INSTITUTE FOR EMPLOYMENT RESEARCH
The Research Institute of the Federal Employment Agency

IAB-FORSCHUNGSBERICHT

Results from the project work of IAB

7|2021 Extracting Skill Requirements from Job Ads – the "Machbarkeitsstudie Kompetenz-Kompass"

Michael Stops, Ann-Christin Bächmann, Ralf Glassner, Markus Janser, Britta Matthes, Lina-Jeanette Metzger, Christoph Müller, Joachim Seitz

ISSN 2195-2655

Extracting Skill Requirements from Job Ads – the “Machbarkeitsstudie Kompetenz-Kompass”

Michael Stops (IAB)
Ann-Christin Bächmann (Leibniz-Institut für Bildungsverläufe)
Ralf Glassner
Markus Janser (IAB)
Britta Matthes (IAB)
Lina-Jeanette Metzger (IAB)
Christoph Müller (IAB)
Joachim Seitz (IT-Systemhaus der BA)

Assisted by:
Alina Hanebrink
Lea Lataster
Gerrit Müller (IAB)

Mit der Publikation von Forschungsberichten will das IAB der Fachöffentlichkeit Einblick in seine laufenden Arbeiten geben. Die Berichte sollen aber auch den Forscherinnen und Forschern einen unkomplizierten und raschen Zugang zum Markt verschaffen. Vor allem längere Zwischen- aber auch Endberichte aus der empirischen Projektarbeit bilden die Basis der Reihe.

By publishing the Forschungsberichte (Research Reports) IAB intends to give professional circles insights into its current work. At the same time the reports are aimed at providing researchers with quick and uncomplicated access to the market.

Contents

1 Summary 12

1.1 Selection of occupational sets 12

1.2 Method 12

1.3 Results 14

1.3.1 Hard skill requirements 14

1.3.2 Regional distribution 14

1.3.3 Soft skill requirements 15

1.3.4 Conclusions and outlook 16

2 Knowledge about Skill Requirements – Potential Benefits 17

3 Existing Approaches 17

4 “Machbarkeitsstudie Kompetenz-Kompass” 20

5 Data 22

5.1 Data from the BA’s employment website 22

5.2 Skill dictionaries 26

5.2.1 Hard skill requirements 26

5.2.2 Soft skill requirements 30

6 Results 32

6.1 Overview 32

6.2 The short-term development of skill requirements in job ads – analysis framework and example 37

6.3 Hard skill requirements 43

6.3.1 Preliminary remark 43

6.3.2 MAE occupations 43

6.3.3 ICT occupations 53

6.3.4 HES occupations 62

6.4 Soft skill requirements 71

7 Conclusion 79

8 Outlook 82

8.1 Current, periodic access to the evaluation results 82

8.2 Increasing the content-related scope 82

8.3 Further development of the methodologies 83

9 References 85

10 Appendix 88

10.1 Methods 88
10.1.1 Pre-processing method 88
10.1.2 Vacancies segmentation 88
10.1.3 On the identification of new hard skills 91
10.2 Individual skills according to Heyse/Erpenbeck (2004) 93
10.3 New skills found 95
10.4 Regional development of selected skill requirement 106
10.5 Additional results for soft skills 112
10.6 Number of skills found per job ad 119
10.7 Alternative data differentiations 121

Figures

Figure 5.1: Skills catalogue („Kompetenzatlas“) according to Heyse/Erpenbeck (2004) 31

Figure 6.1: The 25 most frequently mentioned hard skill requirements according to the three occupational sets ... 35

Figure 6.2: The 25 most frequently mentioned soft skill requirements according to the three occupational sets ... 36

Figure 6.3: Classification of the skill occurrence trajectories in job ads ... 39

Figure 6.4: Relative number of occurrences of skills in April/May 2019 and their development as compared to October/November 2019 ... 42

Figure 6.5: The 25 hard skill requirements in MAE occupations which gained most in importance ... 47

Figure 6.6: The 20 hard skill requirements in MAE occupations which gained most in importance, according to skill levels ... 48

Figure 6.7: MAE occupations, “skilled tasks” level: relative number of occurrences of skills in April/May 2019 and their development as compared to October/November 2019 ... 49

Figure 6.8: Development of the “photolithography” skill ... 50

Figure 6.9: Development of the “industrial mechanics” skill ... 51

Figure 6.10: Order of the number of relative occurrences of hard skills for vacancies for “machine building and operation expert” in Germany and in the federal states, October/November 2019 ... 52

Figure 6.11: The 25 hard skill requirements in ICT occupations which gained most in importance ... 56

Figure 6.12: The 20 hard skill requirements in ICT occupations which gained most in importance, according to skill levels ... 57

Figure 6.13: ICT occupations, “skilled tasks” skill level: relative number of occurrences of skills in April/May 2019 and their development as compared to October/November 2019 ... 58

Figure 6.14: Development of the “design patterns” skill ... 59

Figure 6.15: Development of the “development” skill ... 60

Figure 6.16: Order of the number of relative occurrences of hard skills for vacancies for “computer science experts” in Germany and in the federal states, October/November 2019 ... 61

Figure 6.17: The 25 hard skill requirements in HES occupations which gained most in importance ... 65

Figure 6.18: The 20 hard skill requirements in HES occupations which gained most in importance, according to skill levels ... 66

Figure 6.19: HES occupations, “skilled tasks” skill level: relative number of occurrences of skills in April/May 2019 and their development as compared to October/November 2019 ... 67

Figure 6.20: Development of the “laboratory diagnostics” skill ... 68

Figure 6.21: Development of the “anaesthetics” skill ... 69

Figure 6.22: Order of the number of relative occurrences of hard skills for vacancies for "health and nursing care experts" in Germany and in the federal states, October/November 2019 70
Figure 6.23: Relative number of occurrences of "personal skills" according to Heyse/Erpenbeck (2004) in job ads 75
Figure 6.24: Relative number of occurrences of "activity and action skills" according to Heyse/Erpenbeck (2004) in job ads 76
Figure 6.25: Relative number of occurrences of "functional and methodical skills" according to Heyse/Erpenbeck (2004) in job ads 77
Figure 6.26: Relative number of occurrences of "social and communication skills" according to Heyse/Erpenbeck (2004) in job ads 78
Figure 10.1: The manually segmented job ads vectorised by the algorithm serve as input for classifier training 89
Figure 10.2: The classifier can be applied to all job ads for automatic segmentation..... 89
Figure 10.3: Development of the "photolithography" skill 106
Figure 10.4: Development of the "industrial mechanics" skill 107
Figure 10.5: Development of the "design patterns" skill 108
Figure 10.6: Development of the "development" skill 109
Figure 10.7: Development of the "laboratory diagnostics" skill 110
Figure 10.8: Development of the "anaesthetics" skill 111
Figure 10.9: Total relative number of occurrences and relation of the relative number of occurrences between the different skill levels for personal skills according to Heyse/Erpenbeck (2004), October/November 2019 112
Figure 10.10: Relation of the relative number of occurrences between the different skill levels for activity and action skills according to Heyse/Erpenbeck (2004) .. 114
Figure 10.11: Relation of the number of relative occurrences between the different skill levels for functional and methodical skills according to Heyse/Erpenbeck (2004) 116
Figure 10.12: Relation of the relative number of occurrences between the different skill levels for social and communication skills according to Heyse/Erpenbeck (2004) 118

Tables

Table 5.1: Number of job ads ... 23
Table 5.2: Selected economic sectors (WZ08) and selected occupational main groups (KldB 2010) ... 24
Table 5.3: Number of evaluable vacancies according to the selected occupational sets ... 25
Table 5.4: Skill groups in BERUFENET and their usage ... 27
Table 5.5: Final result of the procedure for the identification of new skills ... 29
Table 5.6: New skills count of assignments to skill groups ... 29
Table 5.7: Examples of skills from BERUFENET ... 30
Table 6.1: Number of identified skill requirements ... 33
Table 6.2: Distribution of the number of skills across the deduced development types ... 41
Table 6.3: The 25 most frequently mentioned hard skill requirements for MAE occupations ... 45
Table 6.4: The ten most frequently mentioned hard skills for MAE occupations, according to skill levels ... 46
Table 6.5: The 25 most frequently mentioned hard skill requirements for ICT occupations ... 54
Table 6.6: The ten most frequently mentioned hard skills for ICT occupations, according to skill levels ... 55
Table 6.7: The 25 most frequently mentioned hard skill requirements for HES occupations ... 63
Table 6.8: The ten most frequently mentioned hard skills for HES occupations, according to skill levels ... 64
Table 6.9: The ten most frequently mentioned soft skill requirements according to occupational sets ... 72
Table 10.1: Quality of the classifier for vacancies segmentation ... 90
Table 10.2: Individual skills according to Heyse/Erpenbeck (2004) ... 93
Table 10.3: New skills ... 95
Table 10.4: Number of skills found per job ad ... 120
Table 10.5: Number of vacancies related to vacancies without temporary employment and all vacancies, October/November 2019 ... 121
Table 10.6: Number of skill requirements identified in job ads without temporary employment ... 122
Table 10.7: The 25 most frequently mentioned hard skill requirements in MAE occupations for vacancies without temporary employment vs. all vacancies, October/November 2019 ... 123
Table 10.8: The 25 most frequently mentioned hard skill requirements in ICT occupations for vacancies without temporary employment vs. all vacancies, October/November 2019 ... 124

Table 10.9: The 25 most frequently mentioned hard skill requirements in HES occupations for vacancies without temporary employment vs. all vacancies, October/November 2019 125
Table 10.10: The 25 most frequently mentioned hard skill requirements for MAE occupations in the job ads without considering the number of vacancies vs. all vacancies, October/November 2019 126
Table 10.11: The 25 most frequently mentioned hard skill requirements for ICT occupations in the job ads without considering the number of vacancies vs. all vacancies, October/November 2019 127
Table 10.12: The 25 most frequently mentioned hard skill requirements for HES occupations in the job ads without considering the number of vacancies vs. all vacancies, October/November 2019 128

Abbreviations

BA	Bundesagentur für Arbeit (Federal Employment Agency)
BA-Jobbörse	Employment website of the Federal Employment Agency, https://jobboerse.arbeitsagentur.de
BAuA	Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (German Federal Institute for Occupational Safety and Health)
BIBB	Bundesinstitut für Berufsbildung (Federal Institute for Vocational Training)
BMAS	Bundesministerium für Arbeit und Soziales (Federal Ministry of Labour and Social Affairs)
IAB	Institut für Arbeitsmarkt- und Berufsforschung (Institute for Employment Research)
ICT occupations	Occupations in computer sciences and information and communication technology (occupational main group 43 German Classification of Occupations 2010)
HES occupations	Medical occupations in health care (occupational main group 81 of the German Classification of Occupations 2010); non-medical occupations in health care, personal hygiene, and well-being, medical engineering (occupational main group 82); education, social and household occupations, theology (occupational main group 83)
KldB 2010	German Classification of Occupations 2010
MAE occupations	Occupations in mechanical and automotive engineering (occupational main group 25 German Classification of Occupations 2010)
rF	The average number of occurrences of a skill requirement per job ad; also referred to as the "relative number of occurrences" or "relative frequency of occurrences" in this report.
R.	Ranking
WEF	World Economic Forum
WZ08	Classification of economic activities 2008
ZEW	Leibniz-Zentrum für Europäische Wirtschaftsforschung (Leibniz Centre for European Economic Research)

Abstract

Knowing what skills are required by employers when recruiting new workers is an important basis for the work of all labour market actors. In the 2nd part of the “Machbarkeitsstudie Kompetenz-Kompass” project, we developed a methodology to identify recent hard and soft skill requirements in job ads published on the “BA-Jobbörse” employment website provided by the Federal Employment Agency. We focus on three broad occupational sets with job contents that comprise economic activities such as mechanical engineering, information services, and human health and social work activities. Based on example analyses, we show that our methodology potentially allows us to identify the development of up-to-date skill requirements in job advertisements broken down to job titles, skill levels, and regions. We also developed a methodology for the completion of skill dictionaries with new skill categories and new search terms. Our methodology is also able to support the selection of specific skills according to their relevance in job ads for education providers and training institutions. We conclude this report with a short description of the most relevant measures to provide general access to the detailed results, access to the further analysis potential, and further improvement of our methodology.

Zusammenfassung

Kenntnisse darüber, welche Kompetenzen von Arbeitgebern bei der Besetzung neuer Stellen gefordert werden, sind wichtige Arbeitsgrundlagen für alle Arbeitsmarktakteure. Zu der Frage, wie solche Kenntnisse generiert werden können, haben wir vom 1. Juni 2019 bis 30. Mai 2020 das Projekt "Machbarkeitsstudie: Kompetenz-Kompass" durchgeführt. In diesem Bericht informieren wir über das Teilprojekt 2, in dessen Rahmen wir ein Verfahren zur Identifikation aktueller fachlicher und überfachlicher Kompetenzanforderungen aus veröffentlichten Stellenangeboten der Jobbörse der Bundesagentur für Arbeit entwickelt haben. Dabei fokussieren wir auf drei Berufsgruppen mit Einzelberufen, die die Hauptbetätigungsfelder der Branchen des Maschinenbaus, der Informationsdienstleistungen und des Gesundheits- und Sozialwesens abdecken. Wir zeigen anhand ausgewählter Analysen, dass es mit unserem Auswertungsverfahren potenziell möglich ist, die Entwicklung von Kompetenzanforderungen in Stellenanzeigen mit hoher Aktualität und mit hoher Validität entlang von Berufen, Anforderungsniveaus und Regionen nachzuzeichnen. Zudem entwickeln wir eine Methode, mit der man in den Kompetenzwörterbüchern bisher nicht bekannte Kompetenzen oder Suchwörter ergänzen kann. Das Verfahren kann damit in Ergänzung zu anderen Informationsquellen zum Arbeitsangebot die Auswahl von spezifischen Kompetenzen nach ihrer Relevanz für die Gestaltung von Aus- und Weiterbildung unterstützen. Wir schließen den Bericht ab mit einer kurzen Beschreibung der aus unserer Sicht wichtigsten Maßnahmen zur Nutzbarmachung der detaillierten Ergebnisse, zur weiteren Erschließung des Auswertungspotenzials von Stellenanzeigen sowie der weiteren Verbesserung des Auswertungsverfahrens.

Acknowledgements

This research report is the English version of the German BMAS-Forschungsbericht 553 “Machbarkeitsstudie Kompetenz-Kompass - Teilprojekt 2: Beobachtung von Kompetenzanforderungen in Stellenangeboten”[1] that was created on behalf of the German Federal Ministry of Labour and Social Affairs.

The research has been conducted and the conclusions from this research have been drawn by the authors in their own scientific responsibility. The German Federal Ministry of Labour and Social Affairs expressly does not assume any liability for the validity, accuracy, and completeness of this research. The authors thank the German Federal Ministry of Labour and Social Affairs for the allowance to publish this English version as IAB-Forschungsbericht.

The text was thoroughly translated together with “Text im Fluss GmbH”, Fürth. The authors also thank Judith Gilsbach and Fiona Holden for technical assistance. However, only the authors are responsible for any remaining errors and appreciate any feedback, comments, and questions (please write an email to michael.stops@iab.de).

[1] Stops, Michael; Bächmann, Ann-Christin; Glassner, Ralf; Janser, Markus; Matthes, Britta; Metzger, Lina-Jeanette; Müller, Christoph; Seitz, Joachim; Hanebrink, Alina (Mitarb.); Lataster, Lea (Mitarb.); Müller, Gerrit (Mitarb.) (2020): Machbarkeitsstudie Kompetenz-Kompass * Teilprojekt 2: Beobachtung von Kompetenzanforderungen in Stellenangeboten. (Bundesministerium für Arbeit und Soziales. Forschungsbericht, 553), Berlin, 142 p., LINK, last download on 9 July 2021

1 Summary

For labour market actors, it is essential to know the current and most relevant skill requirements of employers that recruit new workers. It allows the Federal Ministry of Labour and Social Affairs and the Federal Employment Agency to monitor the demand side of the labour market more accurately and draw conclusions for the orientation and implementation of labour market policy more quickly; this information may help employers to align their recruiting strategies, and employees may reference the results on current skill requirements when it comes to planning their personal careers.

Previous approaches to identifying current or future skill requirements for the German labour market have been based on projections, expert databases, surveys, or the evaluation of job ads. However, no analyses have yet been presented that systematically differentiate between different requirement categories such as hard and soft skill requirements and evaluate them individually. Moreover, to our knowledge it has not yet been attempted to make current, valid, and sophisticated statements on the specific skill requirements for selected individual occupations and regions and the related changes to such requirements.

The project “Machbarkeitsstudie: Kompetenz-Kompass” project supported by the BMAS and carried out between 1 June 2019 and 30 May 2020 focused on these gaps. In this report, we will inform about the partial project 2, where we developed a methodology for the systematic, content-oriented evaluation of hard and soft skill requirements based on job ads published on the employment website of the Federal Employment Agency (BA-Jobbörse).

1.1 Selection of occupational sets

We focused on three occupational sets covering the main areas of activity of mechanical engineering and information services as well as the health and social sector. These sectors were chosen because distinct differences regarding the skill requirements could be expected for these occupations. Moreover, these are occupational sets that have relatively high employment shares compared to the overall economy; therefore, sufficient variation in the job ads along the planned evaluation dimensions could be expected.

1.2 Method

For our evaluations, we used two access samples for the selected occupational sets of all job ads published on the BA-Jobbörse website. The job ads of the first access sample were published in April/May 2019, and the job ads of the second access sample were published in October/November 2019.

The job ad texts were first subjected to comprehensive pre-processing. This included text mining procedures used to standardise texts. These procedures comprised the conversion of certain characters (e. g. uppercase to lowercase), the deletion of non-relevant words using a stop word list, the “fragmentation” of the text into evaluable word units, and shortening different synonymous words with the same word stem to use only that word stem.

The parts of the job ad texts relevant for our analyses are those where the employers state the skills they require from the applicants and describe the tasks to be performed. In order to identify these parts of the job ad texts, we used a "segmentation procedure" based on machine learning algorithms. This segmentation procedure is required because otherwise certain words occurring in other parts of the job ad texts might incorrectly be interpreted as skill requirements. For example, a job ad usually also contains texts introducing the company itself, which often include descriptions of skills, which, however, refer to the company and not to the vacancy.

To identify the hard skill requirements, we used the catalogue of the BA's BERUFENET expert database, and to identify the soft skills, we employed the skills catalogue ("Kompetenzatlas") by Heyse/Erpenbeck (2004). Both catalogues also underwent the above-mentioned pre-processing procedure. Furthermore, any word listings in the skill catalogues were dissolved. Afterwards, the terms were transferred to skill dictionaries where one or more keywords were assigned to the individual skill requirements. "Search and find" rules had to be specified for skill requirements with more than one term: Identifying each of these requirements in the job ad texts made it necessary to decide which terms to include and in which combination.

Additionally, we developed and tested a methodology to complement the hard skill dictionary with additional keywords and skills not yet recorded. To do so, we used an algorithm based on a neural network and machine learning procedure called "word embedding" to generate assignment suggestions for new skill terms. These suggestions were then reviewed as part of a consensual validation procedure by several subject matter experts. In doing so, we defined a total of 284 additional hard skills and generated a very high number of additional keywords or combinations of keywords. The latter result from a number of keywords belonging to a certain skill that had to appear in one or more possible combinations in the job ad text to be examined in order to indicate the occurrence of this skill. The additionally identified skills are both "new" skills and those that fill existing gaps in the hard skill dictionary. This methodology could generally also be applied to other dictionaries.

In total, there are 7,270 requirements with 10,116 keywords and 23,158 different keyword combinations for the dictionary of hard skills that are distinguishable in terms of content. The dictionary of soft skills consists of 64 requirements that are distinguishable in terms of content; this includes 83 keywords and 71 different keyword combinations. For the interpretation of the number of keywords in both dictionaries it should be considered that word stems were counted. This implies that the number of potentially recorded synonymous words derived from the word stems is larger.

On the basis of the edited dictionaries, we found an average of between two and slightly over eight hard and soft skill requirements per job ad in the job ad texts. The number varies dsitinctly between the occupational sets and skill levels. The largest number of requirements per vacancy was identified for information services occupations, followed by mechanical and automotive engineering occupations, and health and social sector occupations. For all occupational sets, considerably more hard skill than soft skill requirements were identified. Moreover, the number of hard skill requirements identified increases with higher skill level, whereas no such pattern can be found for soft skill requirements.

