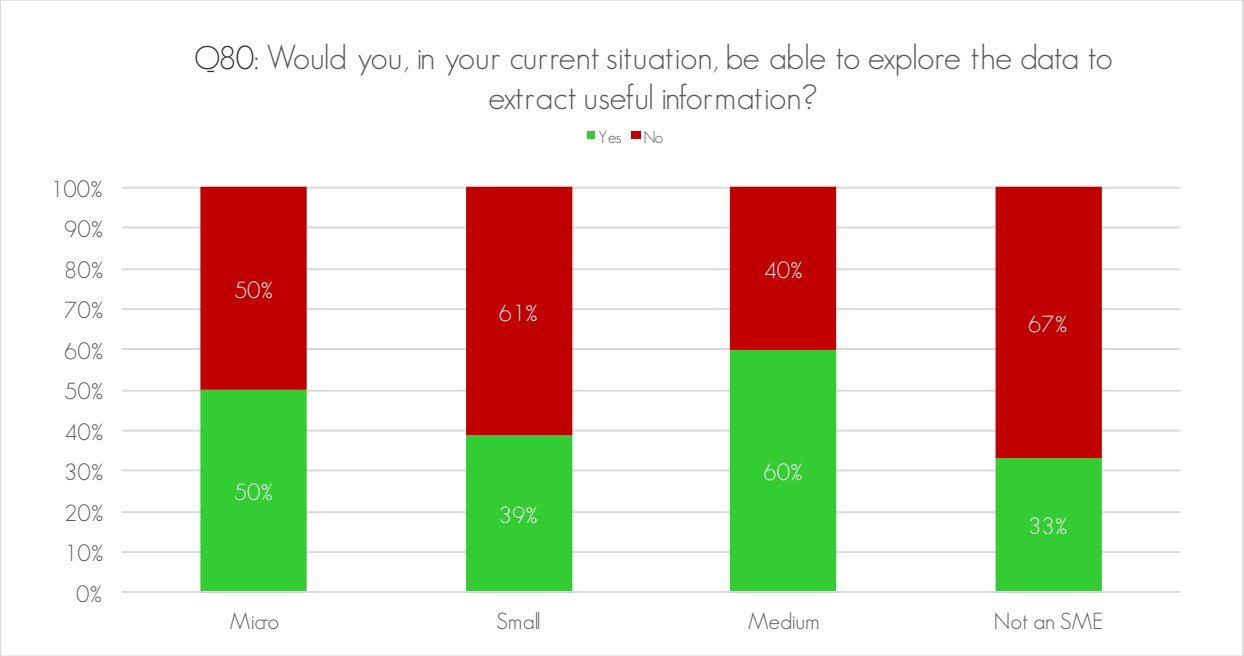


Fig. 80: Estimation of available data mining skills (in %, n = 39)