The methodology developed makes it possible to evaluate skill requirements according to their occurrences along occupations, regions, and skill requirement levels. This is documented in the

study by means of exemplary evaluations for the two survey periods and for the short-term changes between the two periods of time.

1.3 Results

1.3.1 Hard skill requirements

The results for hard skill requirements show, as expected, that the skills most frequently mentioned in the job ads can be considered typical for each of the observed occupational sets . For example, the skill requirements “service, repair, maintenance”, “industrial mechanics”, “mechatronics”, “work according to drawings”, and “mechanics” occurred most often in the job ads for mechanical and automotive engineering occupations from October/November 2019. For information services occupations, they were “development”, “analysis”, “management”, “software implementation”, and “Java programming language”. For health and social sector occupations, the skills “nursing care”, “geriatric care”, “treatment care”, “nursing documentation”, and “basic nursing” were mentioned most frequently.

In some cases, the degree of abstraction of the skills mentioned increased with higher skill levels. For mechanical and automotive engineering occupations, very specific and simple activities were frequently required for the “unskilled or semiskilled tasks” skill level (e. g. “loading”, “deburring”, “packing”), whereas for the “complex tasks” skill level, terms such as “mechatronics”, “mechanics”, or “construction” were mentioned. No such pattern was found for the information services occupations. And for the health and social sector occupations, this kind of pattern was found to some extent only in the ranking. For example, “washing” was mentioned frequently as a very specific and simple requirement for “unskilled or semiskilled tasks”, while “supervision/management” as a more general and complex requirement was among the most frequently mentioned terms for “highly complex tasks” only.

In order to classify the changes to hard skill requirements along their importance as yet and the extent of their transformation, the study recommends a simple, descriptive framework suitable for the evaluation options which embraces the idea of a “lifecycle” for skills, analogous to product lifecycles. The importance of a skill is measured by means of the average number of occurrences per job ad.

In the study, this framework is applied by way of example to the identified hard skill requirements in the three occupational sets. In addition to that, those skills, which occurred more frequently in the job ads between the two survey periods, are examined in more detail. The results showed that skill requirements mentioned less frequently in the first survey period were very much regionally located at first and expanded in the second survey period, or the regional focus changed.

1.3.2 Regional distribution

When looking at the regional distribution of occurrences of the relatively seldom mentioned “laboratory diagnostics” requirement in the job ads for health and social sector occupations, for example, we can see that this skill requirement was required in all federal states except for Saarland, Thuringia, Brandenburg, and Saxony-Anhalt in April/May 2019. In October/November 2019, this skill requirement showed an increase in almost all federal states, only in Saxony-Anhalt and Saarland it was still not required, and in Schleswig-Holstein, the number of occurrences in the job ads

decreased slightly. By comparison, Mecklenburg-Western Pomerania and Hesse showed the highest increases, followed by Bavaria, Saxony, and Berlin.

For skills frequently mentioned at a supraregional level, we can see that they were widely used at the regional level in the first survey period, and in the second survey period, either the total number of occurrences increased in all regions, or the regional focus shifted as well.

For the "industrial mechanics" requirement frequently mentioned in the job ads for mechanical and automotive engineering occupations, it can be said, by way of example, that it was mentioned in job ads for all federal states. There were regional differences: in North Rhine-Westphalia, the skill was mentioned in job ads much more frequently than, for example, in Thuringia. In October/November 2019, however, the relative demand in the job ads decreased in the eastern federal states and in Saarland. Regional differences became apparent here as well. For example, the relative number of occurrences of "industrial mechanics" in job ads decreased to a greater extent in Mecklenburg-Western Pomerania than in Saxony-Anhalt. In contrast, in the western federal states, the relative demand in the job ads even increased, and in Hamburg, for example, it increased to a greater extent than in Bavaria.

At the level of one selected individual occupation per occupational set, the results showed similarities but also considerable differences in the ranking of the hard skill requirements occurring most often in the individual federal states. These results also show the importance of evaluations at the regional level.

For the individual occupation "computer science specialist", for example, the "system integration" requirement was almost always the most frequently required skill. In Brandenburg and Saxony, this requirement was in the second place, and in Hesse, it was in the third place of all occurrences. In contrast, the "planning" requirement for the same individual occupation, for example, ranked between the third (Schleswig-Holstein) and 40th place (Bremen) of occurrences.

1.3.3 Soft skill requirements

The comparative analysis of soft skill requirements showed that only very few of these requirements were mentioned frequently in the job ads across all occupational sets. They included, among others, "ability to work in a team", "reliability", or "communication skills". Among the ten most frequently mentioned soft skills in the respective occupational sets, there were four additional requirements that were mentioned less frequently, but also across all occupational sets: "self-management", "resilience", "commitment", and "willingness to learn".

In addition to that, there were two skill requirements that were mentioned frequently in the mechanical and automotive engineering occupations and in the information services occupations, but not in the health and social sector occupations: "project management" and "dialogue ability customer orientation". And there were requirements that occurred only in one of the three occupational sets in the ranking of most frequently mentioned skill requirements. They were "mobility" for mechanical and automotive engineering occupations, "analytical skills" for information services occupations, and "expertise" as well as "social commitment" for health and social sector occupations.

Another considerable result was the relatively high heterogeneity with regard to the number of relative occurrences of the individual soft skill requirements between the three occupational sets.

Even where these requirements were mentioned relatively often within the occupational sets, the number of occurrences of these requirements varied distinctly between the occupational sets. With regard to the evaluation along the skill levels, again no obvious patterns could be identified. The results do not suggest that there is a typical combination of soft skill requirements which are equally relevant to all (examined) occupational sets or skill levels.

1.3.4 Conclusions and outlook

We conclude that this methodology can be used to trace the status and development of skill requirements in job ads with a high degree of topicality and validity. The methodology has the potential – from the labour demand perspective – to identify the respective specific skill requirements in the occupations and regions according to their relevance and thus to support the orientation of training and further education measures. For specific measures, further information would have to be used, especially assessments geared towards a comparison with the available labour supply.

However we see a necessity for further development of the methodology.

In order to ensure topicality, access samples must be evaluated on a regular basis. The analyses to date show that there are already high dynamics in the occurrences of skills with a survey frequency of six months. With a survey frequency of six months, intra-annual development patterns – which occur, for example, with regard to seasonal effects or economic turning points – could also be recorded at least on a general basis.

This report was only able to give some indications of the information potential of the methodology developed. For a detailed, individual occupation-specific or region-specific results representation, we think a business intelligence system with front ends would be required where the data and analysis results can be presented clearly and in a target group-specific way.

Additional dictionaries besides the hard and soft skill dictionaries could be included in the evaluations; for example, on languages or vocational qualifications. For each of these dictionaries, however, both data selection and pre-processing must be specifically defined. Besides the information gain, the rate of evaluable text material would also increase further.

Moreover, an evaluation of job ads according to economic sectors would generally be desirable. Currently, information on the economic sectors is available for almost two thirds of all job ads. It would be conceivable to test classification procedures which use the contents of the job ad texts to identify the economic sector they belong to.

Possible improvements to the methodologies would be aimed at identifying skill requirements in the texts not identified to date and, with regard to the skill requirements already identified, to further reduce the number of faulty evaluations and to increase the validity of the developed importance measures for the skill requirements.

2 Knowledge about Skill Requirements – Potential Benefits

Knowledge about current skill requirements and their changes is an important working basis for all labour market actors.

The following potential benefits arise for the Federal Ministry of Labour and Social Affairs and the Federal Employment Agency:

- Valid and more up-to-date observation of the demand side of the labour market
- More transparency on the labour market due to the utilisation of the results in labour market reporting
- Better alignment of the (regional) further education programmes

For employers, this information can be used to take measures to cover their (future) demand for skilled workers. For example, the information can help with creating and comparing skill and talent profiles of the employees and job profiles. This makes it possible to identify individual qualification needs and align in-company further training programmes.

Employees may use the information on current skill requirements for planning their own carriers and further training paths.[2]

In addition, there is huge research potential for the scientific community by linking the data to other data sources on the structural characteristics surveyed (e. g. region, occupation, economic sector, company, etc.). Manifold economic and social science-related questions could be examined.

This report presents an approach on how skill requirements can be extracted from job ads, and how the development of the requirements' importance can be measured.

3 Existing Approaches

Previous approaches to identifying current or future skill requirements have been based on projections, expert databases, surveys, or the analysis of job ads.

For projections, i. e. studies on the prediction of the future labour market structure, it can generally be said that the further they look into the future, the more general the indications on future developments of skill requirements and/or employment structures must be (see the model-based labour market projections of the Institute for Employment Research which refer to the occupational fields level and not to the skill level, Zika et al. 2018). Any prediction of the importance of specific or individually definable skill requirements is thus impossible.

[2] This requires the information to be presented in a most widely differentiated form (occupations, sectors, regions). Otherwise, it could not be ruled out that the skill profiles of employees are more likely to converge, which would not satisfy a job structure with differentiated requirements.

One possibility of (at least approximately) identifying current skill requirements for Germany is the analysis of heuristics such as the BERUFENET[3] database of the Federal Employment Agency. BERUFENET contains idealized descriptions of occupations. Although their relevance and validity is ensured by a number of procedural requirements and institutional coordination processes, new skills are only added with a temporal delay. Moreover, it is assumed that there are no differences regarding the skill requirements in the occupations. In practice, they do vary because there are specific requirements in different regions or economic sectors, e. g. due to the specific economic structure in a given region.

Survey data are another source for analysing skill requirements. In the BIBB/BAuA employee survey, for example,[4] approx. 20,000 employees are interviewed in approx. five year intervals about their specific professional activities (among other things).[5] For a standardised set of categories, data are collected on how frequently certain specified activities must be completed or requirements must be met. Although there is the possibility of entering information on activities or requirements not addressed in free text form, this information is seldom used because the interviewees struggle to add anything to the categories surveyed, which are, after all, very abstract. In addition to that, less common occupations are generally not included in the surveys – even with the high number of interviewees. Furthermore, it cannot be guaranteed due to the number of cases that representative statements on the requirements in the associated individual occupations can be derived from the information provided by the interviewees about their jobs. Valid statements on individual occupations can thus not be ensured. Generally, the survey frequency also determines whether analyses can be performed on an up-to-date basis. With a relatively low survey frequency as is the case with the BIBB/BAuA employee survey, this is possible only to a limited extent.

More frequently performed (establishment or firm) surveys such as the IAB Job Vacancy Survey also address skill requirements; however, this survey focuses on selected general skill categories.[6] The "Arbeitswelt 4.0" establishment survey jointly initiated by the IAB and the Leibniz Centre for European Economic Research traces the changes in skill requirements from the establishment point of view, but also focuses on a standardised set of categories (for implementation information, see Arntz et al., 2016).

Bitkom research (2015) interviewed 300 companies on the specific knowledge and skill sets that were becoming more important at the time of the survey and would become more important over the next ten years. First, this survey is limited to a low number of cases and only a few sectors. Additionally, the question of a predetermined set of skills carries the risk that relevant but unmentioned skills cannot be identified. Moreover, each of the companies involved is forced to look into the "crystal ball" in a manner of speaking, regardless of the degree of knowledge and innovation.

On the basis of an analysis of job ads, the World Economic Forum, for example, specified the ten most important skill requirements for the present (2018) and future (2022), respectively, as well as

[3] BERUFENET is an online portal for vocational information of the Federal Employment Agency and describes the typical requirements of and activities to be performed in the jobs; see https://berufenet.arbeitsagentur.de/.

[4] "BIBB" stands for "Bundesinstitut für Berufsbildung" and "BAuA" for "Bundesanstalt für Arbeitsschutz und Arbeitsmedizin".

[5] https://www.bibb.de/de/12138.php

[6] In the survey of the fourth quarter 2015, these were, for example, "longer experience in this line of work", "knowledge and skills which are only acquired in seminars or courses after vocational training", "intercultural competencies", "knowledge of foreign languages", "social competence, communication skills, capacity for teamwork", and "leadership skills", see http://doku.iab.de/fragebogen/IABSE_Papier-Fragebogen_IV_2015.pdf.

the ten skill requirements that will become least important (WEF 2016, 2018). The US O*NET shows a similar destination route and reports the 50 most frequently mentioned "hot technologies".[7] More specifically, these are technical requirements that can be found very frequently in job ads by employers (Lewis/Norton 2016). Both approaches are based on data and technology by burning-glass, a company which provides labour market data and analyses. According to Taska (2017), burningglass collects data from job ads on employment websites. As a commercial provider, burningglass provides pre-specified evaluations of its collected and provided data. To the knowledge of the authors of this study, there is no intention to provide direct access to the data and/or analysis options resulting from them, for example, with regard to the expansion of evaluation options beyond existing skill sets, the questions on representativeness, and also on the scope of the data material across the economic sectors or individual occupations.

Another example for the analysis of job ads is the "Swiss Job Market Monitor", which deals with the automated processing of job ads. To date, it has been used to answer more general questions such as the extent of qualitative mismatches (see Buchs and Buchmann 2017, p. 58).[8] We are not aware of any current published analyses concerning the development of skill requirement occurrences with any professional or regional differentiations for Switzerland.

The "Skills Online Vacancy Analysis Tool for Europe" (Skills OVATE, see Cedefop 2019)[9] is another example. Skills OVATE currently provides an overview of skills required by employers in seven European countries, including Germany. These are classified by regions, occupations, and skills on the basis of internationally comparable classifications.[10] Although country-specific evaluations are possible, the focus is on international comparability. Therefore, classifications are taken as a basis for the occupational and skill dimensions which primarily are to provide comparability, while the consideration of specific conditions of individual national labour markets and/or regional economic structures is less important.

The Federal Institute for Vocational Training (BIBB) presented a methodical study on the identification of job ad text segments on the basis of a number of employment website data from the BA collected on an annual basis with a deadline in October (Hermes and Schandock, 2016). Moreover, the BIBB developed a taxonomy of means of work on the basis of job ad texts (Güntürk-Kuhl et al. 2017). Both papers are to support the content-based analysis of job ads. The BIBB uses a skill catalogue from Austria as a basis in order to identify skill requirements in job ads (Schandock 2019).[11] The BIBB job data analyses on the basis of multi-year continuance waves aim at supporting the BIBB's alignment work and the design of contents of dual vocational training. In particular, research is done on how to validly identify those means of work and skills that could become an imminent part of certain professional activities over a longer period of time in the future. The focus

[7] https://www.onetonline.org/search/hot_tech/; "Hot technologies are requirements frequently included in employer job postings".

[8] On the website, the job market analysis is explicitly mentioned, though, especially the "investigation of long-term structural trends and short-term economic fluctuations in job ads, particularly with regard to the qualitative shifts in the company qualification needs" (https://www.stellenmarktmonitor.uzh.ch/de/research.html, last downloaded on 4 March 2019).

[9] http://www.cedefop.europa.eu/en/data-visualisations/skills-online-vacancies; last downloaded on 25 April 2019.

[10] ISCO-08 for the occupations, ESCO version 1 for skills, NUTS-2 for regional differentiation, see also previous footnote.

[11] In addition to that, Rengers (2018) investigated whether the BA-Jobbörse data could be used for the official statistics. This investigation was primarily about the quantitative recording of vacancies. As compared to the undertaking described here, the level of detail of the information to be processed is much lower.

is not on a differentiated consideration across the regions. To our knowledge, short-term, intra-annual developments are not evaluated.

With the increasing use of online job ads, a potential data source has been emerging which can be used to trace developments of certain skill requirements of particular importance to employers up to the latest available data.

However, there have been no analyses yet that systematically differentiate between different requirements categories such as hard and soft skill requirements and evaluate them individually for the German labour market. Moreover, to our knowledge it has not yet been attempted to make current, valid, and sophisticated statements on the specific skill requirements for selected individual occupations and regions and the related changes to such requirements.

4 "Machbarkeitsstudie Kompetenz-Kompass"

The objective of the "Machbarkeitsstudie Kompetenz-Kompass" project was to process and report on the current hard and soft skill requirements from job ads as well as their changes in terms of job titles, skill levels, and regions.

Moreover, the importance of the skill requirements mentioned in the job ads is to be measured using the average number of their occurrences per job ad (in the following referred to as "relative number of occurrences" or "relative frequency of occurrences"), so that when comparing different points in time, conclusions can be drawn as to whether one skill requirement gained so much importance that it may become a typical (core) skill for one or more occupations.

With regard to the terms "skill" and the "skill requirements" derived from it, the study follows the skill definition by Weinert (2014, p. 27): Skills are "the cognitive capabilities and abilities available in individuals or acquired by them to solve specific problems, and the related motivational, volitional and social readiness and capabilities to use problem solutions in variable situations in a successful and responsible way […]" .[12]

Moreover, the following definitions apply to the study:

- "Hard skills" are individual capabilities to master tasks and situations within a specific context of a professional activity autonomously and independently.
- "Soft skills" are also individual capabilities of people which allow them to master or at least facilitate specific tasks and situations. Soft skills, however, do not have any specific content-related connection to theoretical or factual occupation distinctions.
- "Skill requirements" are the expectations regarding hard and soft skills of employees to be recruited which are verbalised in the employers' job ads. This definition includes job descriptions, since a sharp term-related differentiation of requirements and job descriptions is neither done in the job ads nor in the (hard) skill catalogues. Moreover, the verbalisation of job descriptions can be understood as constituting implicit requirements.

[12] Own translation from German into English.

We assume that employers do not verbalise by far all their core requirements for a given job in the job ads. We furthermore assume that employers include core requirements explicitly in those situations when they consider them to be inevitable for carrying out the activities in the job they offer. There are other criteria as well:

- Employers consider these requirements to be uncharacteristic, i. e., usually not part of the occupational profile. This may be the case when they consider skills to be "new" requirements for the jobs they offer; or
- employers find that applicants for a certain occupational profile frequently do not have the skills they require; or
- employers are not even looking for a specific occupational set but are interested in applicants covering the majority of the skill requirements.

We assume that skill requirements explicitly mentioned in the job ads generally have a high relevance when it comes to recruiting labour force. This also applies to the expectations associated with the occurrence of a job title with regard to the typical skills coming along with it.[13] However, explicitly mentioning a specific skill requirement in a job ad emphasises the relevance of this requirement for the performance of the required tasks.

For the analyses, job ad texts from the BA's employment website (BA-Jobbörse) and relevant German reference catalogues for hard and soft skills were used. The data were comprehensively preprocessed, and in particular the skill catalogues were transferred to skill dictionaries which assign one or more keywords to each skill. [14]

Furthermore, methodologies were developed which allow for completing both the skills and the keywords behind them. Using this methodology, the existing dictionary of hard skills was supplemented with new skills. Attention should be paid to the fact that not all new skills found can be classified as "innovative" or "new".[15] On the one hand, the methodology can therefore serve the purpose of filling gaps in the skill dictionaries that have existed for a longer period of time, and on the other hand, of identifying innovative, new skills early on.

We use samples from all job ads published for the first time in April/May 2019 and October/November 2019. The time periods of the samples were chosen such that the feasibility study, which was designed for one year, could be created on the basis of current data. This results in a data set of two access samples which can be used for a twofold examination of skill requirements according to occupations, skill levels, and regions.

Therefore, it can be examined whether any changes in the skill requirements in job ads can be identified at all and to what extent. An analysis of how fast skill requirements change, what determinants there are, and whether this change takes place with clear trends, and if so, in what areas, or whether it is rather volatile, can be performed only if additional access samples are evaluated in the future.

[13] The skills mentioned in a job ad for a specific job alone do not necessarily have to represent all the required skills for this job; thus, especially the job title and corresponding heuristics for the assignment of job titles and skills are still very important (e.g. BERUFENET).

14 The skill catalogue for hard skills is the BERUFENET skill catalogue; for soft skills, the skills catalogue („Kompetenzatlas") according to Heyse/Erpenbeck (2004). For details and their further processing, see also Section 5.2.

[15] The assessment of skill requirements not being "innovative" or "new" is based on our subjective evaluation. The basis was our review of the data material and any further research, if required. The assessment of the degree of innovation of a skill seems to be a great deal more complex and may be subject to further research.

The feasibility study generally focuses on occupational sets that are typically found in mechanical engineering and information services as well as in the health and social sector.

These career fields were selected under the assumption that in the industries in which these occupations are dominant differences in the occurrence of skill requirements in job ads can be observed due to their diversity. Moreover, these are occupational sets that have high employment shares compared to the overall economy; therefore, sufficient variation in the job ads along the evaluation dimensions can be expected.

The evaluations were developed such that regional skill requirements can be reported down to the district level, skill levels can be differentiated, and evaluations are possible down to the level of individual occupations (5-digit code of KldB 2010).