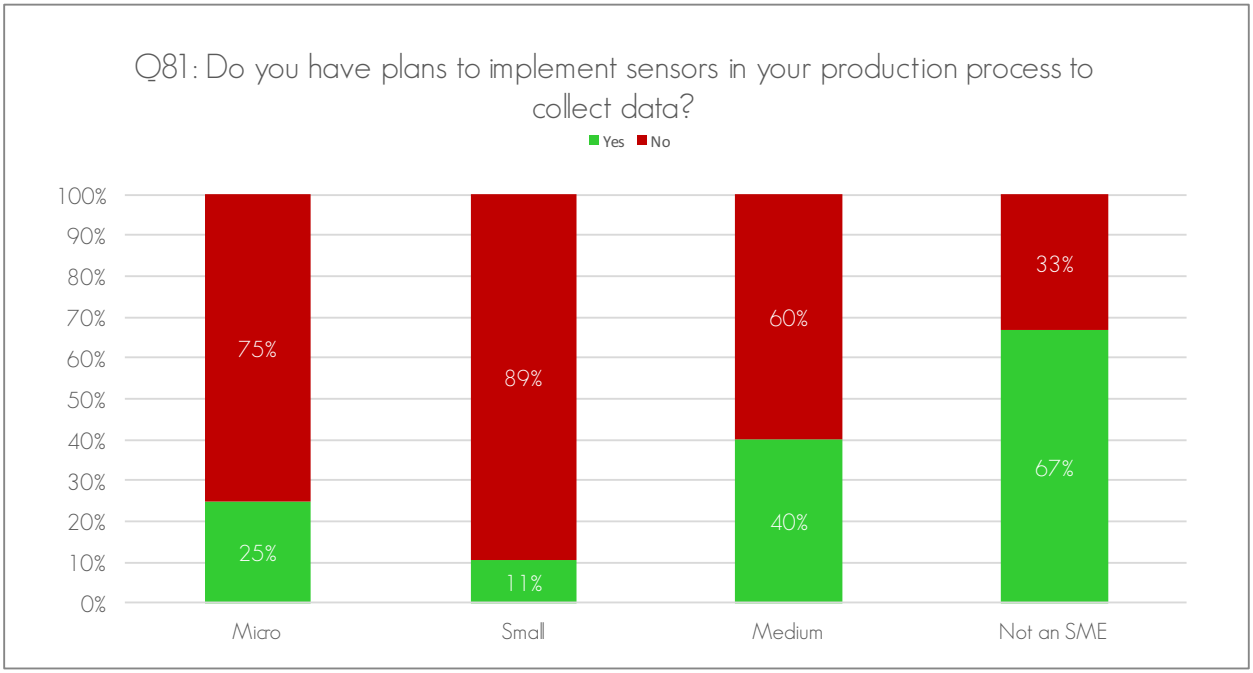


Fig. 81: Estimation of sensor implementation for data collection (in %, n = 40)

- Companies of all types currently see difficulties in implementing data mining solutions (61% of small and 40% of medium-sized companies).
- Even more negative are the estimations concerning the implementation of sensors in production processes for data collection: 89% of small and 60% of medium-sized business do not intend to undertake this.

2.8 Product data and management

Similar to the section Data collection, the section Product could also be optionally skipped by respondents by answering Q82 positively or negatively. Here the positive answers received are represented.

Q83: PRODUCT-PORTFOLIO

The related set of questions aimed at investigating the number of different products to be manufactured, lifetime of products and production volume.

The related results are represented in the Table 10:

Number of different products (in absolute figures)	Lowest value	Average value	Highest value
Micro	1	56	500
Small	1	1,451	30,000
Medium	1	377	2,500
Not a SME	10	6,314	60,000
In total	1	1,338	60,000

Answering to any of these questions with '0', means the company is not producing anything. Since the survey focused on production companies, these answers were not taken into consideration for this question. The fields where answers were not taken into consideration, are marked in orange. Also the average is calculated without these numbers.

Amount produced /year	Lowest value	Average value	Highest value
Micro	1	10,591	200,000
Small	4	638,963	10,000,000
Medium	4	3,471,815	100,000,000
Not a SME	25	3,819,993	38,000,000
In total	1	1,684,278	100,000,000

Average lifetime of product (in years)	Lowest value	Average value	Highest value
Micro	1	7.4	20
Small	1	12.6	100
Medium	2	11.1	30
Not a SME	1	10.2	25
In total	1	10.8	100

Tab. 10: Product portfolio of respondents (n = 104, in absolute figures)

Small companies demonstrate quite a wide range of products manufactured, 1,451, compared to 56 for micro and 377 for medium-sized companies. However, the annual production levels of small companies are significantly lower.

The respondents also provided data about the average time it takes to reach the point of launching products onto the market (in months):

What is your time to market? (in months)	Lowest value	Average value	Highest value
Micro	0,5	4.2	12
Small	0,5	7.8	50
Medium	1	8.0	48
Not a SME	2	11.5	36
In total	0,5	7.6	50

Tab. 11: Time to market of respondents (in months) (n = 104, in absolute figures)

According to Table 11, small and medium-sized businesses need on average 7.8 – 8 months to be able to launch their products onto the market.

Furthermore, the respondents were asked about product tracing during and after the production process. Figures 82 – 83 provide companies' estimation about this:

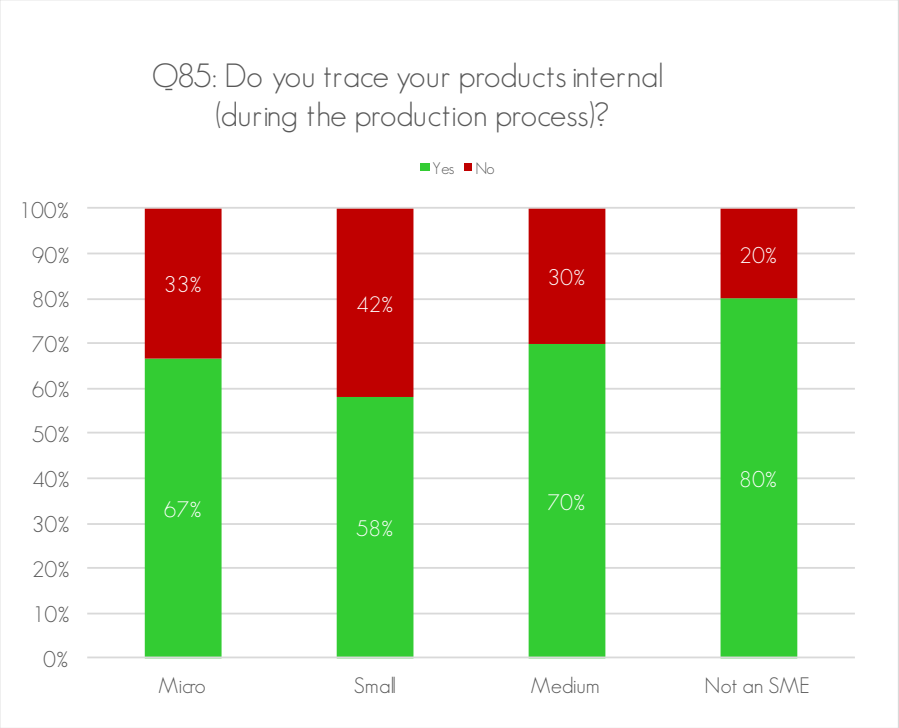


Fig. 82: Product tracing during production (in %, n = 104)

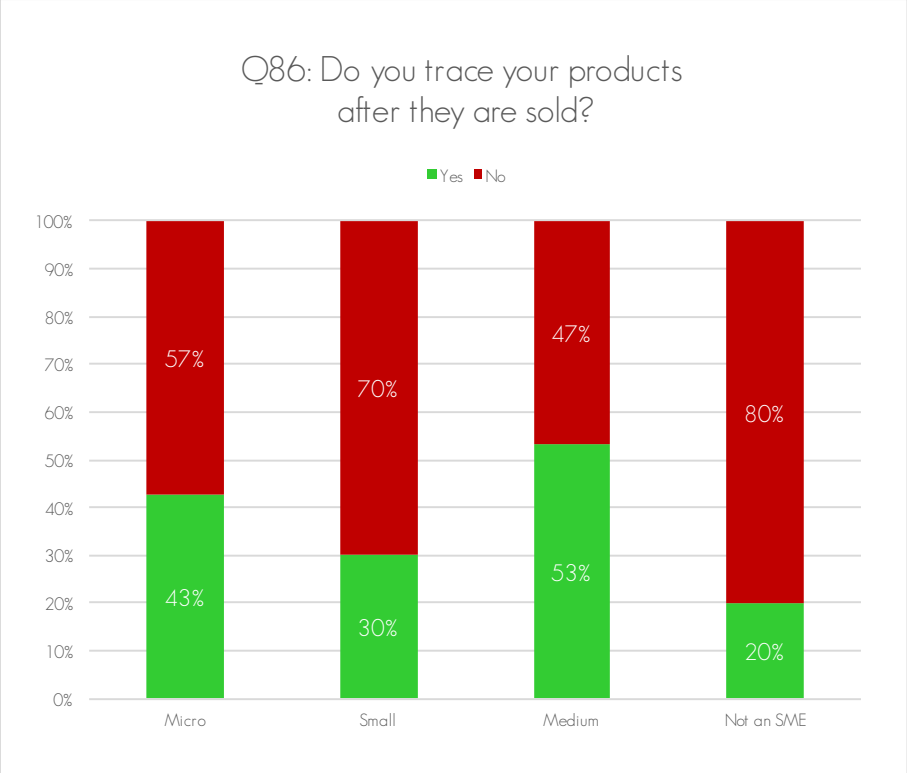


Fig. 83: Product tracing after sales (in %, n = 104)

Internal product tracing during the production process is rated higher by all company types than tracing after sales.

Particularly medium-sized businesses indicate internal product tracing with 70% and undertaking sales product tracing with 53% as being highly relevant.

After sales product tracing within small companies decreases almost by half compared with tracing during production (30% and 58% respectively).

Data concerning the influence of customers and suppliers on a company's products was also obtained, and is presented below in tables 12 and 13:

Q87: How much do your customers influence the product?	Lowest value	Average value	Highest value
Micro	4%	62,4%	100%
Small	0%	68,4%	100%
Medium	1%	70,6%	100%
Not a SME	12%	74,0%	100%
In total	0%	68,4%	100%

Tab. 12: Customer influence on products (in %, n = 104)

Q88: How much do your suppliers influence the product?	Lowest value	Average value	Highest value
Micro	0%	38,7%	100%
Small	0%	30,0%	71%
Medium	0%	33,2%	84%
Not a SME	2%	49,2%	90%
In total	0%	34,5%	100%

Tab. 13: Supplier influence on products (in %, n = 104)

- Generally, customers have greater influence on a product than suppliers (on average 68.4% vs 34.5%).
- Customer influence increases slightly with company size but the differences are quite insignificant.
- Large companies seem to be more orientated towards their customers and suppliers (74% and 49.2%).