5 Data

5.1 Data from the BA's employment website

"BA-Jobbörse" is one of the largest online job portals[16] in Germany. On 14 August 2019, 1,630,338 vacancies were registered in the database.

"BA-Jobbörse" is free of charge for applicants and companies. The search for vacancies can be done directly (without registration) on the BA-Jobbörse site. For further offers, both applicants and companies must register. For example, companies can create a profile and use it to create and publish job ads. Published job ads are available up to 30 days. Companies can renew the activation and/or publication of their job ads. Moreover, companies can request support by the BA's placement services.[17]

As an alternative to a publication based on manual entries, job ads can be published automatically via the "HR-BA-XML interface". Companies with job board websites equipped with adequate technical arrangements can be connected to the BA's interface and automatically submit the job ads.

For our evaluations, we used two samples from all job ads published on the BA-Jobbörse website, with the exception of training positions. The job ads of the first sample were created between 1 April 2019 and 31 May 2019, and the job ads of the second sample between 1 October 2019 and 30 November 2019. More precisely, they are samples according to the creation date (access samples). This is to ensure that in these drawings, but also in any repeated, future ones, each job ad is included only once.[18]

According to this selection, almost 1.26 million job ads were included in the first examination period in April/May 2019. Information on the economic sectors is available for only 742,742 or almost 59 percent of all job ads. These shares range between 49 and 79 percent in the different federal states (Table 5.1). Information on the occupation, however, is available for almost all job ads. Therefore, we decided to initially focus our analyses on a selection of occupations which contain

[16] https://jobboerse.arbeitsagentur.de/ or https://con.arbeitsagentur.de/prod/jobboerse/jobsuche-ui/

[17] The additional offers for applicants include the option of creating an applicant profile. Companies can then search for these profiles and contact potentially suitable applicants directly. No applicant data are examined as part of this feasibility study.

[18] This would not be the case with a cross-sectional survey of job ads being actively published during a given period of time which is longer than the survey frequency. These vacancies would then be included multiple times.

the main fields of work[19] in the selected economic sectors of mechanical engineering, information services, and the health and social sector.

Table 5.1: Number of job ads

Region	Total	of that			
		with information on the economic sector		with information on the occupation	
		abs.	in %	abs.	in %
Germany	1,262,738	742,742	58.82	1,262,725	100.00
By federal states					
Baden-Wuerttemberg	191,035	114,384	59.88	191,035	100.00
Bavaria	252,725	141,067	55.82	252,721	100.00
Berlin	75,430	49,653	65.83	75,430	100.00
Brandenburg	29,470	23,052	78.22	29,468	99.99
Bremen	18,821	9,368	49.77	18,821	100.00
Hamburg	51,341	26,193	51.02	51,341	100.00
Hesse	93,154	50,170	53.86	93,152	100.00
Mecklenburg-Western Pomerania	19,763	14,556	73.65	19,763	100.00
Lower Saxony	110,674	62,027	56.04	110,674	100.00
North Rhine-Westphalia	248,421	130,399	52.49	248,421	100.00
Rhineland-Palatinate	47,873	30,922	64.59	47,873	100.00
Saarland	7,254	5,037	69.44	7,254	100.00
Saxony	77,333	54,318	70.24	77,328	99.99
Saxony-Anhalt	29,932	22,441	74.97	29,932	100.00
Schleswig-Holstein	44,006	25,537	58.03	44,006	100.00
Thuringia	26,624	18,903	71.00	26,622	99.99

Explanation: The sum of job ads in the federal states (1,323,856) exceeds the number of qualified job ads for Germany. The reason is that many job ads for a larger number of vacancies were published in several federal states. The corresponding job ads for Germany are included in the table exactly once, and for the classification by federal states exactly once for each federal state for which the job ad contains at least one place of work.

Source: Data from the BA employment website, access sample, period of time: 1 April 2019 to 31 May 2019. Authors' calculations. © IAB

Table 5.2 contains detailed information. We selected the mechanical and automotive engineering occupations (in the following referred to as the occupational set "MAE occupations") for mechanical engineering; the occupations in computer sciences, information and communication technology (occupational set "ICT occupations") for information services; and the medical occupations in health care, non-medical occupations in health care, personal hygiene, and well-being, medical engineering occupations as well as education, social, and household occupations and theology-related occupations (occupational set "HES occupations" occupational set) for the health and social sector.

[19] Meaning those occupations that define the respective industry. The classifications of occupations and economic sectors are not congruent. In particular, this means that individual occupations can usually be found in several economic sectors. By examining main occupational sets, the focus is not distinctly on the selected economic sectors, either.

Table 5.2: Selected economic sectors (WZ08) and selected occupational main groups (KldB 2010)

Focused economic sectors (WZ08 classification)	Associated occupational main groups acc. to KldB 2010 (occupational set)
Mechanical engineering (WZ08: 28)	Occupations in mechanical and automotive engineering (occupational main group 25) (MAE occupations)
Performance of information technology services (62) and information services (63)	Occupations in computer sciences, information and communication technology (occupational main group 43) (ICT occupations)
Health care (WZ08: 86), residential care (87), social services (88)	Medical occupations in health care (81) as well as non-medical occupations in health care, personal hygiene, and well-being, medical engineering (82), education, social and household occupations, theology (83) (HES occupations)

Source: Authors' classification. © IAB

Generally, employers may create a job ad for several vacancies with the same characteristics and for different places of work. Therefore, if only the number of job ads were considered, the labour demand and thus the relevance of the skill requirements mentioned in these job ads would be quantitatively underestimated. Thus, in order to determine the relevance of skills, the scope of labour demand must be taken into account. For that reason, we adjusted the number of job ads according to the information in the data regarding the number of vacancies and their locations (thus, the places of work).[20]

There were 706,041 vacancies from 339,921 job ads for the first access cohort of April/May 2019, and 706,461 from 291,826 job ads for the second access cohort of November/December 2019, which we will analyse in this feasibility study. The relation in the access sample of April/May 2019 is about two vacancies per job ad. With approx. 2.5 vacancies per job ad, the relation for November/December 2019 is even higher. Table 5.3 contains further details on the job structure according to federal states and the selected occupational sets.

The job ad texts were subjected to comprehensive pre-processing.[21] This was followed by a procedure to determine those parts of the job ad texts where the employers verbalised the skill requirements expected of the applicants and described the activities to be performed. This so-called segmentation procedure is required in particular because otherwise certain words occurring in the job ad texts might incorrectly be interpreted as skill requirements. Generally, job ad texts are to serve a number of functions: Besides the already stated parts, job ads frequently contain a presentation of the company or establishment as well as functional parts with legal notes or notes on the consideration of certain applicant groups or on the application process.

[20] Strictly speaking, it would have been necessary to consider the requested working time as well to be able to estimate the volumes of work. In this study, we have abandoned this option for the time being, not least because there are frequently no exact specifications in the job ads.

[21] Appendix 10.1.1 contains details on the pre-processing procedure.

Table 5.3: Number of evaluable vacancies according to the selected occupational sets

Region	April/May 2019				October/November 2019			
	Number	including number of vacancies according to occupational sets in %			Number	including number of vacancies according to occupational sets in %		
		MAE occu-pa-tions	ICT occu-pations	HES occu-pations		MAE occu-pa-tions	ICT occu-pations	HES occu-pa-tions
Germany	706,041	23	14	63	706,461	18	12	71
By federal states								
Baden-Wuerttemberg	104,075	27	19	55	93,388	19	15	67
Bavaria	104,621	29	16	55	100,681	24	15	61
Berlin	31,451	17	22	62	26,208	21	24	54
Brandenburg	19,413	19	5	76	28,385	12	3	85
Bremen	9,105	21	11	67	11,591	14	10	76
Hamburg	20,943	24	18	57	21,662	21	15	64
Hesse	43,503	20	29	50	31,963	16	27	56
Mecklenburg-Western Pomerania	10,232	20	6	74	10,316	22	8	71
Lower Saxony	77,185	17	7	76	87,758	12	5	83
North Rhine-Westphalia	149,736	22	11	67	142,891	18	11	70
Rhineland-Palatinate	23,925	31	9	60	17,644	29	12	60
Saarland	3,898	25	11	64	3,918	19	11	70
Saxony	37,698	27	17	56	46,310	17	12	71
Saxony-Anhalt	14,414	28	9	63	10,941	27	10	63
Schleswig-Holstein	43,085	13	5	83	63,319	5	3	92
Thuringia	12,757	29	14	58	9,486	33	14	52

Explanation: MAE occupations refers to occupations in mechanical and automotive engineering (occupational main group 25); ICT occupations refers to occupations in computer sciences, information and communication technology (occupational main group 43); HES occupations refers to occupations in health care (occupational main group 81); non-medical occupations in health care, personal hygiene, and well-being, medical engineering (occupational main group 82); education, social and household occupations, theology (occupational main group 83).

Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

There is a risk of confusion in particular for terms used in the presentation of the company, which frequently also contains skill descriptions that apply to the establishment but not necessarily to the vacancy. Notes on the application process, too, should be excluded from evaluation, since their phrasing might contain terms which are identical to skill terms from the administration sector.

In accordance with our definition of skill requirements in Section 4, the explicitly verbalised requirements expected of applicants as well as the job descriptions in particular are relevant for our evaluations. Using a classification procedure based on machine learning algorithms, we thus tagged the relevant part of the job ad texts as "job description" and separated it from the part "other", which was irrelevant for the analyses of this study.[22]

[22] Additional details on the segmentation procedure are described in Appendix 10.1.2.

5.2 Skill dictionaries

5.2.1 Hard skill requirements

With BERUFENET,[23] the BA provides free information on all occupations known in Germany. Job and occupation titles will be included in BERUFENET if there is regulated initial or advanced vocational training or if a job is classified as relevant for the job market. An occupational activity will be considered relevant for the job market, for example, if its job title is used in collective agreements, if a certain number of employees are working in this job, or if generally binding advanced training options are available in this occupation. It can be assumed that BERUFENET includes nearly all job titles used in Germany (cf. Matthes et al. 2008; p. 42, Dengler et al. 2014).

BERUFENET uses a database containing a total of approximately 8,000 distinguishable job requirements.[24] To ensure constant up-to-dateness, the database can be continuously updated; for example, by employer specifications when searching for suitable employees, by analysing job ads and advanced training offers, or in the context of the BA's Customer Response Management. The potentially new job requirements are reviewed for redundancy and included in BERUFENET, if applicable, and assigned to the core occupations (cf. Dengler et al. 2014, p. 39).

In BERUFENET, the requirements to perform the corresponding occupational activity are assigned to each occupation. Overall, the requirements necessary to perform a particular job are described very comprehensively; the skills and knowledge required for the description of an occupation are used, and it can be assumed that the skills and knowledge required to perform a particular job are assigned validly(op. cit.).

BERUFENET serves as a source of information for job descriptions which are, on average, valid for the entire German labour market. With its differentiation between core requirements and other requirements, BERUFENET provides only a simple and broad weighting of skills with regard to their importance and/or occurrence in the individual occupations.

A regional differentiation is not provided, either. Additionally, BERUFENET does not provide any focussing on the skill level (which is completely appropriate for its purpose) in order to be able, for example, to further investigate the relevance of individual skill requirements as done in this project.

The skill requirements listed in BERUFENET, however, provide an excellent basis for the identification of already known skills in job ads.

Table 5.4 presents the skill groups at the frist level of BERUFENET to give an impression of the requirements that are contained.

[23] For more information, please visit the BERUFENET website provided by the Federal Employment Agency: http://berufenet.arbeitsagentur.de/berufe/index.jsp, last downloaded on 23 July 2019.

[24] This catalogue can also be downloaded from BERUFENET at: http://download-portal.arbeitsagentur.de/files/.

Table 5.4: Skill groups in BERUFENET and their usage

Skill group	Usage as hard skill group (this section)	Usage as additional skill group
Agriculture, forestry, and horticulture	x	
Production, processing, technology	x	
Construction, architecture	x	
Economy, administration	x	
Transport, traffic	x	
Hotels, restaurants, tourism	x	
Services	x	
IT, DP, computers	x	
Science, research, development	x	
Social affairs, education, health, sports	x	
Media, art, design	x	
Knowledge of goods and products		Not yet
Licences, permits, driver's licences		Not yet
Language skills		Not yet
Additional groups		
"Forms of work and usage", "places of work", "sectors"		No

Source: Requirement matrix from BERUFENET, last updated: 24 March 2020. © IAB

Besides the hard skill requirements assigned to the skill groups, BERUFENET also contains additional groups, which we do not define as "hard skill requirements", though. These include "knowledge of goods and products" and "licences, permits, driver's licences". Without doubt, a separate evaluation of these groups would benefit and complement the analysis of hard skill requirements. At the time of the report, however, these groups had not been evaluated. An evaluation would also require intensive manual processing of the respective catalogues into dictionaries. The processing would partially be different, since, for example, the keyword corpus for the "licences, permits, driver's licences" group would have to be expanded considerably by common abbreviations.

Additional groups not evaluated here are "languages", "forms of work and usage", "places of work", and "sectors". The reason for this is either our focus on hard and soft skill requirements (that's why we excluded "languages") or the fact that we did not think the groups could be put on a level with the skill requirements (that's true for all other categories); see the definition of skill requirements in Section 4.[25]

[25] However, these parts may still have a high relevance; for example, when it comes to the question of whether the different parts of the job ad texts can be fully identified and/or classified. In this regard, there is another field of research to be taken up.

The BERUFENET skill catalogue was subjected to the same pre-processing steps as the employment website data. In addition to that, any word listings of skill terms were removed.[26] Moreover, additional processing steps were required to generate a dictionary from the skill catalogue which contains associations of skill descriptions with keywords which ultimately are to serve for the identification of skill requirements in job ad texts.

For the association of terms in the job ad texts not yet listed in the BERUFENET skill catalogue, we developed different methodologies.[27] Initially, we used, among others, a so-called word embedding procedure based on machine learning algorithms.[28] The job ad texts of all approx. 7.2 million different vacancies available in October 2018 were used as a basis.[29]

Where the extracted terms did not correspond exactly to the already known hard skill terms and/or keywords, they were included in a list of suggestions together with closely related already known skill terms; these terms were directly derived from the machine learning algorithm or from a partial string search.

The suggestions were then reviewed – with relatively high effort – as part of a consensual validation procedure;[30] Table 5.5 contains the results of the procedure. It must be noted that not all extracted terms were processed. A selection was made by applying, among others, the criterion that the terms had to appear in at least 50 job ads.

In total, 221 new keyword combinations for 151 already listed hard skills were generated. By means of further contextualisation, 13,375 keyword combinations for 289 hard skills already listed as well were generated. The high number of keyword combinations results, among others, from the combination possibilities of adjectives and nouns, which were developed systematically and by using the job ad text material. Finally, the procedure described was used to define 284 “new” skills and a total of 1,022 related keyword combinations.

[26] For the details, see Appendix 10.1.1.

[27] For details on the following, see Appendix 10.1.3.

[28] Generally, a comparison with the other dictionaries may also be considered. This has not yet been accomplished as part of the feasibility study. However, rejection of a suggestion and manual allocation to one of the other dictionaries was possible.

[29] The lead time resulted from the technical analysis options, which had still to be developed in the early phase of the project. Particularly the evaluation of the data from the first survey period of April/May 2019 would have been possible only at a much later point in time in the project and would have considerably delayed the course of the project. In the future, the required lead time will depend on the technical and manual time requirements for the evaluations only.

[30] For details, also see Appendix 10.1.3.

Table 5.5: Final result of the procedure for the identification of new skills

	Association category (code)	Keywords were generated for … Skills	Generated keyword combination per skill			
			Median	Smallest number	Largest number	Total
(1)	Skill already listed, suggestion accepted (1)	151	1	1	8	221
(2)	Skill already listed, own research (11)	289	275	1	1,123	13,375
(3)	New skills (2, incl. 21)	284	15	1	309	1,022
	Total	724	244	1	1,223	14,618

Explanation: Part of the 151 skills in row (1) may be identical to a corresponding part of the 289 skills in row (2). The 284 new skills in row (3), however, do not coincide with the skills in row (1) or (2).

Source: Authors' classifications from job ad text material of BA-Jobbörse of October 2018. Authors' calculations. © IAB

Moreover, the new skills were assigned to the skill groups from BERUFENET (Table 5.6). According to that, most new skills were identified for the "IT, DP, computers" skill group, followed by "production, processing, technology" and "economy, administration". No new skills were assigned to the "hotels, restaurants, tourism" skill group, though.

Table 5.6: New skills count of assignments to skill groups

Skill groups	Number of new skills	Share of all new skills
Agriculture, forestry, and horticulture	2	0.7 %
Production, processing, technology	72	25.3 %
Construction, architecture	7	2.5 %
Economy, administration	47	16.5 %
Transport, traffic	1	0.4 %
Hotels, restaurants, tourism	-	-
Services	2	0.7 %
IT, DP, computers	122	42.8 %
Science, research, development	9	3.2 %
Social affairs, education, health, sports	20	7.0 %
Media, art, design	2	0.7 %
Total	**284**	**100.0 %**

Source: Requirement matrix from BERUFENET, last updated: 24 March 2020; authors' classification, see also Appendix 10.3. Authors' calculations. © IAB

A detailed description of the new skills is available in Appendix 10.3. Even if we cannot draw on criteria for the assignment of a "degree of innovation" of the extracted skills, the list still allows for the conclusion that not all new skills found can be classified as "innovative".

We conclude from these findings that, besides the completion of keywords in the hard skill dictionary, we can fill gaps which have existed for a longer period of time as well as identify actual "innovative" skills with our methodology.

Part of the 6,987[31] skill requirements already listed in BERUFENET as well as the 283 new ones are frequently described with more than one word. More precisely, there are 3,744 skill terms with one word, 2,073 skill terms with two words, and 1,453 skill terms with three or more words (see examples from BERUFENET in column 2 of Table 5.7).

As soon as a requirement is described or must be searched for with more than one word, rules had to be defined whether all or only some of the words have to be found in a job ad text in order for the requirement to be assigned to this skill. For example, for two words it had to be decided whether one of the two words was sufficient as a keyword to identify the skill, or if both words were required as keywords. The rules were differentiated accordingly for the skills with three or more words. For example, the "installation (ropes, nets, technical manufacture)" skill requirement would be counted if the terms "installation" and either "ropes", "nets", or the two terms "technical" and "manufacture" occurred together in the job ad text, see column 3 of Table 5.7.

Table 5.7: Examples of skills from BERUFENET

Number of words describing the requirement	Examples	Search rule
1	"Blutentnahme" (Taking blood samples)	"Blutentnahme"
2	"Schleifen (Metall)" [Grinding (metal)]	"Schleifen" and "Metall"
> 2	"Bildbearbeitungsprogramm Paintshop Pro" (Paintshop Pro image editing program)	"Paintshop" and "Pro"
	"Montage (Seile, Netze, technische Konfektion)" [Installation (ropes, nets, technical manufacture)]	"Montage" and ["Seile" or "Netze" or ("technische" and "Konfektion")]

Source: Requirement matrix from BERUFENET, last updated: 24 March 2020. © IAB

In total, the dictionary of hard skills consists of 7,270 requirements that are distinguishable in terms of content; this includes 10,116 keywords and 23,158 different keyword combinations. For the interpretation of the number of keywords, it must be noted that word stems are counted which were generated as part of the pre-processing procedure.[32] This means that the number of potentially recorded words not reduced to the word stem is much larger.

5.2.2 Soft skill requirements

For the identification of soft skill requirements in the job ads, we used the skills catalogue („Kompetenzatlas") by Heyse/Erpenbeck (2004). This catalogue distinguishes four basic soft skills:

- Personal skills (P): Capability of being prudent and critical towards oneself, of being able to develop productive attitudes, values, and ideals
- Activity and action skills (A): Capability of being able to strong-mindedly and actively implement all knowledge and expertise, all results of social communication, all personal values and ideals

[31] Last updated: 24 March 2020.

[32] Appendix 10.1.1 contains further information on "stemming".