The final question aimed at the general estimation of a product's alignment with new (smart) technologies. Figure 84 visualises the level of adjustment as follows:

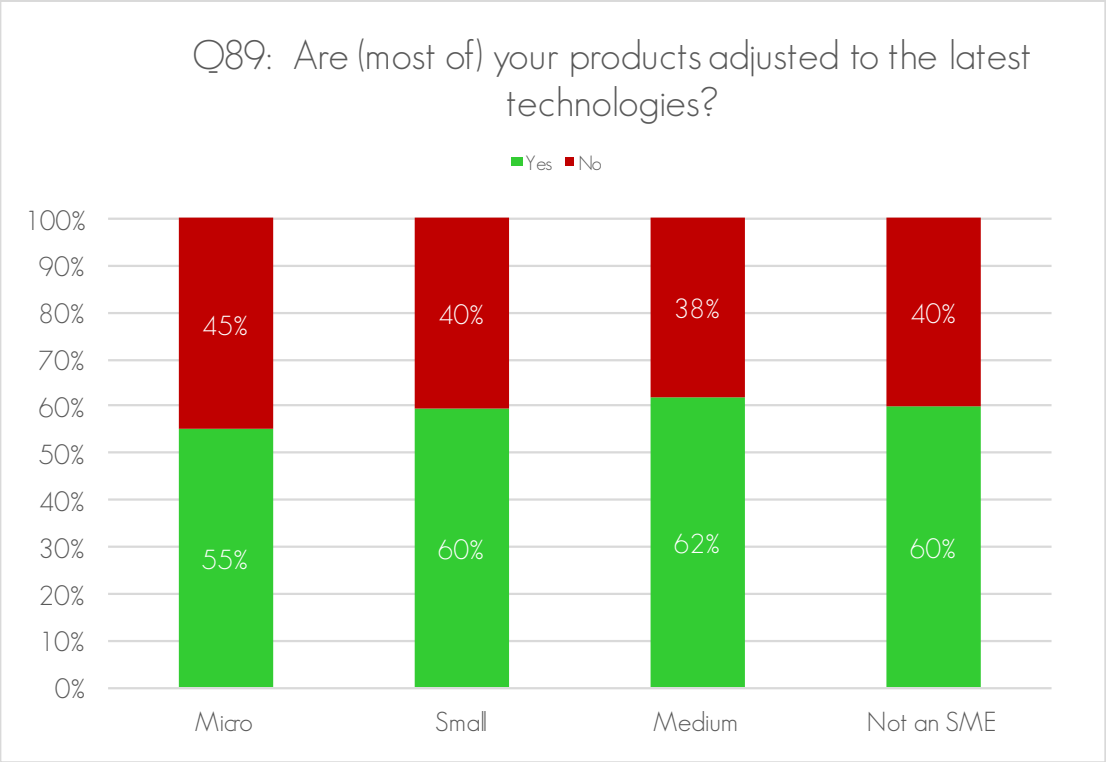


Fig. 84: Alignment of products with new technologies (in %, n = 101)

- The general estimation of product smartness is rather high by all companies (between 55% and 62%).
- The self-estimation by micro-companies, who earlier in the survey provided the most rated answers, is in this case the lowest of the four company size groups. Do they underestimate themselves or do the others overestimate themselves?

3. Results of the qualitative research

The outcomes below illustrate the most relevant findings from the semi-standardised qualitative interviews carried out in the participating SMeART partner countries. These findings are described country by country.

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emp Min
mp Max
mp Ambient
15,56 C
33,94 C
32,13 C
Date
Time
Job
XX-XX-XXXX
XX:XX
WW25D76
Customer
Status
Scale
World
Worki
MAX

AUSTRIA

In Austria, two small and three medium-sized companies were interviewed. The specific interview focus was on the success factors enabling sustainable cooperation between companies and HEIs in the field of smart engineering.

Most of the Austrian businesses maintain contacts with HEIs. However, the real benefits of this cooperation are mostly seen in the use of the HEIs' specific areas of expertise. This can be testing new products and materials or performing a chemical analysis for a product. These expectations correspond to the survey findings presented in figure 19: most businesses are interested in gaining innovative knowledge from the research sector.

Smart technologies are being used to a certain extent by the companies interviewed. Most difficulties experienced are caused by data security. For this reason, cloud systems are not popular digital solutions for data storage. However, companies do anticipate the smart future and are ready to undergo related challenges.

The technical staff interviewed wished for more strategic decisions and related investments from managements in relation to smart industry. Thus, investment in staff training plays a huge role.

BELGIUM

In Belgium, the interviews show that the largest demand of companies concerns finding the right people. This is also what they need most from HEIs, that they attract more students to technical subjects, and that they are taught insight and understanding.

Most companies realise they will still need to teach the newcomers the specifics in relation to the work of their company, however at present they see that many new staff often lack the most basic insights.

Companies are willing to work together with HEIs; however, this has not worked well so far.
Collaboration with smaller companies (such as start ups) are more common and seem to work better.

In Belgium the use of the cloud is also not common, as security continues to be the main reason behind keeping the data on the premises.

The vision of management is moving more towards smart industry.

GERMANY

The German companies interviewed seem to be very aware of smart industry, widely referred to as Industry 4.0 in Germany. Therefore, the demands of German companies are more specific and more concrete. There is no need to explain theoretical concepts to engineers and managers, but rather real solutions need to be presented. They want to know exactly what to do and how to do it to become smarter.

There are differences between Germany's more advanced and less developed companies in terms of their estimations about being smart. Those who have already had experience of smart industry seem quite annoyed about this hype and highlight that flexible collaboration between different stakeholders to commonly generate innovations is routinely practiced in Silicon Valley. However, many German companies, especially SMEs, tend to reinvent the wheel or rebuild already existing knowledge.

Companies with less experience wish to be supported in solving quite practical problems, such as the digitalisation of the selling process or improving customer relationships.

Collaboration with HEIs seems to work well in Germany, but it is also noted that expectations do differ. Universities need to adapt their working pace to that of SMEs, which is as a rule quite fast.

ITALY

The SMEs interviewed in Italy demonstrated a medium to very high level of smart production. All companies have a vision of becoming smart or improve their smart specialisation strategies. The digital future is typically connected with business expansion and planning new services, digitising data collection and analysis, after sale traceability, informing potential customers about the benefits of digitisation, lean manufacturing, and finally, improving the quality and quantity of products. This might be achieved, according to most companies, through qualified staff, who keep pace with new technologies.

At the same time, the constant training of employees seems to be the greatest need of most Italian companies. Related support can thus be provided by HEIs with their "fresh" knowledge concerning the latest technological developments and their application. Current levels of cooperation between Italian SMEs and HEIs is insufficient and needs to be improved, in particular, with a view to ensuring easier and transparent access to HEIs' offers for businesses.

SLOVENIA

The Slovenian companies interviewed operate under the umbrella of the Slovenian Digital Coalition and showed greater commitment to sharing their views about smart industry-related topics.

Many interviewees stated having smart industry strategies within their companies and pursuing related objectives. However, some of them are still at the initial implementation stage and therefore were not yet aware how companies could significantly improve their competitiveness through digitalisation.

Companies seem quite confident using smart industry-related applications such as Enterprise Resource Planning (ERP) or Manufacturing execution system (MES). At the same time, relevant technologies like machine interoperability or data mining are not yet widely used. The reason for this might be because employees lack specific competences, which are generally stated as being quite good but still need to be improved. In particular, staff need to be trained in IT systems, data analysis, data security, testing and verification of assistance system. Additionally, the relevance of transversal skills such as systemic and analytical thinking is highlighted.

Many companies are highly interested in developing new services using the advantages of digitalisation. Therefore, some good practice examples highlighting transformation to a smart company might be of great help to businesses.

SPAIN

The companies interviewed in Spain were drawn mostly from the mechanical engineering sector in the Biscay region (four of the five respondents), and which can be generally characterised as being small enterprises taking small steps towards digitalising their activities. These companies have only just started the transition from paper to digital files, and from drawings to easy CAD solutions. Data collection or analysis occurs in a quite traditional way using Excel files. Digital product design techniques are not implemented yet, and the companies just develop tailored suggestions for their clients using the most applicable process of manufacturing the products. No cooperation with researchers was indicated.

However, the future seems digital: due to increasing production volumes, manufacturing techniques need to be improved and the related investments – among others, in terms of regular staff training - are expected to be made by the management.

The demands and visions concerning digitalisation are most obvious at companies manufacturing electrical power modules. They have quite specific needs in relation to technical knowledge in big data, cloud computing, collaborative robotics, additive manufacturing and augmented reality.

THE NETHERLANDS

In the Netherlands, mostly medium-sized enterprises from the mechanical engineering industry were interviewed, who are niche market leaders (i.e. manufacturing batch mixers, weighing equipment for the food industry) and who are also at different stages of operating as smart factories. About 80% to 95% of the companies' activities involve export worldwide (i.e. to the Czech Republic and Saudi Arabia).