- Functional and methodical skills (F): Capability of being able to creatively solve apparently insoluble problems by applying functional and methodical knowledge
- Social and communicative skills (S): Capability of being able to partner and dispute with others on one's own initiative; to cooperate and communicate creatively

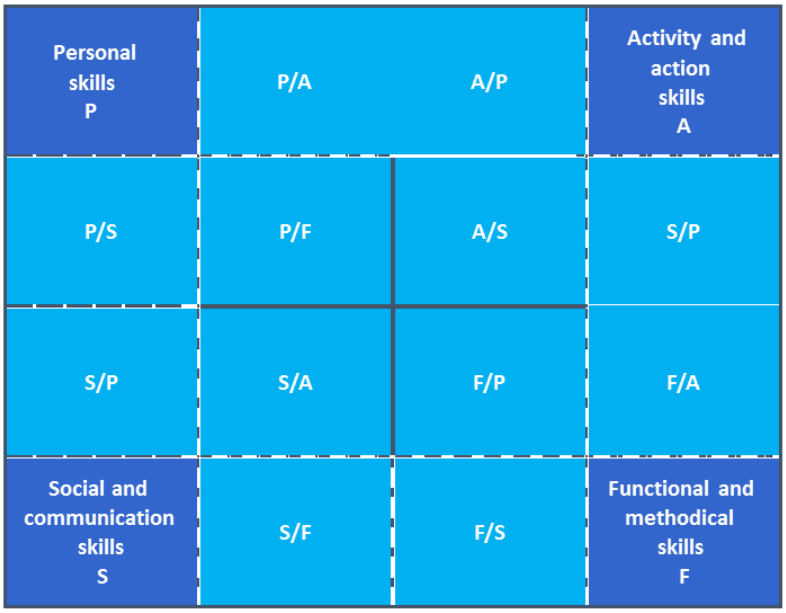
In addition to that, there are another twelve basic skills which are a mixture of the four basic skills (Figure 5.1). Each of these 16 basic skills is assigned to four individual skills so that the skills catalogue („Kompetenzatlas") by Heyse-Erpenbeck (2004) distinguishes 64 basic skills; the entire catalogue can be found in Table 10.2 in the Appendix.

With a few exceptions, these skills are described with one word, and therefore, we used the skills catalogue as a skill dictionary with next to no modifications.

For this skill catalogue, we assumed that the skills were recorded completely on the individual skills level. However, this does not rule out that either individual skills must be further differentiated or alternative keywords must be added for certain skills in future analyses.

In total, the dictionary of soft skills consists of 64 requirements that are distinguishable in terms of content; this includes 83 keywords and 71 different keyword combinations. Also in this case, the word stems were counted for the interpretation of the number of keywords. This means that the number of potentially recorded words not reduced to the word stem is larger in this case as well.

Figure 5.1: Skills catalogue („Kompetenzatlas") according to Heyse/Erpenbeck (2004)



Source: Authors' account based on Heyse/Erpenbeck (2004). © IAB

6 Results

6.1 Overview

The identification of skill requirements in the job ad texts was performed by means of an exact comparison of the processed individual terms of the respective segments in the job ad texts containing the "job description" (Section 5.1) with the keyword entries in the prepared skill dictionaries (Section 5.2).[33] With our methodology, we were able to assign an average of 64 percent of the terms contained in the "job description" segment of the job ad texts.

The dictionaries also contain skills for the identification of which more than one keyword can be found. For these skills, a decision had to be made regarding the maximum distance of keywords. This is based on the decision whether the keywords describe the respective skill requirement only if they occur directly next to each other in the job ad text, or whether other words not relevant for the skill requirement may exist between the keywords.

Initially, we tested a number of variants for maximum keyword distance.[34] The results showed that keyword combinations supposedly belonging to a skill requirement were found more frequently when no keyword distance was specified, although they were not at all linked in terms of content and thus actually did not fulfil the description of a specific skill requirement intended by the employer. In contrast, a keyword distance of zero, i. e. no other words may exist between the words, led to very restrictive results and variations in the descriptions of skill requirements (and therefore in the arrangement of keywords).

The specified maximum keyword distance therefore plays an important role with regard to the objective of identifying as many skill requirements as possible and allowing for a certain tolerance regarding the spelling and arrangement of the keywords for a skill requirement, but nevertheless reliably assigning all identified keywords in a specific combination to skill requirements as intended by the employer.

Theoretically, there is an optimum distance measure for the keywords of each skill, but after reviewing some job ad texts in more detail, we found that this is not the same for all skill requirements. The identification of a skill-specific distance measure should therefore be subject to further research. We ultimately decided against a non-restricted variant and chose the variant with a maximum word distance of three words between the keywords.

On this basis, the evaluations can now be effected. In total, 3,473 hard skill requirements were identified in the three occupational main groups in the first access cohort, and 3,355 hard skill requirements in the second access cohort. With 2,168 and 2,063 skill requirements, respectively, most skill requirements were found in the ICT occupations (see Table 6.1). With 1,863 and 1,820 skill requirements, respectively, the HES occupations follow, and then the MAE occupations with 1,766 and 1,701 skill requirements, respectively. Out of 64 possible requirements in the area of soft

[33] Other types of comparison may also be applied, e. g. fuzzy matching. Fuzzy matching means that not an exact match of a keyword is searched in the job ad texts, but a specific tolerance to be implemented by the search algorithm is allowed. We decided against this very computing-intensive procedure in this case. On the one hand, the literature suggests that fuzzy matching does not lead to improvements as compared to exact matching (Crockett et al. 2018). On the other hand, the stemming procedure in particular as well as the keyword corpus already ensure that there is a tolerance range for the identification of requirements.

[34] Specifically, we compared a non-restricted variant, i. e. without a maximum keyword distance, to variants with a keyword distance of zero, one, or three words.

skills, a total of 56 requirements were identified across the three occupational main groups. Most of these requirements were mentioned in the HES occupations, and the fewest in the MAE occupations.

Table 6.1: Number of identified skill requirements

Dictionaries	April/May 2019				October/November 2019			
	Total	including by selected occupational main groups			Total	including by selected occupational main groups		
		MAE occupations	ICT occupations	HES occupations		MAE occupations	ICT occupations	HES occupations
Hard skills	3,473	1,766	2,168	1,863	3,355	1,701	2,063	1,820
Soft skills	56	46	53	55	56	48	52	56

Explanation: MAE occupations refers to occupations in mechanical and automotive engineering (occupational main group 25); ICT occupations refers to occupations in computer sciences, information and communication technology (occupational main group 43); HES occupations refers to occupations in health care (occupational main group 81); non-medical occupations in health care, personal hygiene, and well-being, medical engineering (occupational main group 82); education, social and household occupations, theology (occupational main group 83).

Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

These figures initially show how much the occupational sets vary with regard to the occurrence of skill requirements. In the following, we will examine (1) how many skills per job ad were mentioned within a specified area of occupation and (2) what weight the respective skill areas and their individual skills had in the respective areas of occupation or other evaluation dimensions.

With regard to the first question, it can be said that an average between two and slightly more than eight hard and soft skill requirements were found per job ad in the occupational sets within the skill levels. In the job ads evaluated by us, the ICT occupations showed most requirements across all skill levels, followed by the MAE and then the HES occupations. In total, these figures are within or above the range of similar evaluations (e. g., see Crockett et al. 2018).

We found a considerably higher number of hard skill requirements (between one and slightly more than seven) as compared to soft skill requirements (between 0.6 and 0.9). Moreover, the number of hard skill requirements found increased with the skill level, whereas such systematic variation of the number of soft skill requirements could not be observed between the skill levels. Further details on these counts are described in Appendix 10.6.

The second question, i. e. the question of the weight or importance of skills based on their occurrences in the job ads, will be examined here and in the following sections in more detail individually for the occupational sets under review and for the additional evaluation dimensions. We will always examine only a manageable range of skill occurrences, chosen according to the frequency of occurrences.

Figure 6.1 shows the 25 most frequently mentioned hard skill requirements according to the three occupational sets and, by way of example, for the second access sample November/December 2019.[35] The individual word clouds in the table document the professional relevance of the skill

[35] The evaluations for April/May 2019 allow for the same conclusions. The following sections also show results from the first access sample.

requirements found. A different colour was assigned to each skill requirement. Their font size reflects how the numbers of relative occurrences are related to one another; an exact comparison of font sizes across different word clouds, however, is not possible, such as a comparison with the evaluations for the soft skills word clouds, since the level of occurrences is much lower there. Nevertheless, we will occasionally also include word clouds in the following, since they allow for a quick impression of the quite comprehensive data material.

Figure 6.2 shows the 25 most frequently mentioned soft skill requirements according to the three occupational sets, and also for the second access sample November/December 2019.[36] It becomes clear that some skills were repeatedly mentioned most frequently, e. g. “ability to work in a team”, “reliability” or “communication skills”. There are also differences, though. While “willingness to learn” was much in demand for MAE occupations, it was “analytical skills” for ICT occupations and “expertise” for HES occupations.

As already mentioned in Section 6.1, our main evaluations are based on all published job ads (except for vocational training positions), taking into account the specified number of vacancies the job ads were created for. In addition to that, we examined[37] whether differences in the results on the basis of alternative data differentiation must be expected. Specifically, we first examined those vacancies which were explicitly not designed for temporary employment, and secondly, we examined all job ads without considering the specified number of vacancies.

From the evaluations of vacancies without temporary employment it can be seen that the number of extracted skills decreased, which may be due to the fact that vacancies for temporary employment are created for somewhat broader application fields. Furthermore, the ranking of most frequently mentioned skills slightly changed according to the frequency of occurrences; their composition, however, remained almost the same. Greater differences, relatively speaking, resulted from the evaluations of job ads without considering the number of vacancies.

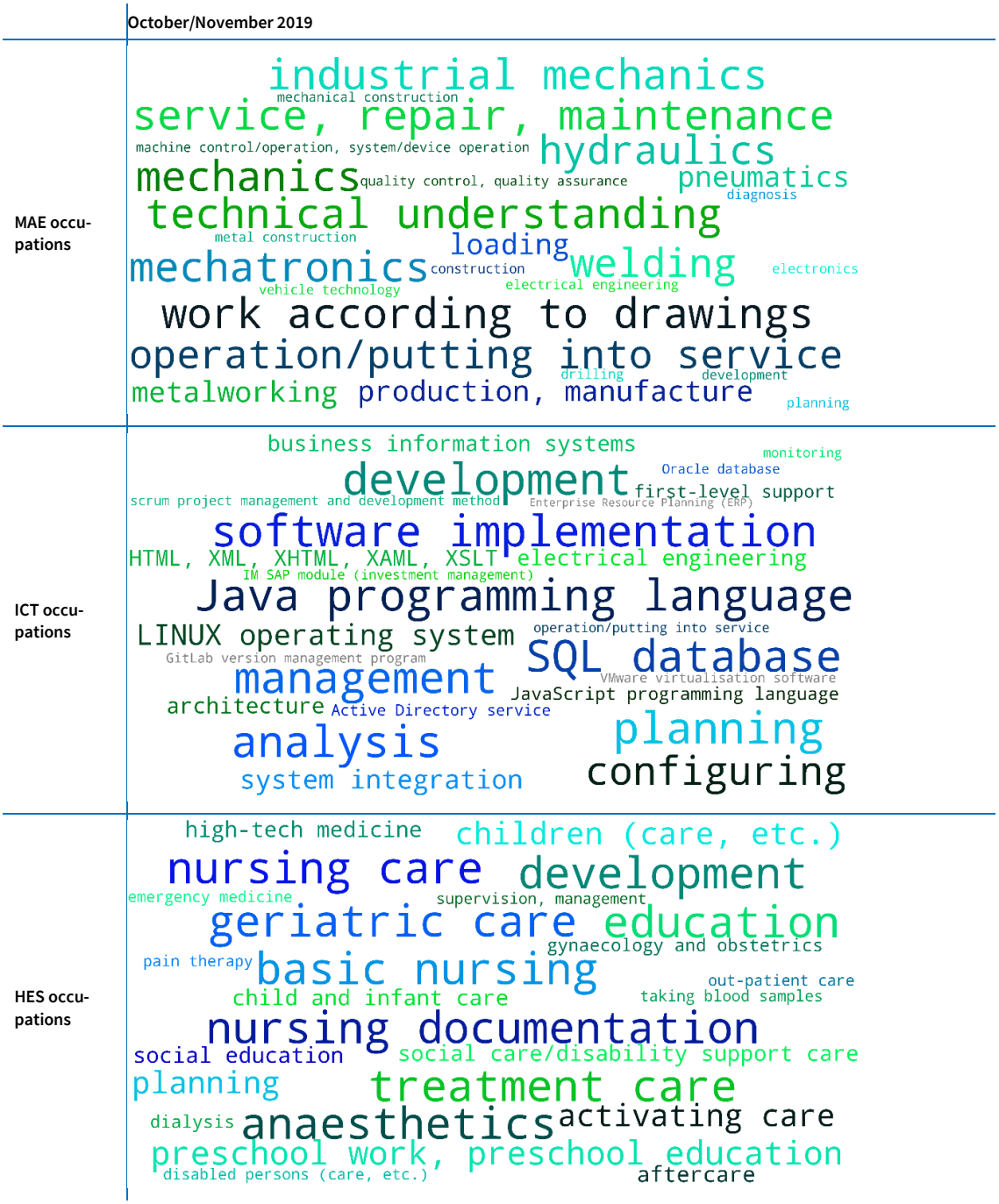
From this we conclude that it is relatively negligible for our analyses to date whether or not job ads for temporary employment are included, even if the results are marginally different. Nevertheless, we think it is advisable for specific detailed analyses to examine vacancies designed for temporary employment separately and thus review the results for their robustness.

Whether the number of job ads or the number of vacancies the job ads are published for should be considered depends more on the formulation of the specific research question, because more distinct differences between the evaluations of the number of job ads and the number of vacancies contains can be expected. For our principal question of the (quantitative) importance and development of skill requirements in job ads, however, we think it would be wrong not to consider the number of vacancies per job ad.

[36] See Footnote 35

[37] See Appendix 10.7.

Figure 6.1: The 25 most frequently mentioned hard skill requirements according to the three occupational sets



Explanation: MAE occupations refers to occupations in mechanical and automotive engineering (occupational main group 25); ICT occupations refers to occupations in computer sciences, information and communication technology (occupational main group 43); HES occupations refers to occupations in health care (occupational main group 81); non-medical occupations in health care, personal hygiene, and well-being, medical engineering (occupational main group 82); education, social and household occupations, theology (occupational main group 83). A different colour was assigned to each skill. Their font size reflects how the numbers of relative occurrences are related to one another; a comparison of font sizes across different word clouds is not possible.

Source: Data from the BA employment website, access sample, period of time: 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

Figure 6.2: The 25 most frequently mentioned soft skill requirements according to the three occupational sets.

Explanation: MAE occupations refers to occupations in mechanical and automotive engineering (occupational main group 25); ICT occupations refers to occupations in computer sciences, information and communication technology (occupational main group 43); HES occupations refers to occupations in health care (occupational main group 81); non-medical occupations in health care, personal hygiene, and well-being, medical engineering (occupational main group 82); education, social and household occupations, theology (occupational main group 83). A different colour was assigned to each skill. Their font size reflects how the numbers of (relative) occurrences are related to one another; a comparison of font sizes across different word clouds is not possible.

Source: Data from the BA employment website, access sample, period of time: 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

With regard to the validity of the computed measures for the importance of skill requirements, it must be taken into account whether the used data material is representative referring to the labour demand in the whole economy. Basically, we think the evaluation and interpretation of the BA-Jobbörse data are justified simply because of their volume and usage by employers, applicants, and the BA or other service providers on the labour market.

However, we cannot rule out that the actual demand for labour force may be underestimated by using the job advertisement data, at least in some sub-areas, because not all job vacancies of the whole economy are published in the BA-Jobbörse. At the same time, overestimations may occur if, for example, a company publishes a new vacancy to be filled in BA-Jobbörse itself, while a third-party company recruiting applicants for this vacancy in the name of the other company places a job ad as well. This is another field for further research. and not the focus of this feasibility study.

Having this in mind for the interpretation of the results, we can concludethat the utilized job advertisement data is suitable to measure the explicit denomination of skills in job ads in order to classify their relevance by occupations and regions.

To further illustrate the analysis potential at the level of the three selected occupational sets, individual occupations, skill levels, and federal states, we will present results selected accordingly in the following sections.

To characterize developments, we will, firstly, introduce an analysis framework in the following section. This will be followed by in-depth analyses on the actual, absolute, and relative volume of occurrences of skill requirements in the job ads. We will examine the hard skill requirements separately according to the selected occupational sets and show a sample evaluation for one selected individual occupation per occupational set compared across the federal states. This will be followed by analyses on the soft skill requirements. In doing so, we will examine the selected occupational sets together in order to be able to better identify similarities and differences.

6.2 The short-term development of skill requirements in job ads – analysis framework and example

In the following, we will suggest a simple and meaningful analysis framework suitable for our data evaluations for the representation of the development of skill requirements in job ads. The results presented can be used to illustrate for the first time whether and to what extent changes in the occurrence of skill requirements in job ads can be observed.

It must be considered that at present only two access samples with a six-month interval between them exist. Therefore, no reference comparisons are available. Apart from this, of course no long-term trends can be derived from these data. Future reference comparisons, i. e. a short-term examination of the demand for survey periods from the past, will help to better understand the differences in the number of job ads, the number of vacancies offered by them, and the required skills which are linked to intra-annual development patterns (e. g. seasonal patterns, seasons, turning points in the economic cycle).

For the (short-term) course of developments, both the number of occurrences of the individual requirements and the changes in occurrences are important. The number or occurrences provides information about the general importance of the skill from the employers' perspective. In accordance with the working hypotheses created by us in Section 4, the requirements mentioned are

those requirements that are considered very important and worth mentioning by employers in their job ads.

Accordingly, a relatively high number of occurrences for a specific skill requirement reflects its high relevance , and a relatively low number reflects its low relevance; changes in the occurrences thus reflect their loss or gain in importance.[38] Both figures are important and will now be examined together by way of example for the hard skill requirements.

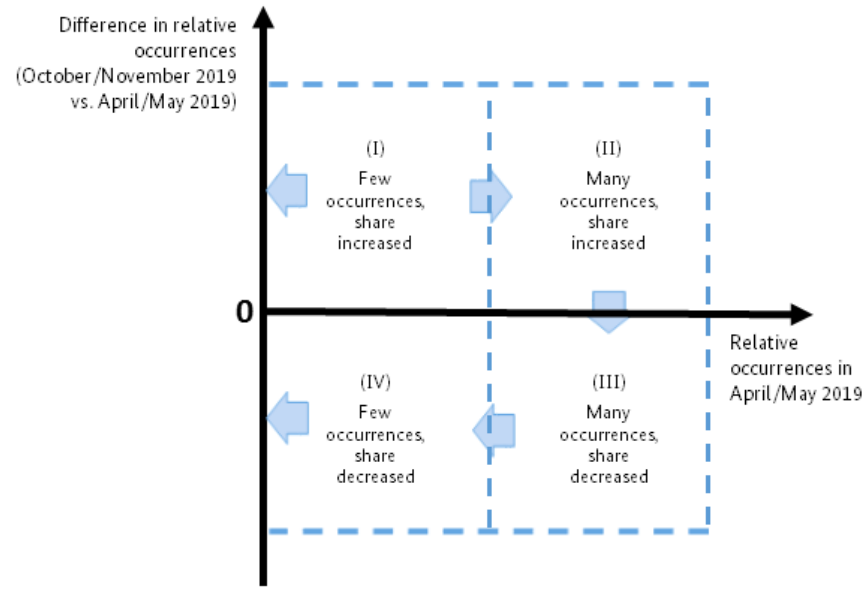
For a simple standardisation of skill requirements according to the number of occurrences and their changes, we initially followed the Boston I matrix (also known as the Boston Consulting Group matrix). Originally, it was designed as an analysis instrument to categorize products or services of a company according to their market potential along the criteria of relative market share and market growth (Hedley 1977). In our case, the relative market share corresponds to the relative number of occurrences of a skill related to all vacancies. The market growth is the corresponding change of this relative number. It can be assumed that the development of the relevance of skill requirements is frequently linked to the lifecycles of specific services or products.[39]

Figure 6.3 combines the two possible variants “few occurrences” and “many occurrences” with the variants “share increased” and “share decreased”. This results in four fields which the individual requirements can be assigned to. With regard to our survey periods to date, type (I) contains requirements with few relative occurrences in April/May 2019 and an increase in relative occurrences in October/November 2019. Type (II) corresponds to many occurrences and an increasing development. Type (III) corresponds to many occurrences and a decreasing share. Type (IV) corresponds to few occurrences and a decreasing share.

[38] A loss in the relevance with regard to the occurrences in job ads would also be imaginable if employers no longer explicitly mention a certain requirement because they assume that it has become an immanent part of the professional activity offered in the job ad; again, please refer to Section 4 for our working hypotheses.