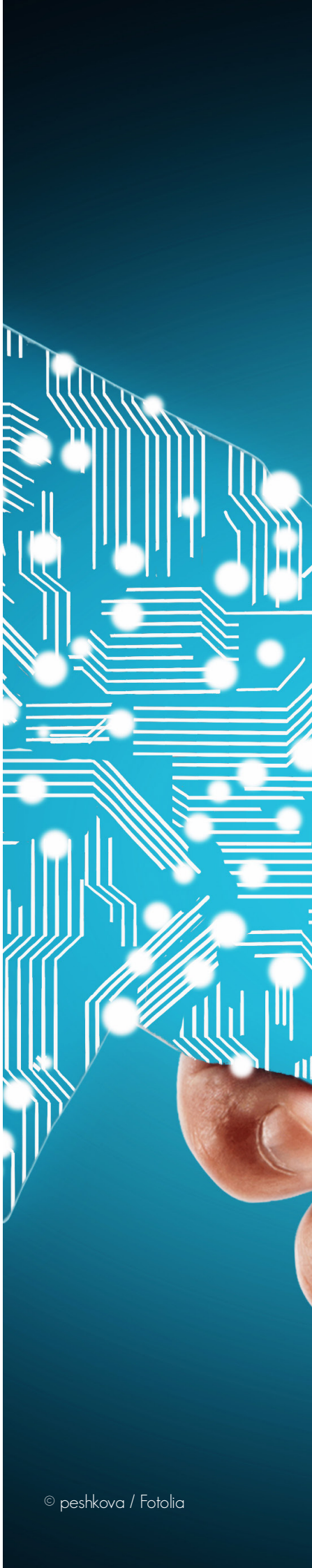
Therefore, companies need to be highly innovative in order to remain competitive in the long-term. Against this setting, innovative smart solutions are greatly appreciated by companies, such as robotics, implementing additional services to the products (servitization) and new organisation models (de-managing).

Due to the high level of awareness of smart industry, companies need to cope with more differentiated challenges, i.e. the correct use of robotics for manufacturing customised or mass production, data security and separation of machine data from customer data and smart measuring. Many companies stated their business visions, in which the customer acts as the co-creator of the products, so they rely on customers' knowledge. To manage these innovations, companies indicated their needs for cooperation with HEIs and researchers, who are relevant providers of specific know-how and young talent.

4. Conclusions

The empirical research conducted within the framework of the European project Knowledge Alliance for Upskilling Europe's SMEs provided useful data about the current situation concerning manufacturing enterprises in Europe in the field of smart engineering. On the one hand, 257 companies from Austria, Belgium, Germany, Italy, the Netherlands, Slovenia and Spain participated in the comprehensive online-survey and expressed their views, needs and expectations related to smart industry. On the other hand, 45 enterprises from these countries were interviewed with the aim to learn more about their visions of the smart factory. Based on both sets of research findings, the report on Learning and Business Consultant Needs of Europe's SMEs in Smart Engineering has been compiled, which reflects the data obtained and outlines a detailed picture of companies' demands as they move towards becoming smart.

The most relevant conclusions can be summarised as follows:



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SAMPLE

Most respondents (63%) are representatives of small and medium-sized manufacturing companies (primarily, business owners and general managers) specialising in metal products, machinery and equipment. The product portfolio ranges from approximately 50 different products (micro- companies) up to 6,000 (large companies). Average annual production volumes range between approximately 950,000 (small companies) and 4 billion (large companies). The average product lifetime is 10 years. The time it takes from product design to market launch is approximately 8 months.
The companies interviewed are mostly located in Europe and operate either within the EU or worldwide. Their typical customers are other businesses (B2B). Customised production is the most popular manufacturing technique.

SMART OR NON-SMART?

At least half of the respondents recognise themselves as being smart when comparing their production processes to the suggested definition of smart industry, which is given as being intelligent IT-based components and systems within all key areas of supply, production and distribution chains. Feeling smart leads to feeling more competitive and to the expectation of achieving fully integrated smart technologies within a maximum of five years. However, only a few SMEs named themselves as good examples of smart industry. Most companies are either at the initial stages or are only just thinking about possible options for introducing smart solutions.

AWARENESS OF SMART INDUSTRY-RELATED CONCEPTS

Not all terms related to smart industry are equally known. Of the 11 terms the respondents were asked about, the three least familiar terms were ‚Cyber production', ‚MES-system', and ‚M2M'. The three most known terms are ‚ERP-system', ‚Lean production', and ‚3D printing in production'. In particular, the respondent group General Managers demonstrated quite a high level of familiarity with smart industry-related terms.

SMART INDUSTRY-RELATED DIFFICULTIES AND CHALLENGES

Coping with data storage, data acquisition, and contractual and legal issues causes the most significant difficulties for respondents. It seems that SMEs and, in particular, micro-companies are better positioned when dealing with different types of difficulties compared to non-SMEs due to their flexibility and smaller dimensions.
Moreover, micro-companies and SMEs do not estimate many smart industry-related issues as being challenges to them or believe at least that they can be overcome with little effort. Thus, these companies can be considered as being agile organisations, able to rapidly adapt their business models, strategic management, business ideas and employee development to market and environmental changes in productive and cost-effective ways. Being agile is a relevant assumption for becoming smart.

KEY MILESTONES FOR BECOMING SMART

The most appreciated enablers of smart industry, which at the same time are claimed as needs by respondents, are knowledge of new sensors, competent staff and process automation. SMEs rate the relevance of qualified staff extremely high. Market knowledge and knowledge of technologies seem to already exist to quite a large extent.

WHERE ARE WE WITH SMART SOLUTIONS

Departments concerned with quality control, machinery and the development of new products are expected to benefit the most from the implementation of smart solutions.

SMART PRE-PRODUCTION

The vast majority of companies interviewed still applies market pull technology when designing a new product: customer needs or market research determine future products.
Data collection for designing new or optimising existing products seems to be an integral part of the pre-production process. However, voluminous and various data sets (big data) are rarely used, particularly by small companies.
Design applications and CAD techniques seem to be used equally by most respondents whilst CAPP technology is quite a new phenomenon for SMEs.

SMART PRODUCTION

ERP solutions are quite popular in today's business landscape and is widely used particularly by medium-sized companies, whilst the integration of automatic sequence planning in production processes is quite low.
Lean production is, on average, appreciated by at least half of all the respondents.
Products are being only partly automatically authorised with a tendency towards the non-usage of automatised technologies for product authorisation.
Monitoring of product development activities takes place at half of the companies interviewed.

SMART MATERIAL SUPPLY

Software solutions for optimising material management such as warehouse management systems (WMS) are more appreciated by SMEs than hardware solutions such as automated conveyor systems. Large companies use both solutions intensively for coordinating the movement of materials.

SMART MANU-FACTURING

Most SMEs still tend to apply less complex digital solutions such as drawings and checklists. However, technical environments at these companies include at least computer-based machinery equipped with software and sensors, e.g. CNC machines.
The use of more sophisticated solutions such as MES or automated product configurators is rather moderate amongst SMEs. Larger companies seem to be more confident with these technologies.
Data acquisition during manufacturing seems to be a must for large companies, however it also takes place at micro-companies and SMEs.
Machine interconnection is used to a lesser extent corresponding to the lack of knowledge about related technology (M2M), as identified previously.

SMART ASSEMBLY AND QUALITY CONTROL

The integration of complex digital solutions like assembly assistance systems within SMEs is quite low.
Small businesses lag significantly behind medium-sized enterprises when automatising quality control processes or identifying products of inferior quality.

SMART POST-PRODUC-TION: AFTER SALES & RECYCLING

Product tracing and data acquisition concerning products sold occurs in at least half of the medium-sized and micro-companies interviewed. Large companies compensate for their lower product tracing activities with data acquisition.
Half of the SMEs interviewed attest a high recycling potential to their products and their compatibility with older ones.

SMART DATA COLLECTION

At least half of the companies interviewed gather and evaluate production data. The most relevant fields for data collection are Quality, Product failures and Production time.
The most stated purposes for data collection by all company types are therefore Quality improvement, Optimisation and Efficiency improvement. Besides, micro-companies increasingly use collected data for developing new services.
Companies that do not practice data collection would potentially use data for achieving similar goals linked to decreasing faults and quality control.
Half of the companies, of all sizes, currently see difficulties in implementing data mining solutions.
Finally, more than half of the respondents from all company types claimed their products as being smart. Surprisingly, the micro-businesses, who previously achieved the highest rates for different smart indicators and therefore were predestinated for manufacturing smart products, are quite moderate with their estimations.

BUSINESS-RESEARCH COOPERATION

Only a quarter of respondents stated maintaining contact with HEIs, knowledge centres, research institutes or other organisations for the purpose of receiving knowledge input. Half of the small businesses interviewed indicated a lack of links with the research sector. This might be a relevant factor hampering the penetration of smart industry within companies.

Possible areas of cooperation between industry and researchers were formulated as follows:

- direct selection and recruitment of future employees
- testing of new products and services
- design and development of innovative products and services
- obtaining new knowledge
- receiving professional consulting
- establishing close cooperation and networks.