[39] Therefore, we used the instrument in a highly modified form. As may be imagined, a provider of further education aims to analyse the “supply” of skills by using the Boston I matrix. The weaknesses of the sole original usage of the instrument as a basis for the determination of standard strategies in companies are comprehensively described in the literature, and it is recommended to use additional analysis instruments (e. g., see Drews 2008). Analogously, we agree that this instrument alone is not suitable to deduce any standard strategies for labour market politics or further training. We also think that other aspects are important to our application case as well which result, among others, from the differences between product markets and, for example, further training markets.

Figure 6.3: Classification of the skill occurrence trajectories in job ads



Source: Authors' account based on the Boston I matrix (Hedley 1977). © IAB

With reference to this classification, we made the following assumptions:

- In light of the observation of structural change, type (I) is of particular importance: it can be assumed that new skill requirements becoming important in the future are initially assigned to this type, since in all probability they occur less frequently in the job ads at the beginning and more frequently after a certain degree of market penetration; this is symbolised in the figure by the blue arrow at the transition between type (I) and type (II). At the same time, the share of occurrences can decrease again, then these skills would disappear from the market. In any case, we assume that further training structures, especially for type (I) skill requirements, are not established and conclude that type (I) should be the focus of any content-related orientation of training and further training. For local positioning, further examination is required regarding the regions where the demand for the individual type (I) skills occurs.
- Type (II) skills, in contrast, are more widely distributed or established, and their demand further increases. Type (III) skills are already established as well, but their demand decreases. For types (II) and (III), we assume that training and further training structures largely exist already; however, there may be quantitative imbalances between supply and demand which require quantitative adjustments of training and further training structures. Here, further examination is required regarding the regions where a high demand for individual type (II) skills exists.
- Finally, type (IV) skill requirements are of little importance, and their demand decreases. Therefore, they play a rather minor role for the content-related and quantitative design of training and further training.
- The blue arrows at the transitions between the four types symbolise an assumption derrived from a product lifecycle model. Each new skill must first be assigned to type (I) and, depending on the development, it will either disappear from the market or will be assigned to type (II). At some point, it will become less important and be assigned to type (III). Finally, the occurrences

in job ads further decrease, and the skill disappears from the market as type (IV). To examine structural change, it would be of great importance to identify those skills for which such development is true and those for which it is not.

For the distinction of the four types, quantitative determinations along the two dimensions described must be made. The skills of which the relative number of occurrences increased or decreased can be distinguished directly. This results directly from our computations. In contrast, the distinction “few occurrences” vs. “many occurrences” is more difficult.

To our knowledge, there are no theoretically derivable criteria. In our view, these are also starting points for further research, especially because such criteria should be clearly determined when further examination waves are included, in order to ensure comparability of results. As part of this feasibility study, we start with a simple relative criterion: we determine that skill occurrences with a volume below or equal to the arithmetic average of the number of relative occurrences are classified as “few occurrences” and skill occurrences with a larger volume as “many occurrences”.

Table 6.2 shows how the hard and soft skill requirements are distributed across the four types. For hard skill requirements, we make a distinction between the hard skill requirements from BERUFENET and the additional new hard skill requirements we found in the job ad texts using our manual procedure as part of this feasibility study (see Section 5.2.1).

It became evident throughout that most skills showed rather “few” occurrences according to our definition and were thus assigned to types I or IV.[40] What is also noticeable is that the number of skills with a decreased relative number of occurrences in October/November 2019 was higher than the number of skills with an increased relative number of occurrences. That was consistently the case throughout all skill groups.

Comparing, for example, the hard skill requirements from BERUFENET with the newly found hard skills results in a similar distribution which differs by a few percentage points at most; 34 and 33 percent, respectively, of the corresponding hard skills with “few” occurrences and only 3 percent, respectively, of the hard skills with “many” occurrences showed an increase in occurrences. In total, only 37 and 36 percent, respectively, of the corresponding hard skills showed an increase in occurrences. In contrast, 53 and 56 percent, respectively, of the hard skills with “few” occurrences and ten and eight percent, respectively, of the hard skills with “many” occurrences showed a decrease in occurrences. In total, 63 and 64 percent, respectively, of the corresponding hard skills were mentioned less frequently.

The distribution pattern of soft skill requirements was quite similar to that of hard skill requirements.

[40] This result is design-related: the distribution of occurrences across the skills is, as already mentioned, clearly left-skewed. A lot of skills are only seldom mentioned; in contrast, a few skills are mentioned (extremely) frequently. The arithmetic average is thus above the median, i. e., the value which divides the number of skills in two equal parts as measured by the number of their occurrences.

Table 6.2: Distribution of the number of skills across the deduced development types

Skill category or skill groups	Classification of skills: changes in the relative number of occurrences October/November 2019 vs. April/May 2019				Total number of skills
	Increase		Decrease		
	"Few" occurrences Type I	"Many" occurrences Type II	"Many" occurrences Type III	"Few" occurrences Type IV	
	Shares in %				
Hard skills – BERUFENET	34	3	10	53	3,520
Hard skills – new	33	3	8	56	273
Soft skills	23	2	12	63	57

Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors' calculations and classifications. © IAB

Even if no consistency of the distribution patterns over time can be examined with these analyses, the results still allow for the interpretation of the similarity of distribution between already known skill requirements (from BERUFENET) and the new skill requirements we found. If the latter were only "new" or innovative skills, we would have expected these to be assigned even more frequently to types I and IV as compared to the already known skills; particularly because it would have to be expected, in accordance with the idea of a skill lifecycle as outlined above, for "new" skills to occur only in job ads by few employers in specific sectors or regions at a certain point in time and therefore to be mentioned only seldom in total. One reason for this is, in our view, that not all new skill requirements found can be classified as "new" or "innovative", as discussed in Section 5.2.1. A lot of the newly found hard skill requirements fill gaps in the hard skill catalogue which have existed for a longer period of time.

Due to these results, we can conclude (for now) that with regard to their distribution across the relative number of occurrences, the newly found skill requirements have a similar relevance in job ads as the skill requirements already recorded. Therefore, we will analyse the two groups together as one group in the following.

We will now further develop the framework for an analysis of the short-term development of requirements using the example of hard skill requirements.[41]

Initially, we examined the development of the relevance of hard skill requirements by using Figure 6.4. The left panel (a) shows the development of requirements and their assignment to one of the four types. Each dot in the figure corresponds to the difference in the relative number of occurrences of a skill in October/November 2019 vs. April/May 2019, shown on the vertical axis, and the relative number of occurrences in April/May 2019, shown on the horizontal axis.

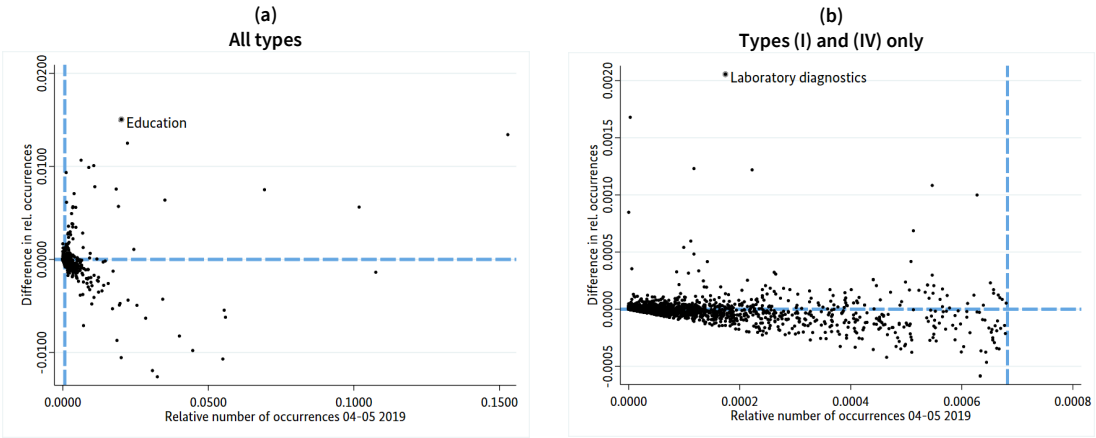
If we now look solely at the relative number of occurrences, it will become clear: the value range of the relative number of occurrences for requirements with "many" occurrences was very much

[41] The following evaluations could also be applied to the other skill categories in this case, such as soft skills, for example. We do not make use of this option, since this result report is designed, above all, to focus on the analysis potential and to illustrate this with examples.

larger than the value range for the requirements with relatively "few" occurrences. Therefore, the vertical blue dotted line separating "many" and "few" occurrences was very close to the zero line. This can be explained by the fact that there are a lot of skills across all occupations which are mentioned in relatively few job ads, and in contrast, there are very few skills which are mentioned in relatively many job ads.

Therefore, the left panel (a) in Figure 6.4 can only be used to give a visual impression of the distribution for skills with "many" occurrences. As expected, we observed skills with "many" occurrences and both increases (type II) and decreases (type III) in their number of occurrences. By way of example, we illustrated the "education" skill of type (II) with the greatest increase. In the first survey wave, "education" was mentioned in 2.01 percent of all vacancies examined by us (in 14,213 of 706,041 vacancies) and in the second survey in 3.52 percent of vacancies (in 24,852 of 706,461 vacancies). The number of vacancies showing the "education" skill requirements thus increased by about 10,000.

Figure 6.4: Relative number of occurrences of skills in April/May 2019 and their development as compared to October/November 2019



Explanation: Results for Germany for all vacancies for the three occupational sets. Each dot in the two panels in the figure corresponds to the difference in the relative number of occurrences of a skill in October/November 2019 vs. April/May 2019 (vertical axis) and the relative number of occurrences in April/May 2019 (horizontal axis). The horizontal blue dotted line divides the skills into skills with an increased number of relative occurrences and a decreased number of relative occurrences. The vertical blue dotted line is the arithmetic average of the relative number of occurrences of all skills. It divides the skills into skills with "few" and skills with "many" occurrences. This results in four types; top left corner: type (I), and then clockwise type (II), type (III), and type (IV).

Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

Figure 6.4, right panel (b), gives a much better impression of the distribution of skill requirements with "few" occurrences. This figure corresponds to panel (a), but shows a much more finer scaling with a lower value range which comprises only skill requirements with "few" occurrences.

Here it becomes evident that there are some requirements in October/November 2019 which were not yet mentioned in April/May 2019.[42] Moreover, requirements can be seen that show a quite high

[42] In April/May 2019, these skills show a relative number of occurrences of zero and are thus vertically above the zero point of the horizontal axis.

increase in October/November 2019, but had very few relative occurrences in April/May 2019. "Laboratory diagnostics" was chosen here as an example, since this skill shows the greatest increase. In the first survey wave, "laboratory diagnostics" was mentioned only in 0.02 percent of all vacancies (in 123 of 706,041 vacancies), and in the second survey, in 0.22 percent of all vacancies (in 1,575 of 706,461 vacancies). This value for October/November 2019 corresponded to 12 times the occurrences for April/May 2019.

In the next step, we can now analyse in which regions the skill requirements were demanded and where the changes occurred. However, we would like to do these evaluations in a more differentiated way by using the development of occurrences for the selected occupational sets. For this reason, we will continue our examination in Sections 6.3.2.2, 6.3.3.2, and 6.3.4.2 individually and by using a selected skill level for the three chosen occupational sets. Before that, we will present general evaluations on the hard skill requirements for each of the three selected occupational sets in the next section.

6.3 Hard skill requirements

6.3.1 Preliminary remark

In the following, we will show sample evaluations on the hard skill requirements.[43] We have seen that the hard skill requirements differ distinctly between the three selected occupational sets. Therefore, we will perform the evaluations separately for each occupational set. The results are presented in three steps:

- In the respective first sub-sections, we will present general results from the counts of skill requirements. In particular, we will determine the most frequently mentioned hard skill requirements across the two survey waves in total and according to four skill levels (from the lowest skill level "unskilled or semiskilled tasks" to "skilled tasks" to "complex tasks" to the highest skill level "highly complex tasks").[44]
- In the respective second sub-sections, we will examine the short-term development of hard skill requirements and also continue our examination from Section 6.2.
- In the respective third sub-sections, we will show sample evaluations for one individual occupation with regard to the differences between the federal states regarding the most frequently mentioned hard skill requirements.

6.3.2 MAE occupations

6.3.2.1 General evaluation and evaluations by skill level

Table 6.3 contains the number of occurrences and the relative number of occurrences for the 25 most frequently mentioned hard skill requirements in MAE occupations for the two survey waves.

[43] We defined this term in Section 4. Detailed information is available in Section 5.2.1.

[44] These skill levels are defined according to the German Classification of Occupations 2010; jobs with "unskilled or semiskilled tasks" usually require no formal qualification; jobs with "skilled tasks" require dual vocational education and training or a certificated off-the-job training; jobs with "complex tasks" require a bachelor degree from university, a master craftsman certificate or an equivalent (formal) qualification; jobs with "highly complex tasks" require a master or higher degree form university or equivalent (formal) qualifications.

According to this, “maintenance, repair, servicing” (mentioned in 23 percent of all vacancies in both survey periods), “industrial mechanics” (mentioned in 19 and 20 percent, respectively, of all vacancies), as well as “mechatronics” (mentioned in 17 percent of all vacancies) were the most frequently mentioned skill requirements in the job ads for MAE occupations in Germany across both periods. Differences could be observed only for the subsequent skill requirements; these differences, however, were rather marginal in the ranking. The table also shows that the number of job ads considerably decreased in the second survey period as compared to the first survey period.

We will now take an even more differentiating approach and will look at the counts by the skill levels. Table 6.4 contains the results for the respective ten most frequently mentioned skill requirements. At first, it becomes apparent that jobs with “unskilled or semiskilled tasks” required rather very specific, simple activities (e.g. “loading”, “deburring”, “packing”), and the skill requirements became more abstract with higher skill levels; for example, “mechatronics”, “mechanics”, or “construction” in jobs with “complex tasks”.

We also found (plausible) differences between the skill levels. When comparing the survey periods, it becomes clear that within a skill level, the most frequently mentioned skill requirements remained in the list and the ranking patterns remained stable, with a few exceptions. It also became evident that the number of vacancies in jobs with “complex tasks” increased in contrast to the vacancies in other skill levels.

Table 6.3: The 25 most frequently mentioned hard skill requirements for MAE occupations

Ranking	April/May 2019			October/November 2019		
	Skill	Number of occurrences	Relative frequency	Skill	Number of occurrences	Relative frequency
1	Service, repair, maintenance	36,637	0.23	Service, repair, maintenance	27,948	0.23
2	Industrial mechanics	31,476	0.19	Industrial mechanics	24,601	0.20
3	Mechatronics	27,098	0.17	Mechatronics	21,136	0.17
4	Work according to drawings	22,885	0.14	Work according to drawings	13,377	0.11
5	Mechanics	21,614	0.13	Mechanics	13,194	0.11
6	Technical understanding	15,282	0.09	Technical understanding	12,116	0.10
7	Production, manufacture	13,456	0.08	Operation/putting into service	8,475	0.07
8	Hydraulics	13,079	0.08	Hydraulics	6,928	0.06
9	Operation/putting into service	10,641	0.07	Welding	6,188	0.05
10	Welding	8,651	0.05	Production, manufacture	6,165	0.05
11	Pneumatics	7,023	0.04	Metalworking	5,066	0.04
12	Metalworking	6,765	0.04	Pneumatics	5,044	0.04
13	Machine control/operation, system/device operation	5,963	0.04	Loading	4,630	0.04
14	Construction	5,691	0.03	Machine control/operation, system/device operation	4,501	0.04
15	Development	5,669	0.03	Development	4,421	0.04
16	Loading	5,406	0.03	Planning	4,314	0.03
17	Quality control, quality assurance	5,147	0.03	Electronics	4,046	0.03
18	Planning	5,073	0.03	Metal construction	4,042	0.03
19	Tunnel construction	5,019	0.03	Quality control, quality assurance	3,896	0.03
20	Electronics	4,755	0.03	Construction	3,780	0.03
21	Metal construction	4,669	0.03	Electrical engineering	3,459	0.03
22	Diagnosis	4,063	0.02	Car manufacturing, vehicle technology	2,999	0.02
23	Measuring	3,867	0.02	Mechanical construction	2,896	0.02
24	Car manufacturing, vehicle technology	3,824	0.02	Drilling	2,844	0.02
25	Electrical engineering	3,796	0.02	Diagnosis	2,818	0.02
	Total number of vacancies					
		162,623			124,140	

Explanation: Vacancies for Germany and MAE occupations. MAE occupations refers to occupations in mechanical and automotive engineering (occupational main group 25 of the KldB 2010).

Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

Table 6.4: The ten most frequently mentioned hard skills for MAE occupations, according to skill levels

R.	Unskilled or semiskilled tasks	rF	Skilled tasks	rF	Complex tasks	rF	Highly complex tasks	rF
				April/May 2019				
1	Packing	0.10	Service, repair, maintenance	0.25	Service, repair, maintenance	0.28	Development	0.31
2	Machine control/operation, system/device operation	0.09	Industrial mechanics	0.23	Mechatronics	0.20	Planning	0.24
3	Quality control, quality assurance	0.07	Mechatronics	0.18	Mechanics	0.11	Construction	0.23
4	Technical understanding	0.07	Work according to drawings	0.17	Operation/putting into service	0.10	Car manufacturing, vehicle technology	0.17
5	Loading	0.06	Mechanics	0.15	Industrial mechanics	0.10	Electrical engineering	0.15
6	Deburring	0.05	Technical understanding	0.10	Development	0.09	Process engineering	0.14
7	Service, repair, maintenance	0.04	Hydraulics	0.09	Construction	0.09	Analysis	0.12
8	Metalworking	0.04	Production, manufacture	0.09	Planning	0.09	Mechatronics	0.12
9	Quality control (simple control activity)	0.03	Operation/putting into service	0.07	Hydraulics	0.08	Production, manufacture	0.11
10	Production, manufacture	0.02	Welding	0.06	Electrical engineering	0.07	Operation/putting into service	0.09
				Number of vacancies				
	9,655		133,371		6,951		12,646	
				October/November 2019				
1	Packing	0.10	Service, repair, maintenance	0.27	Service, repair, maintenance	0.17	Development	0.30
2	Technical understanding	0.10	Industrial mechanics	0.24	Mechatronics	0.17	Planning	0.23
3	Loading	0.08	Mechatronics	0.18	Industrial mechanics	0.08	Construction	0.21
4	Machine control/operation, system/device operation	0.07	Work according to drawings	0.13	Planning	0.07	Car manufacturing, vehicle technology	0.17
5	Deburring	0.05	Mechanics	0.12	Operation/putting into service	0.07	Electrical engineering	0.16
6	Quality control, quality assurance	0.04	Technical understanding	0.11	Mechanics	0.07	Mechatronics	0.16
7	Measuring	0.03	Operation/putting into service	0.07	Electrical engineering	0.06	Process engineering	0.14
8	Sorting	0.03	Hydraulics	0.06	Hydraulics	0.06	Production, manufacture	0.10
9	Cleaning	0.03	Welding	0.06	Electronics	0.06	Analysis	0.10
10	Service, repair, maintenance	0.03	Metalworking	0.05	Development	0.06	Using CAD (computer-aided design) systems	0.09
				Number of vacancies				
	7,602		97,901		8,023		10,614	

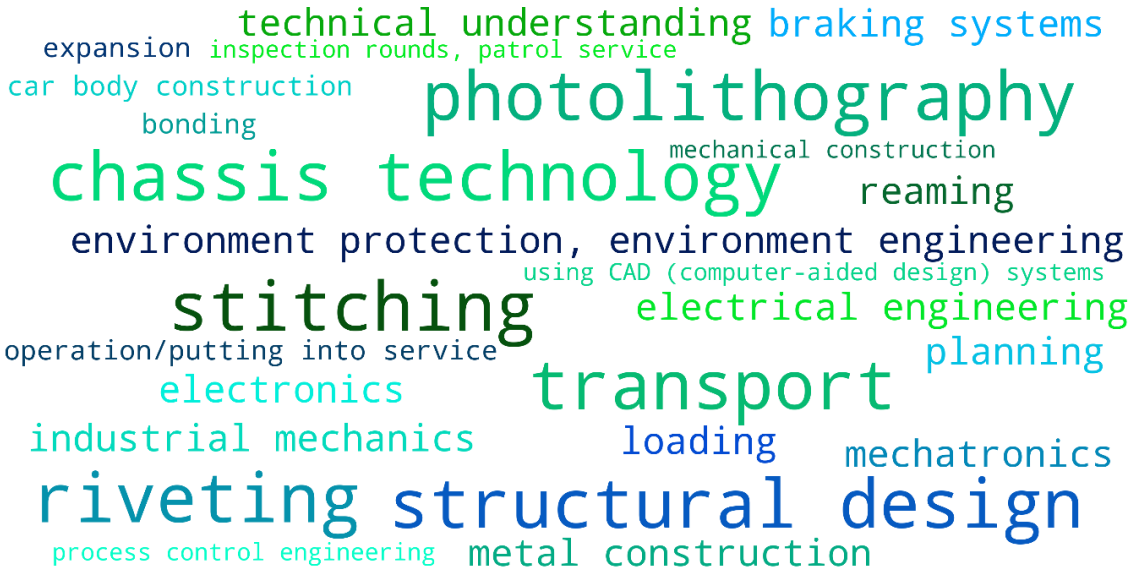
Explanation: All vacancies for Germany and MAE occupations. MAE occupations refers to occupations in mechanical and automotive engineering (occupational main group 25 of the KldB 2010). The “R” column refers to “ranking”. The “rF” columns contain the respective relative frequency of occurrences of the skills on the left according to skill level.

Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors’ calculations. © IAB

6.3.2.2 Short-term development

The word cloud in Figure 6.5 shows the 25 hard skill requirements in MAE occupations which gained the most importance, measured against the difference in the relative number of occurrences in the two survey waves. What is noticeable is that many of the skill requirements could be expected in MAE occupations. Only the “inspection rounds, patrol service” skill stepped out of line.

Figure 6.5: The 25 hard skill requirements in MAE occupations which gained most in importance



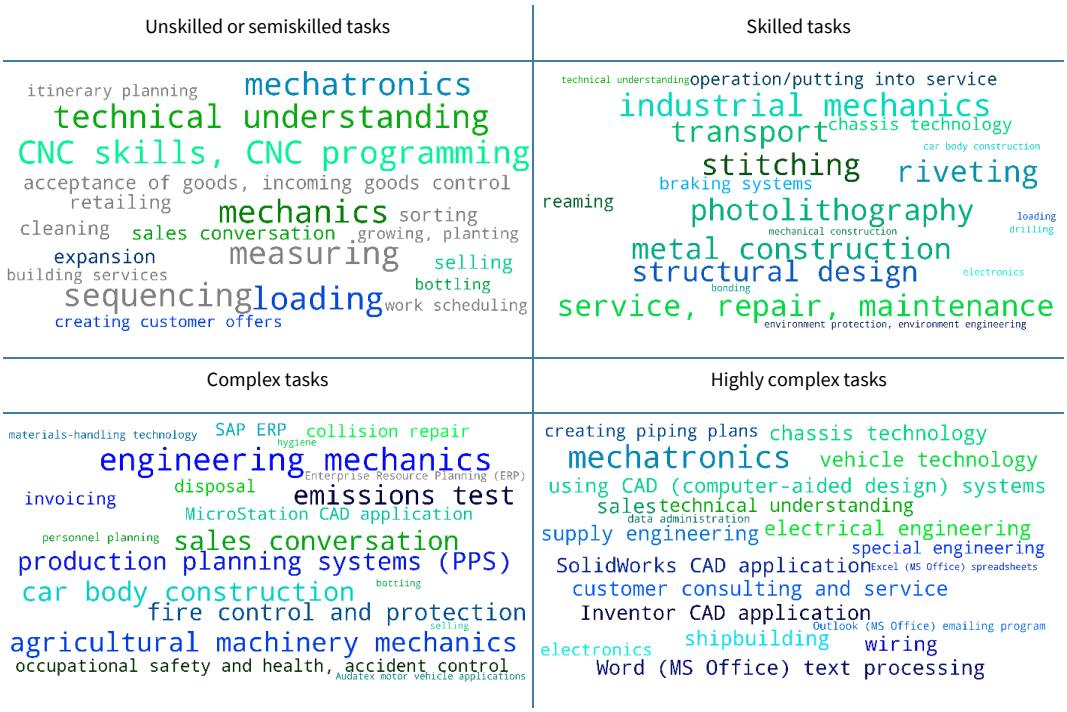
Explanation: All vacancies for Germany and MAE occupations. MAE occupations refers to occupations in mechanical and automotive engineering (occupational main group 25 of the KldB 2010). A different colour was assigned to each skill. A relatively big font size for a skill requirement indicates that the difference in the relative number of occurrences of this skill requirement between the two survey periods is high as compared to skill requirements with a small font size; a comparison of font sizes across different word clouds is not possible.

Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors’ calculations. © IAB

Now we further differentiate the picture according to skill levels. This showed considerable, expectable differences, but also some noticeable developments. For example, “mechatronics” or “CNC knowledge” were more frequently required for jobs with “unskilled or semiskilled tasks”, too. For jobs with “highly complex tasks”, it was striking that particularly the demand for very specific CAD applications increased (Figure 6.6).

The results to date are sufficient for a first impression; to derive recommended actions, for example, in-depth analyses can now be performed to find out in which regions the demand was observed and how it changed at the regional level. Therefore, we continue the examination as part of the analysis strategy outlined in Section 6.2.

Figure 6.6: The 20 hard skill requirements in MAE occupations which gained most in importance, according to skill levels



Explanation: All vacancies for Germany and MAE occupations. MAE occupations refers to occupations in mechanical and automotive engineering (occupational main group 25 of the KldB 2010). A relatively big font size for a skill requirement indicates that the difference in the relative number of occurrences of this skill requirement between the two survey periods is high as compared to skill requirements with a small font size; a comparison of font sizes across different word clouds is not possible.

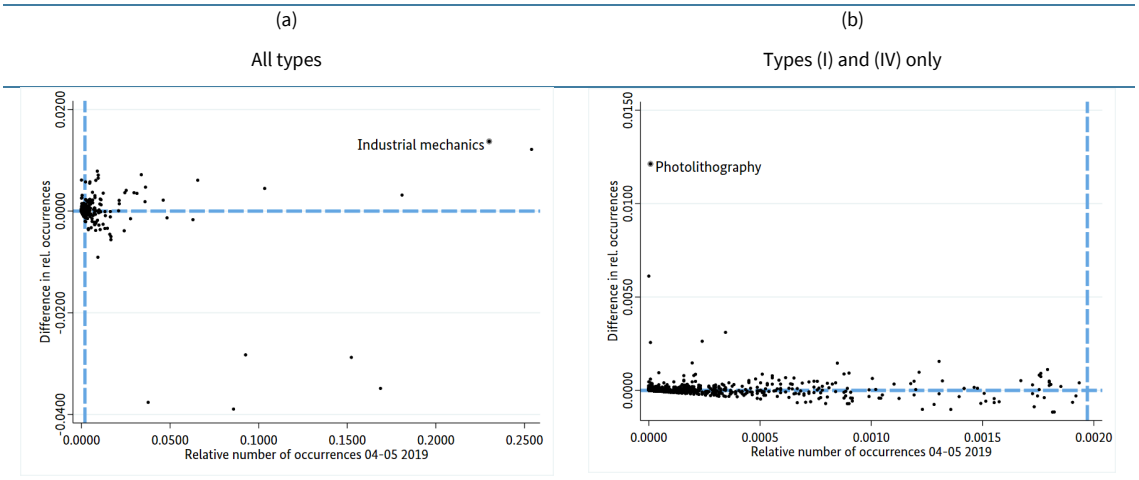
Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

We limited the examination to one skill level and chose the "skilled tasks" level.[45] For mechanical and automotive engineering occupations with the "skilled tasks" level, the analysis resulted in the development patterns from Figure 6.7. The pattern for all four types (left figure) was very similar to the pattern observed for all occupational sets examined by us in Section 6.2. For types (I) and (IV) (right panel b), a few skill requirements of type (I) were identified, which showed relatively high increases in their relative number of occurrences. The skill "photolithography"[46] showed the highest increase in this context. For type (II) this was "industrial mechanics". Now we would like to further examine the regional positioning of these two skills.

[45] This has no content-related reasons, since of course such analysis could be performed for the other skill levels as well.

[46] The "photolithography" skill refers to the proficiency in a lithographic reproduction process, which is used to apply patterns to materials by means of exposure. The process is used in solid-state technology and in printing technology (source: https://www.chemie.de/lexikon/Fotolithografie.html, last downloaded on 15 July 2020).

Figure 6.7: MAE occupations, "skilled tasks" level: relative number of occurrences of skills in April/May 2019 and their development as compared to October/November 2019



Explanation: Vacancies for Germany and MAE occupations, "skilled tasks" skill level. MAE occupations refers to occupations in mechanical and automotive engineering (occupational main group 25 of the KldB 2010). Each dot in the two panels in the figure corresponds to the difference of relative occurrences of a requirement in October/November 2019 vs. April/May 2019 (vertical axis) and the relative number of occurrences in April/May 2019 (horizontal axis). The horizontal blue dotted line divides the requirements into requirements with an increased and a decreased number of relative occurrences. The vertical blue dotted line is the arithmetic average of the relative number of occurrences of all requirements. It divides the requirements into requirements with "few" and requirements with "many" occurrences. This results in four types; top left corner: type (I), and then clockwise type (II), type (III), and type (IV). The requirements of types (I) and (II), respectively, with the highest increases are highlighted. They are "photolithography" (April/May 2019: 0.00 percent occurrences or 1 occurrence in 133,371 vacancies; October/November 2019: 1.21 percent occurrences or 1,188 of 97,901 vacancies); "industrial mechanics" (April/May 2019: 23.01 percent occurrences or 30,685 of 133,371 vacancies; October/November 2019: 24.38 percent occurrences or 23,867 of 97,901 vacancies).

Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

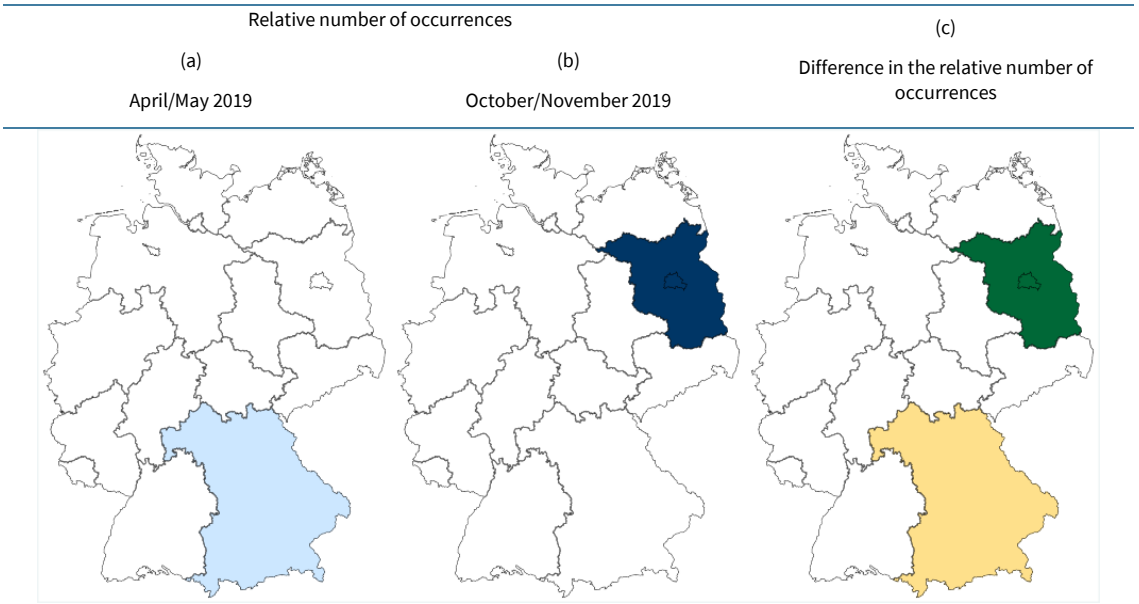
For the "photolithography" skill, there was exactly one occurrence in April/May 2019 and 1,188 occurrences in October/November 2019. From the left map in Figure 6.8 (left panel a), we can see that the "photolithography" vacancy in April/May 2019 was located in Bavaria.

In panel (a) and (b), those federal states which had no occurrences of a specific skill in job ads were highlighted in white. Federal states highlighted in blue had corresponding skill occurrences. The more relative occurrences were observed, the darker the shade of blue becomes. The value ranges apply to the shades of blue of both maps in (a) and (b) within one figure, so that comparisons of the colour shades are possible. [47]

The 1,188 vacancies for which "photolithography" was mentioned in October/November 2019, however, were distributed among Berlin and Brandenburg, with approx. the same number of occurrences, measured against the number of vacancies for MAE occupations in the "skilled tasks" skill level (Figure 6.8, centre map, panel b).

[47] The same maps with a corresponding detailed legend can be found again in Appendix 10.4. For reasons of clarity, we did not include a legend here.

Figure 6.8: Development of the “photolithography” skill



Explanation: Vacancies for Germany and MAE occupations, “skilled tasks” skill level. MAE occupations refers to occupations in mechanical and automotive engineering (occupational main group 25 of the KldB 2010). Centre and left maps: federal states highlighted in blue had corresponding occurrences of skill requirements. The more occurrences were observed, the darker the shade of blue becomes. The value ranges apply to the shades of blue of both maps, so that comparisons of the colour shades are possible. Right map: in federal states with a yellow or red colour, the relative number of occurrences decreased, and in federal states with a green colour, the relative number of occurrences increased. The more distinctive the change is, the more intensive or darker the respective colour shades become. Maps with a detailed legend can be found in Appendix 10.4.

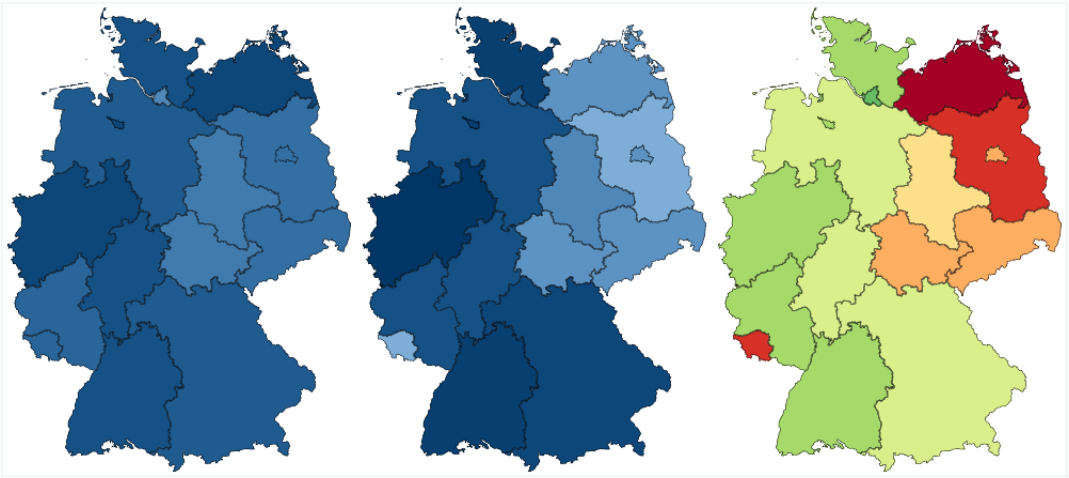
Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors’ calculations. © IAB

The right map (panel c) illustrates the changes by means of the corresponding difference in the relative number of occurrences in October/November 2019 vs. April/May 2019. In federal states with a yellow or red colour, the relative number of occurrences decreased, whereas in federal states with a green colour, the relative number of occurrences increased. Again, the more distinctive the change is, the more intensive or darker the respective colour shades become.

In October/November 2019, the “photolithography” skill was no longer required in job ads in Bavaria, but was now greatly in demand in Berlin and Brandenburg (more relative occurrences). For the “photolithography” skill the demand was thus clearly locally situated. Furthermore, a considerable demand was not to be expected until the second survey wave.

The frequently mentioned “industrial mechanics” skill (type II), however, was more widely used at the regional level; it was included in job ads in all federal states. Regional differences could be observed; in North Rhine-Westphalia, for example, the skill was demanded more frequently in job ads than in Thuringia (Figure 6.9). In October/November 2019, however, the relative demand in the job ads decreased in the eastern federal states and in Saarland. Regional differences became apparent here as well. For example, the relative number of occurrences of “industrial mechanics” in job ads decreased to a greater extent in Mecklenburg-Western Pomerania than in Saxony-Anhalt. However, in the western federal states, the relative demand in the job ads even increased, and in Hamburg, for example, it increased to a greater extent than in Bavaria.

Figure 6.9: Development of the "industrial mechanics" skill



Explanation: Vacancies for Germany and MAE occupations, "skilled tasks" skill level. MAE occupations refers to occupations in mechanical and automotive engineering (occupational main group 25 of the KldB 2010). Centre and left maps: federal states highlighted in blue had corresponding occurrences of skill requirements. The more occurrences were observed, the darker the shade of blue becomes. The value ranges apply to the shades of blue of both maps, so that comparisons of the colour shades are possible. Right map: in federal states with a yellow or red colour, the relative number of occurrences decreased, and in federal states with a green colour, the relative number of occurrences increased. The more distinctive the change is, the more intensive or darker the respective colour shades become. Maps with a detailed legend can be found in Appendix 10.4.

Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

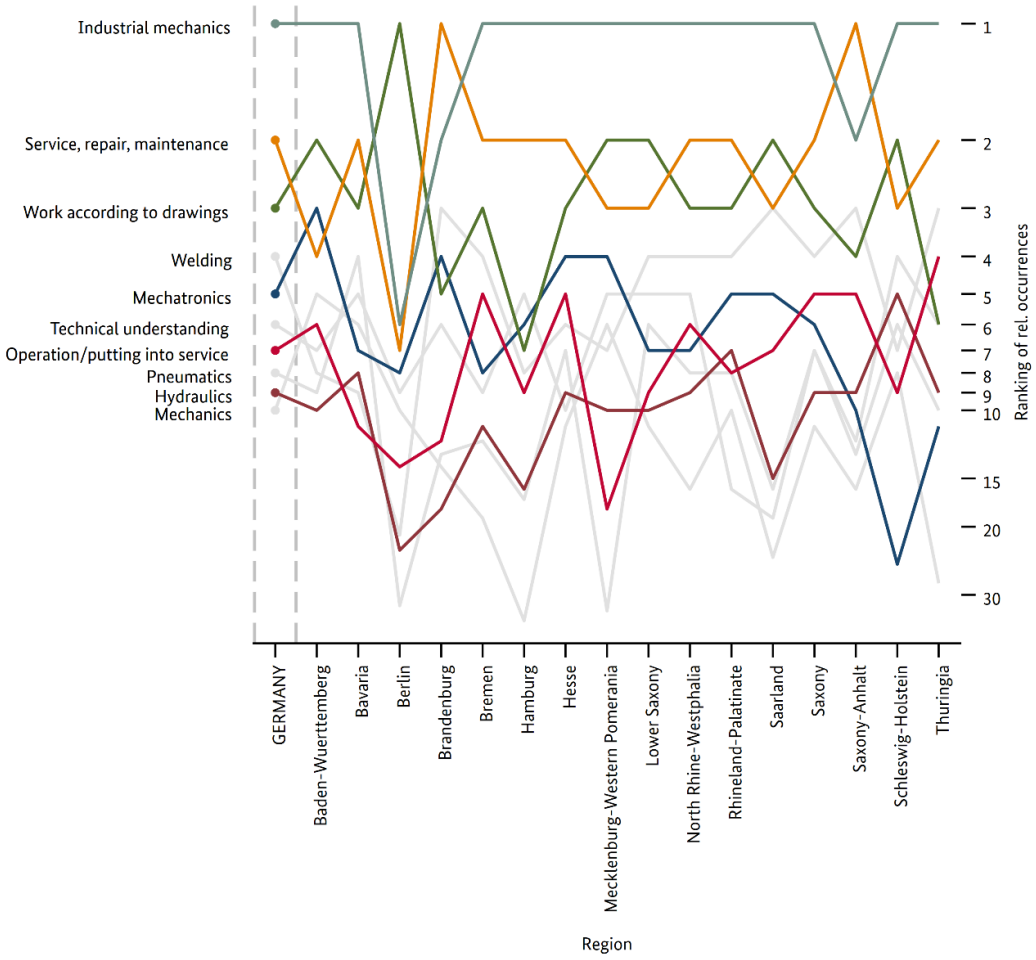
6.3.2.3 Evaluation at the level of individual occupations

By way of example, we would like to take one individual occupation to address the question of whether and to what extent the pattern of the relative number of occurrences of hard skill requirements differs between Germany and the individual federal states. To this end, we examined the ten most frequently mentioned hard skill requirements for Germany and analysed how often these requirements were mentioned in the job ads for the different federal states.