Half of the companies are primarily interested in obtaining and adapting specific knowledge offered by the research and HEI sector, especially related to (new) technologies.
One of the main factors jeopardising HEI-business cooperation is, according to the research results, the overly-strong theoretical approach by the research sector, their lack of practical orientation and their underestimation of SME development needs. This should be considered when designing a long-term business-research cooperation model.

Last but not least: the qualification and upskilling of employees is a point that continually crops up, in the online-survey as well from the in-depth interviews.

In smart industry, the tasks of employees change a lot. Therefore, they will need knowledge of new technologies and related skills on their application, transversal skills, and generally, more advanced insights into new concepts. Moreover, entire business models are changing what is required from management, so a high level of adaptability is essential. Appropriate skills to master these challenges are urgently needed.

This is a point upon which the higher education and research sector should interact with companies and support them in becoming smart. Report findings might be used by HEIs when (re)designing and delivering study programmes for their students, enabling them to successfully operate in tomorrow's smart factories. Furthermore, tailored training for today's employees can be designed, both formally and informally, allowing individually-paced learning. Business consultancies can provide services to management staff aimed at (re)designing business strategies for smart companies.

5. Looking ahead to the SMeART supporting tools

The comprehensive overview of the current situation and smart industry-related needs of SMEs provided in this report allows some relevant assumptions to be made in terms of developing supporting tools for SMEs as well as some predictions for SMEs helping them to take the necessary steps towards becoming smart.

In the past, and in the present, some key technologies significantly influenced the path to smart industry. When putting these technologies on a timeline a sort of 'technical roadmap' becomes clear. By connecting key technologies with today's smart companies, which have already implemented them, it might be easier for other companies to follow in their footsteps.

These steps can be identified from the answers to a few key questions, such as questions 18 and 19 of the survey. The known technologies, when they started to be used, and when they became 'common', can help identify the different milestones, and the general order of achieving them. In this manner, the questions 'Where do I stand?', 'What is my goal?' and 'How can I reach that goal?' might be asked and answered.

When setting up the survey and in-depth interviews, no clear idea of real SME demands was available. However, during the evaluation of the results obtained, a vision of the guidelines appeared, which would mirror SME needs and adequately address them by providing practical recommendations. Thus, the following guideline structure was drafted, based primarily on the survey questions and completed by other relevant aspects (marked in orange):

GUIDELINE PART 1: TECHNICAL TOPICS

2. PRODUCTION

Questions: 9, 24(c-g), 33, 36/58, 38/60, 41/63, 42/64, 47/69, 49/71,50/72,

a. Manufacturing/engineering
Questions: 13c, 19(h, i), 23
b. Assembly
Questions: 13b, 45/67, 48/70
c. Logistics and technical services
Questions: 35/57, 39/61, 40/62,
d. Infrastructure and applications
Questions: 19(e, h), 25(f, h), 34, 37/59, 85
e. Data management
Questions: 19(a-d), 25g, 28, 31, 34/56, 44/66, 46/68, 51, 52, 75, 76, 78, 79, 80

3. BUSINESS OPPORTUNITIES

Questions: /8, 10, 13 f - g, 25d, 27, 30, 32, 43/65, 49/71, 54, 55, 76(h, i), 78 (h, i), 83, 84, 86,

a. Marketing/product management
Questions: 13g, 30, 32, 43/65, 49/71, 54, 55, 83
b. Distribution management
Questions: 8, 13f, 86
c. Market needs
Questions: 10,25d, 27, 76(h, i), 78(h, i), 84

4. MANAGEMENT:

a. Human resource development
Questions: 13, 19f
b. Business law and compliance
Questions: 19g,25e
c. Controlling, administration
Questions: 24b, 25b, 38/60

GUIDELINE PART 2: PEDAGOGICAL ASPECTS

5. BUSINESS-HEI COOPERATION
a. Management of cooperation HEI/SME
Questions: 16, 17
b. Community setup for know-how exchange
Questions: 18, 25(a, g), 29,

6. CONSULTING & COACHING
a. Consulting plan setup
b. Monitoring and evaluation of the development processes

7. TRAINING

Questions: 24j, 25c, 47/69d,
a. Professional training plans
b. Informal vs. formal learning (VET/HE)
c. Adoption of recent learning activities

PART 3: ORGANISATIONAL ASPECTS

8. ORGANISATION MODEL
a. Agility
Questions: 15, 19i, 24(h-i)
b. Network (Supplier/Customer intimacy)
Questions: 13, 29, 53, 87, 88
c. Innovation
Questions: 21, 22, 24a, 25(a, g), 28, 77, 81, 89

Interested in receiving the Guidelines and benefiting from its findings? Follow SMeART developments by visiting the website www.smeart.eu and/or contacting the project team.

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