For MAE occupations, we chose "machine building and operation expert" as the individual occupation.[48] Our examination was limited to the vacancies for the second survey period of October/November 2019. In total, 20,852 job ads with 40,442 vacancies were published in this period of time. Thus, the number of vacancies for this occupation constituted about 40 percent of all evaluable vacancies with the same skill level in the field of MAE occupations; see the lower part of Table 6.4 for the "skilled tasks" skill level.

[48] The occupational type number 25102 according to the classification of occupations 2010 (KldB2010) is assigned to this job title.

Figure 6.10: Order of the number of relative occurrences of hard skills for vacancies for "machine building and operation expert" in Germany and in the federal states, October/November 2019



Explanations: Evaluation at the level of individual occupations. On the left, the ten most frequently mentioned hard skill requirements are listed in the order of the number of occurrences in job ads for "machine building and operation experts" for all of Germany (occupational type 25102 of the KldB 2010). The ranking of the skill requirements according to their relative number of occurrences in each federal state can be read from the respective location at the connected lines. In keeping with the explanations in the text, only some of the lines are coloured; the remaining lines are light grey. On the right, the ranking is shown on a logarithmically scaled axis. This has the advantage that large deviations from the first ten ranks can still be visually represented. However, it must be kept in mind that the relative space between the ranks must not be interpreted: although there is no quantitative difference, the space between ranks 1 and 2 seems to be quite large as compared to the gap between ranks 9 and 10.

Source: Data from BA-Jobbörse, access sample, survey period 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

This also explains that the ten most frequently mentioned hard skill requirements in Germany for "machine building and operation experts" listed in Figure 6.10 (left side) more or less correspond to the ten most frequently mentioned requirements for all individual occupations for MAE occupations.

If we examine the occurrences according to federal states in Figure 6.10, the similarities but also the differences become clear. There are requirements that were in more or less similar demand in all federal states. These include "industrial mechanics" and "service, repair, maintenance" as well as "work according to drawings". Other skills such as "pneumatics", "technical understanding", or "operation/putting into service" varied dramatically between the federal states with regard to the

ranking of their relative number of occurrences (see the coloured lines; for reading the respective rank, see the logarithmic axis on the right side of Figure 6.10).

In total, this results in a correspondingly heterogeneous picture, which implies that the explicit demand for skills for an individual occupation is not at all coherent, and that the underlying vacancies differ accordingly with regard to their activities and specific requirements.

6.3.3 ICT occupations

6.3.3.1 General evaluation and according to skill levels

Table 6.5 contains the number of occurrences and the relative frequency, measured against the number of vacancies for the 25 most frequently mentioned hard skill requirements for the two survey waves.

According to this table, “development” and “analysis” were the most frequently mentioned requirements in the job ads for ICT occupations in Germany in both periods of time. Differences could be observed only for the subsequent skill requirements, these differences, however, were rather marginal also in this ranking, and refer to the ranking of the occurrence of skills with few differences. Also for ICT occupations, the number of job ads considerably decreased in the second survey period as compared to the first survey period.

Table 6.6 contains the counts according to the skill levels. It must be considered that there is no “unskilled or semiskilled tasks” skill level for ICT occupations. What is striking is that the skills in the skill levels hardly differed with regard to their degree of abstraction. Nevertheless, there were differences in the weighting of the individual skill requirements. “System integration” was most frequently mentioned in the “skilled tasks” and played a less important role for the higher skill levels. For the higher skill levels, “development” was the most frequently mentioned hard requirement.

Table 6.5: The 25 most frequently mentioned hard skill requirements for ICT occupations

Ranking	April/May 2019			October/November 2019		
	Skill	Number of occurrences	Relative frequency	Skill	Number of occurrences	Relative frequency
1	Development	26,237	0.27	Development	24,260	0.29
2	Analysis	14,382	0.15	Analysis	11,960	0.14
3	Java programming language	13,823	0.14	Management	11,305	0.14
4	Management	12,251	0.12	Software implementation	10,627	0.13
5	Configuring	11,738	0.12	Java programming language	10,510	0.13
6	Software implementation	11,277	0.12	Planning	9,890	0.12
7	SQL database	10,950	0.11	SQL database	9,156	0.11
8	Planning	10,542	0.11	Configuring	7,996	0.10
9	LINUX operating system	9,843	0.10	LINUX operating system	7,887	0.10
10	System integration	8,574	0.09	System integration	7,223	0.09
11	Business information systems	8,527	0.09	Business information systems	6,874	0.08
12	HTML, XML, XHTML, XAML, XSLT	8,341	0.09	HTML, XML, XHTML, XAML, XSLT	6,735	0.08
13	JavaScript programming language	7,581	0.08	Electrical engineering	6,587	0.08
14	Architecture	6,373	0.07	Architecture	6,489	0.08
15	Electrical engineering	6,336	0.06	JavaScript programming language	6,387	0.08
16	First-level support	6,170	0.06	First-level support	4,783	0.06
17	Operation/putting into service	5,132	0.05	Active Directory service	4,396	0.05
18	Active Directory service	5,082	0.05	Operation/putting into service	4,207	0.05
19	Scrum project management and development method	4,551	0.05	Scrum project management and development method	4,112	0.05
20	Monitoring	4,377	0.04	Monitoring	3,903	0.05
21	Windows 7 operating system	4,188	0.04	Oracle database	3,331	0.04
22	Oracle database	4,138	0.04	IM SAP module (investment management)	3,215	0.04
23	User consulting, user support (IT)	3,746	0.04	git version management program	3,072	0.04
24	PHP programming language	3,644	0.04	VMware virtualisation software	3,045	0.04
25	VMware virtualisation software	3,489	0.04	Enterprise resource planning (ERP)	2,996	0.04
	Total number of vacancies					
	98,041			82,833		

Explanation: Vacancies for Germany and ICT occupations. ICT occupations refers to occupations in computer sciences, information and communication technology (occupational main group 43 of the KldB 2010).

Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

Table 6.6: The ten most frequently mentioned hard skills for ICT occupations, according to skill levels

Ranking	Skilled tasks	rF	Complex tasks	rF	Highly complex tasks	rF
	April/May 2019					
1	System integration	0.21	Development	0.21	Development	0.40
2	Configuring	0.19	Configuring	0.15	Java programming language	0.20
3	Analysis	0.14	Analysis	0.12	Software implementation	0.19
4	Development	0.14	Java programming language	0.11	Analysis	0.18
5	Management	0.13	Planning	0.11	Management	0.14
6	Windows 7 operating system	0.11	LINUX operating system	0.11	Business information systems	0.13
7	SQL database	0.11	Management	0.11	SQL database	0.12
8	LINUX operating system	0.11	SQL database	0.10	Planning	0.12
9	Operation/putting into service	0.10	First-level support	0.09	HTML, XML, XHTML, XAML, XSLT	0.11
10	First-level support	0.10	HTML, XML, XHTML, XAML, XSLT	0.08	Electrical engineering	0.10
	Number of vacancies					
	21,038		39,189		37,814	
	October/November 2019					
1	System integration	0.23	Development	0.23	Development	0.40
2	Configuring	0.18	Planning	0.12	Software implementation	0.19
3	Development	0.17	Configuring	0.12	Java programming language	0.17
4	Management	0.15	Management	0.12	Analysis	0.17
5	Analysis	0.14	Analysis	0.11	Management	0.15
6	First-level support	0.13	SQL database	0.11	Planning	0.12
7	LINUX operating system	0.11	LINUX operating system	0.11	Business information systems	0.12
8	Planning	0.11	System integration	0.09	SQL database	0.12
9	SQL database	0.10	Java programming language	0.09	Electrical engineering	0.12
10	Active Directory service	0.10	Software implementation	0.08	HTML, XML, XHTML, XAML, XSLT	0.11
	Number of vacancies					
	15,978		30,039		36,816	

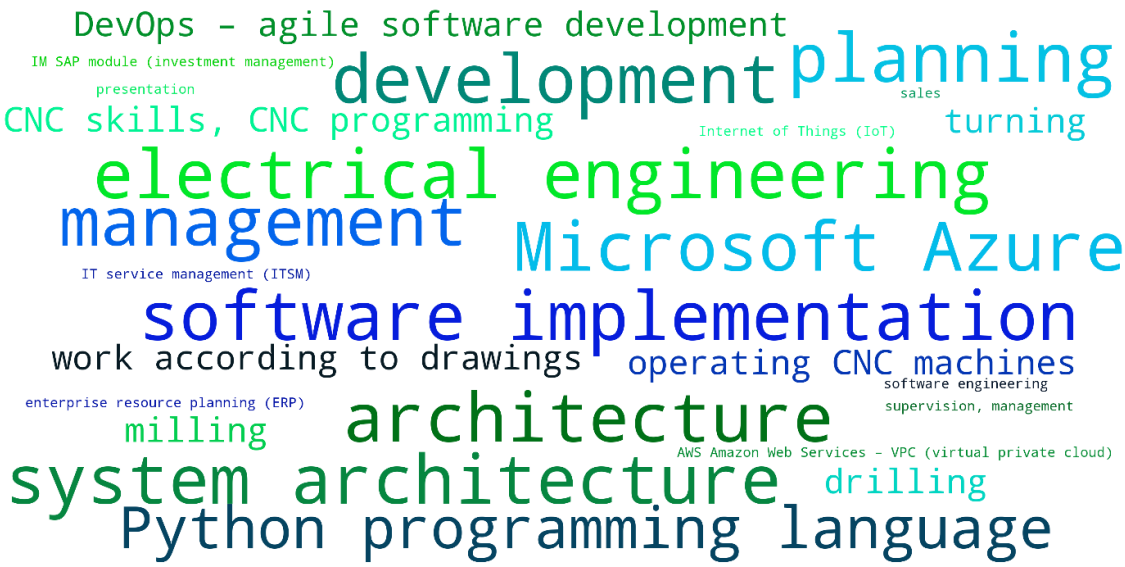
Explanation: Vacancies for Germany and ICT occupations. ICT occupations refers to occupations in computer sciences, information and communication technology (occupational main group 43 of the KldB 2010). The “rF” columns contain the respective relative frequency of occurrences of the skills on the left according to skill level. It must be considered that there is no “unskilled or semiskilled tasks” skill level for ICT occupations.

Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors’ calculations. © IAB

6.3.3.2 Short-term development

The word cloud in Figure 6.11 shows the 25 hard skill requirements for ICT occupations which gained the most importance, measured against the difference of relative occurrences between the two survey waves. Here as well, many requirements were to be expected as “typical for the occupation”; however, there were also a few skill requirements that are primarily more likely to be attributed to other occupational activities. They include skills such as “turning”, “milling”, or “drilling”.

Figure 6.11: The 25 hard skill requirements in ICT occupations which gained most in importance

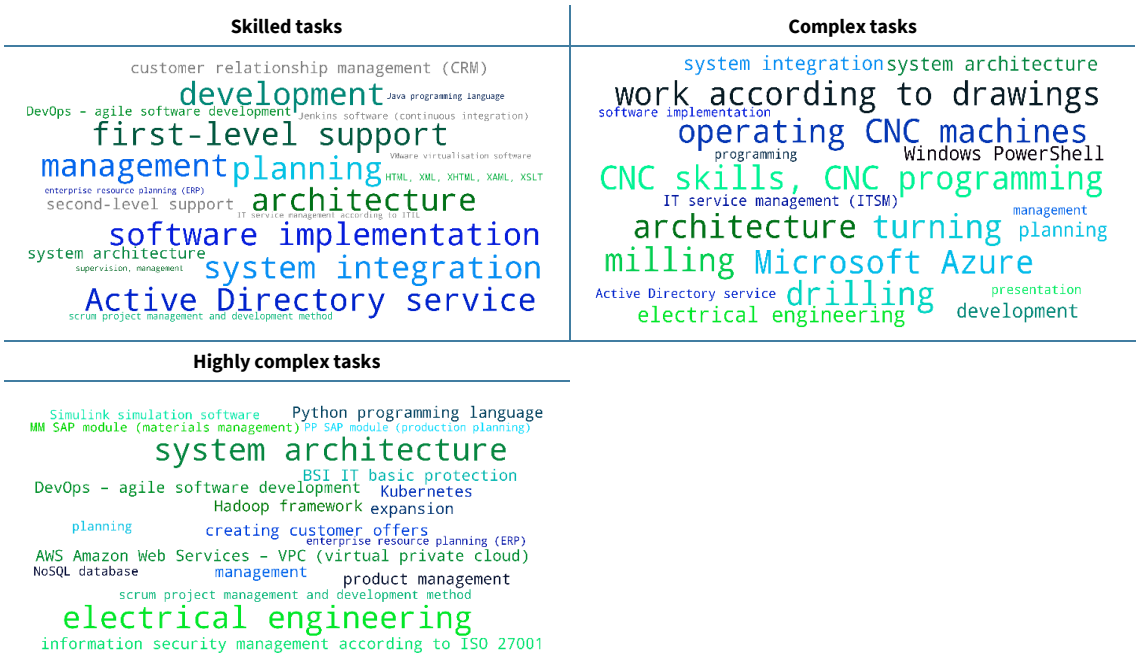


Explanation: Vacancies for Germany and ICT occupations. ICT occupations refers to occupations in information and communication technology (occupational main group 43 of the KldB 2010). A different colour was assigned to each skill. A relatively big font size for a skill requirement indicates that the difference in the relative number of occurrences of this skill requirement between the two survey periods is high as compared to skill requirements with a small font size; a comparison of font sizes across different word clouds is not possible.

Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors’ calculations. © IAB

If we examine the skill requirements with the greatest gain in importance according to skill level, further differences between the three examined skill levels will become apparent (Figure 6.12). Particularly for the ”complex tasks”, a number of skills from the CNC field were demanded, and at least “manual” understanding played a role (“milling”, “drilling”).

Figure 6.12: The 20 hard skill requirements in ICT occupations which gained most in importance, according to skill levels



Explanation: Vacancies for Germany and ICT occupations. ICT occupations refers to occupations in information and communication technology (occupational main group 43 of the KldB 2010). It must be considered that there is no "unskilled or semi-skilled tasks" skill level for ICT occupations. A relatively big font size for a skill requirement indicates that the difference in the relative number of occurrences of this skill requirement between the two survey periods is high as compared to skill requirements with a small font size; a comparison of font sizes across different *word clouds* is not possible.

Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

Now, a sample analysis according to the described analysis framework (Section 6.2) for ICT occupations will follow.

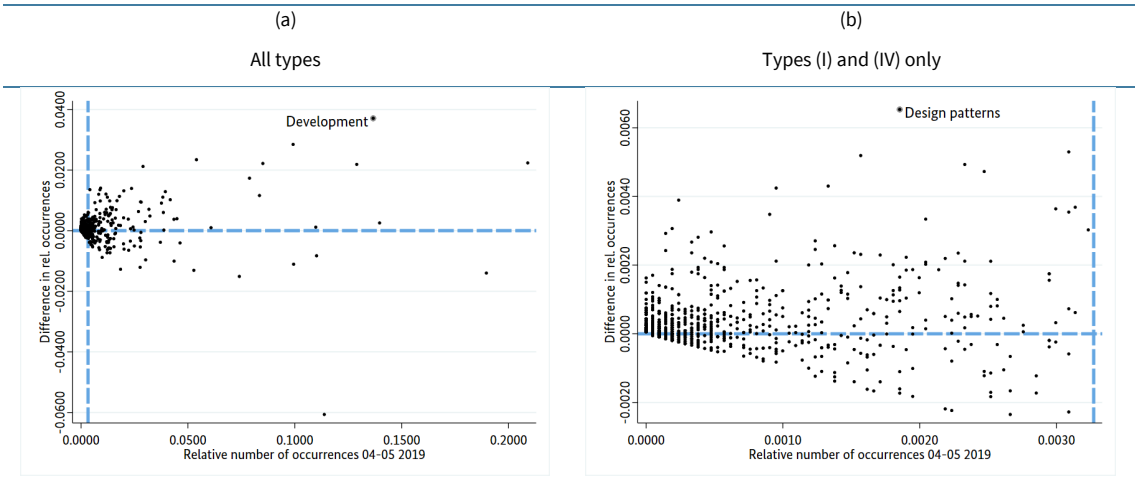
Again, we limited the examination to one skill level and chose the "skilled tasks" skill level.[49] For ICT occupations, too, a development pattern can be observed that is similar to the previous patterns – the frequently mentioned hard skill requirements were very diverse in their occurrences, and the seldom mentioned ones had a very narrow value range.

Within type (I), the "design patterns" skill[50] showed the highest increase in relative occurrences, and within type (II), it was the "development" skill. In contrast to the analysis example for MAE occupations, the type (I) requirement with the highest increase would drop out in case of a limited ranking examination (limited to ten ranks here) (see Figure 6.12, where the "design patterns" skill was not reported for the "skilled tasks").

[49] Also in this case, such analysis could be performed for the other skill levels as well.

[50] "Design patterns" refer to knowledge about explicitly describable solution paths for recurring design problems in software development. By using design patterns, a software design becomes flexible, reusable, expandable, can be used more easily, and is consistent in its basic structure.

Figure 6.13: ICT occupations, "skilled tasks" skill level: relative number of occurrences of skills in April/May 2019 and their development as compared to October/November 2019

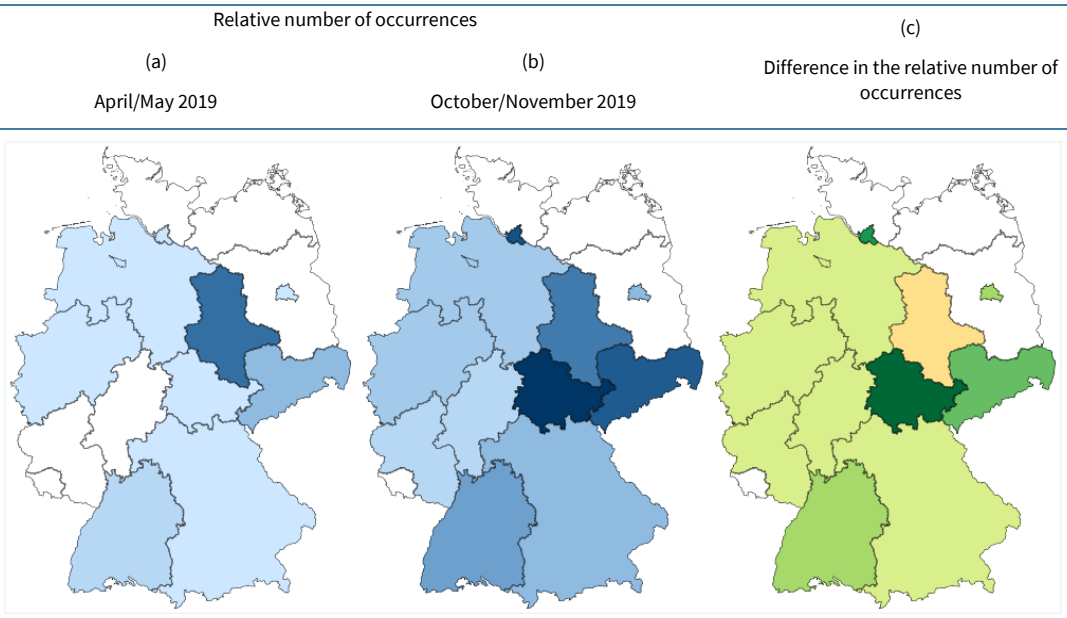


Explanation: Vacancies for Germany and ICT occupations, "skilled tasks" skill level. ICT occupations refers to occupations in information and communication technology (occupational main group 43 of the KldB 2010). Each dot in the two panels in the figure corresponds to the difference of relative occurrences of a requirement in October/November 2019 vs. April/May 2019 (vertical axis) and the relative number of occurrences in April/May 2019 (horizontal axis). The horizontal blue dotted line divides the requirements into requirements with an increased and a decreased number of relative occurrences. The vertical blue dotted line is the arithmetic average of the relative number of occurrences of all requirements. It divides the requirements into requirements with "few" and requirements with "many" occurrences. This results in four types; top left corner: type (I), and then clockwise type (II), type (III), and type (IV). The requirements of types (I) and (II), respectively, with the highest increases are highlighted. The requirements of types (I) and (II), respectively, with the highest increases are highlighted. They are "design patterns" (April/May 2019: 0.19 percent occurrences or 39 in 21,038 vacancies; October/November 2019: 0.84 percent or 134 in 15,978 vacancies); "development" (April/May 2019: 13.67 percent occurrences or 2,875 in 21,038 vacancies; October/November 2019: 17.37 percent occurrences or 2,776 in 15,978 vacancies).

Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

If we look at the regional distribution for "design patterns", it will show that this skill was demanded in 10 federal states in April/May 2019, and, measured against the occurrences in ICT job ads, especially Saxony-Anhalt had great demand in job ads for this skill (Figure 6.14, left map). In October/November 2019, this skill increased in almost all federal states except Saxony-Anhalt, and with Rhineland-Palatinate and Hesse, two additional federal states demanded this skill (Figure 6.14, centre and right map).

Figure 6.14: Development of the “design patterns” skill

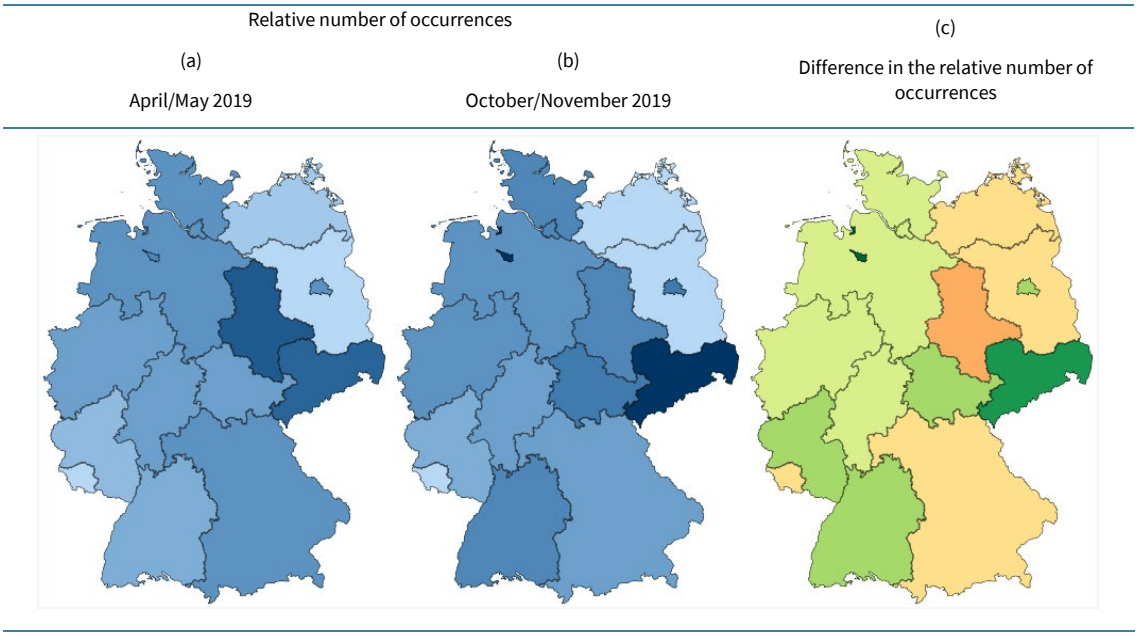


Explanation: Vacancies for Germany and ICT occupations, “skilled tasks” skill level. ICT occupations refers to occupations in information and communication technology (occupational main group 43 of the KldB 2010). Centre and left maps: Federal states highlighted in blue had corresponding occurrences of skill requirements. The more occurrences were observed, the darker the shade of blue becomes. The value ranges apply to the shades of blue of both maps, so that comparisons of the colour shades are possible. Right map: in federal states with a yellow or red colour, the relative number of occurrences decreased, and in federal states with a green colour, the relative number of occurrences increased. The more distinctive the change is, the more intensive or darker the respective colour shades become. Maps with a detailed legend can be found in Appendix 10.4.

Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors’ calculations. © IAB

The results for the “development” skill in April/May 2019 showed that this skill was demanded in job ads in all federal states (Figure 6.15, left map). However, there were regional differences in frequency: For example, the skill was more in demand in Saxony and Thuringia than in Saarland or Brandenburg. In October/November 2019, the skill gained in importance above all in job ads for Saxony – but also for other federal states – whereas it became less important in job ads for Bavaria, Brandenburg, Saarland, and Mecklenburg-Western Pomerania.

Figure 6.15: Development of the "development" skill



Explanation: Vacancies for Germany and ICT occupations, "skilled tasks" skill level. ICT occupations refers to occupations in information and communication technology (occupational main group 43 of the KldB 2010). Centre and left maps: federal states highlighted in blue had corresponding occurrences of skill requirements. The more occurrences were observed, the darker the shade of blue becomes. The value ranges apply to the shades of blue of both maps, so that comparisons of the colour shades are possible. Right map: in federal states with a yellow or red colour, the relative number of occurrences decreased, and in federal states with a green colour, the relative number of occurrences increased. The more distinctive the change is, the more intensive or darker the respective colour shades become. Maps with a detailed legend can be found in Appendix 10.4.

Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

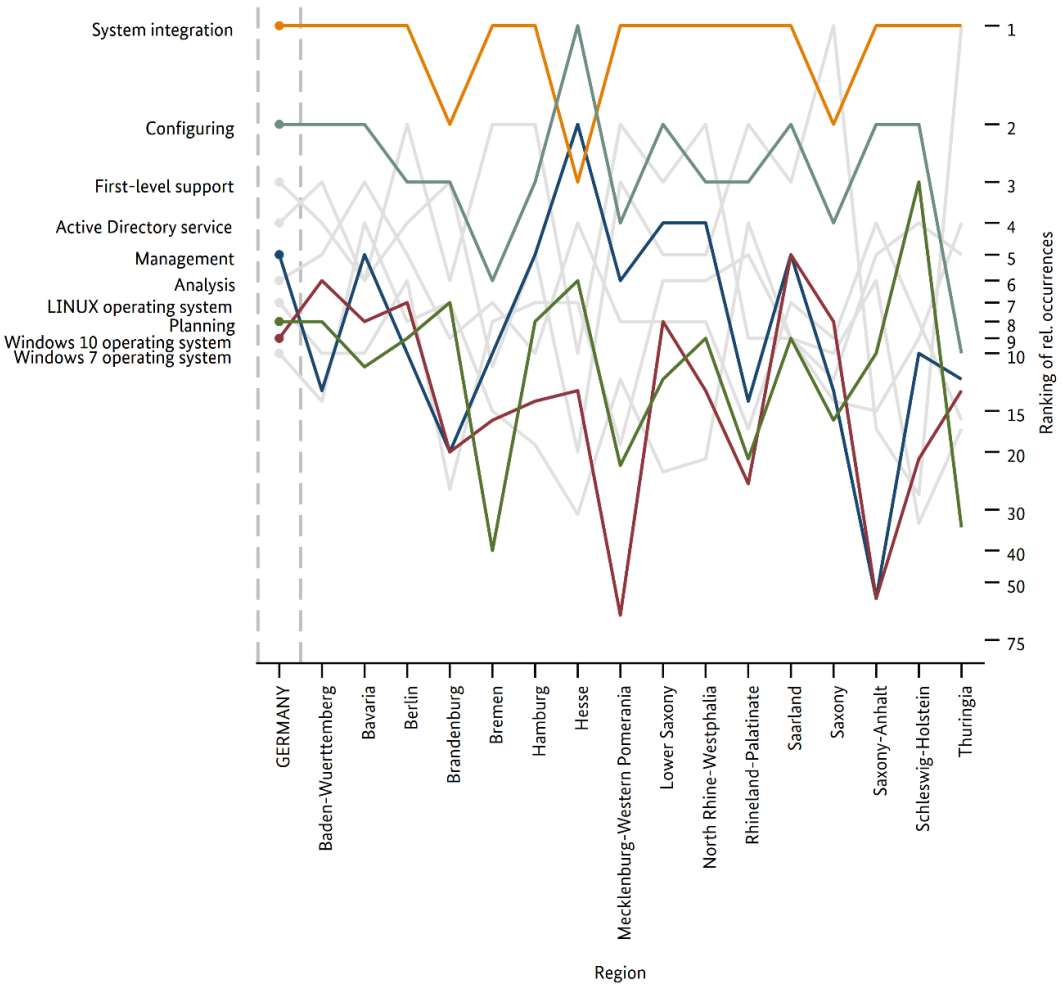
6.3.3.3 Evaluation at the level of individual occupations

For the analysis at the individual occupation level, we selected "computer science expert" as an example for ICT occupations.[51] Again, our examination is limited to the vacancies for the second survey period October/November 2019. In total, 5,558 job ads with 8,706 vacancies were published in this period of time. The vacancies for this individual occupation constituted almost 55 percent of all evaluable vacancies with the same skill level in the field of ICT occupations; see the lower part of Table 6.6 for the "skilled tasks" skill level.

The correlation of the ten most frequently mentioned hard skill requirements in Germany for "computer science experts" listed in Figure 6.16 (left side) with the ten most frequently mentioned skill requirements for all individual occupations for ICT occupations with the same skill level, however, was less pronounced; this points to an overall higher heterogeneity of requirements in ICT occupations.

[51] The "occupational type" code 43102 according to the classification of occupations 2010 (KldB2010) is assigned to this job title.

Figure 6.16: Order of the number of relative occurrences of hard skills for vacancies for "computer science experts" in Germany and in the federal states, October/November 2019



Explanations: Evaluation at the level of individual occupations. On the left, the ten most frequently mentioned hard skill requirements are listed in the order of their number of occurrences in job ads for "computer science experts" for all of Germany (occupational type 43102 of the KldB 2010). The ranking of the skill requirements according to their relative number of occurrences in each federal state can be read from the respective location at the connected lines. In keeping with the explanations in the text, only some of the lines are coloured; the remaining lines are light grey. On the right, the ranking is shown on a logarithmically scaled axis. This has the advantage that large deviations from the first ten ranks can still be visually represented. However, it must be kept in mind that the relative space between the ranks must not be interpreted: although there is no quantitative difference, the space between ranks 1 and 2 seems to be quite large as compared to the gap between ranks 9 and 10.

Source: Data from BA-Jobbörse, access sample, survey period 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

If we examine the occurrences according to federal states, once more considerable differences can be observed. Among the ten most frequently mentioned skill requirements, there were only a few that were in similar demand in all federal states. They include "system integration" and "configuring"; however, the ranking of occurrences of both skill requirements varies very much between the federal states. Dramatic differences between the federal states could be observed for "planning", "management", or "Windows 10" (see the coloured lines; for reading the respective rank, see the logarithmic axis on the right side of Figure 6.10).

Overall, the picture is considerably more heterogeneous with regard to the occurrence of skills in job ads for "computer science experts" in the individual federal states.

6.3.4 HES occupations

6.3.4.1 General evaluation and according to skill levels

Table 6.7 contains the number of occurrences and the relative frequency, measured against the number of vacancies for the 25 most frequently mentioned hard skill requirements for the two survey waves for HES occupations.

The HES occupations with their three consolidated occupational main groups[52] are likely to show the greatest heterogeneity in the requirements. In a way, this can also be seen from the most frequently mentioned requirements: initially, requirements from nursing and geriatric care were among the top requirements for both survey periods. They were followed by skill requirements mainly from the education field ("education", "care of children", and "disabled people"), from "social education" (individual requirement), but also from the medical ("anaesthetics") and non-medical health care sectors ("taking blood samples", "social care/disability support care").

When comparing both survey periods, some differences for the most frequently mentioned requirements could be observed: six skill requirements[53] were "replaced" by six other skill requirements in the ranking.[54] What is striking is that the replaced skill requirements obviously originated from different areas of HES occupations, whereas the skill requirements that became more important could all be associated with the medical health care sector.

We will now take an even more differentiating approach and will look at the counts according to skill level in the following. Table 6.8 contains the results for the respective ten most frequently mentioned skills. The heterogeneity to be explained by the composition of HES occupations can be seen here very clearly. The development from simple requirements for unskilled or semiskilled tasks to abstract requirements for highly complex tasks identified, for example, in MAE occupations could be observed only occasionally in the ranking; for example, "washing" was mentioned frequently as a very specific simple requirement for "unskilled or semiskilled tasks", while "supervision/management" was among the most frequently stated requirements for "highly complex tasks" only.

[52] Medical occupations in health care (occupational main group 81 of the KldB 2010); non-medical occupations in health care, personal hygiene, and well-being, medical engineering (occupational main group 82); education, social and household occupations, theology (occupational main group 83).

[53] "Hygiene", "youths (care, etc.)", "customer consulting and service", "quality management", "dancing", "therapy".

[54] "Out-patient care", "dialysis", "gynaecology and obstetrics", "aftercare", "emergency medicine", "pain therapy".

Table 6.7: The 25 most frequently mentioned hard skill requirements for HES occupations

Ranking	April/May 2019			October/November 2019		
	Skill	Number of occurrences	Relative frequency	Skill	Number of occurrences	Relative frequency
1	Nursing care	107,925	0.24	Nursing care	117,474	0.24
2	Treatment care	75,910	0.17	Geriatric care	75,873	0.15
3	Geriatric care	71,860	0.16	Treatment care	74,987	0.15
4	Nursing documentation	39,149	0.09	Nursing documentation	35,318	0.07
5	Basic nursing	24,759	0.06	Basic nursing	29,281	0.06
6	Children (care, etc.)	24,225	0.05	Development	25,562	0.05
7	Planning	23,844	0.05	Education	24,847	0.05
8	Development	17,010	0.04	Anaesthetics	24,506	0.05
9	Anaesthetics	15,664	0.04	Preschool work, preschool education	24,454	0.05
10	Education	14,211	0.03	Children (care, etc.)	21,217	0.04
11	Preschool work, preschool education	13,888	0.03	Planning	20,889	0.04
12	Social care/disability support care	13,501	0.03	Activating care	18,296	0.04
13	Activating care	12,944	0.03	Social care/disability support care	17,536	0.04
14	People with disabilities (care, etc.)	9,498	0.02	High-tech medicine	14,523	0.03
15	Supervision, management	9,476	0.02	Social education	13,292	0.03
16	Social education	7,765	0.02	Child and infant care	13,289	0.03
17	High-tech medicine	7,467	0.02	Aftercare	11,971	0.02
18	Hygiene	7,080	0.02	Gynaecology and obstetrics	7,733	0.02
19	Youths (care, etc.)	7,025	0.02	Dialysis	7,417	0.01
20	Therapy	6,790	0.02	People with disabilities (care, etc.)	7,123	0.01
21	Child and infant care	6,300	0.01	Out-patient care	7,094	0.01
22	Customer consulting and service	5,123	0.01	Taking blood samples	6,817	0.01
23	Quality management	5,030	0.01	Emergency medicine	6,451	0.01
24	Dancing	4,994	0.01	Supervision, management	6,333	0.01
25	Taking blood samples	4,812	0.01	Pain therapy	6,332	0.01
	Total number of vacancies					
	445,377			499,488		

Explanation: Vacancies for Germany and HES occupations. HES occupations refers to medical occupations in health care (occupational main group 81 of the KldB 2010); non-medical occupations in health care, personal hygiene, and well-being, medical engineering (occupational main group 82); education, social and household occupations, theology (occupational main group 83).

Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

Table 6.8: The ten most frequently mentioned hard skills for HES occupations, according to skill levels

R.	Unskilled or semiskilled tasks	rF	Skilled tasks	rF	Complex tasks	rF	Highly complex tasks	rF
	April/May 2019							
1	Basic nursing	0.34	Nursing care	0.28	Nursing care	0.34	Social education	0.11
2	Treatment care	0.18	Treatment care	0.22	Anaesthetics	0.19	Development	0.09
3	Nursing documentation	0.14	Geriatric care	0.20	Treatment care	0.07	Geriatric care	0.07
4	Geriatric care	0.14	Nursing documentation	0.10	Planning	0.06	Planning	0.07
5	Activating care	0.09	Children (care, etc.)	0.07	Therapy	0.06	Nursing care	0.07
6	Nursing care	0.04	Planning	0.06	Geriatric care	0.04	Social work	0.06
7	Older people (care, etc.)	0.03	Education	0.04	Nursing documentation	0.03	Supervision, management	0.06
8	Washing	0.03	Social care/disability support care	0.04	Gynaecology and obstetrics	0.03	Quality management	0.05
9	Out-patient/home care	0.02	Preschool work, preschool education	0.04	Rehabilitation	0.03	Internal medicine	0.05
10	Hygiene	0.02	Development	0.04	Monitoring	0.03	Children (care, etc.)	0.04
	Number of vacancies							
	47,968		291,168		61,494		44,747	
	October/November 2019							
1	Basic nursing	0.32	Nursing care	0.29	Nursing care	0.26	Social education	0.24
2	Treatment care	0.21	Treatment care	0.18	Anaesthetics	0.18	Development	0.14
3	Geriatric care	0.20	Geriatric care	0.17	Gynaecology and obstetrics	0.14	Education	0.12
4	Activating care	0.11	Nursing documentation	0.08	Pathology	0.10	Preschool work, preschool education	0.11
5	Nursing documentation	0.10	Children (care, etc.)	0.06	Therapy	0.06	Social work	0.11
6	Nursing care	0.03	Education	0.06	Philosophy	0.06	Planning	0.06
7	Out-patient/home care	0.03	Preschool work, preschool education	0.06	Treatment care	0.05	Geriatric care	0.05
8	Washing	0.02	Development	0.05	Geriatric care	0.05	Nursing care	0.04
9	Older people (care, etc.)	0.02	Social care/disability support care	0.05	Planning	0.04	People with disabilities (care, etc.)	0.04
10	Child and infant care	0.02	Planning	0.04	Mothers (care, etc.)	0.04	Supervision	0.03
	Number of vacancies							
	59,901		340,234		52,411		46,942	

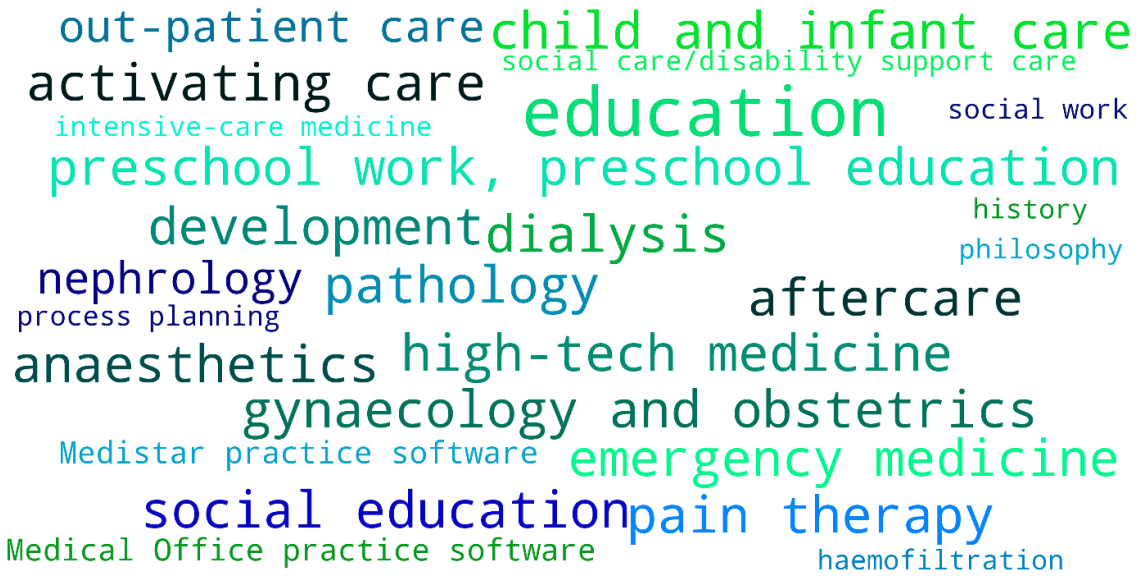
Explanation: Vacancies for Germany and HES occupations. HES occupations refers to medical occupations in health care (occupational main group 81 of the KldB 2010); non-medical occupations in health care, personal hygiene, and well-being, medical engineering (occupational main group 82); education, social and household occupations, theology (occupational main group 83). The “R” column refers to “ranking”. The “rF” columns contain the respective relative frequency of occurrences of the skills on the left according to skill level.

Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors’ calculations. © IAB

6.3.4.2 Short-term development

If we examine the 25 hard skill requirements that gained most in importance in HES occupations, measured against their relative number of occurrences, the picture is again heterogeneous with regard to the range of occupations for which the skill requirements presented can be regarded as typical, which is generally due to the heterogeneity of individual occupations within the HES occupations (Figure 6.17). We can also see a lot of skill requirements which were frequently mentioned in April/May 2019 and in the following gained even more in importance with a corresponding high absolute increase (e. g. “education” with over 10,000 more occurrences).

Figure 6.17: The 25 hard skill requirements in HES occupations which gained most in importance

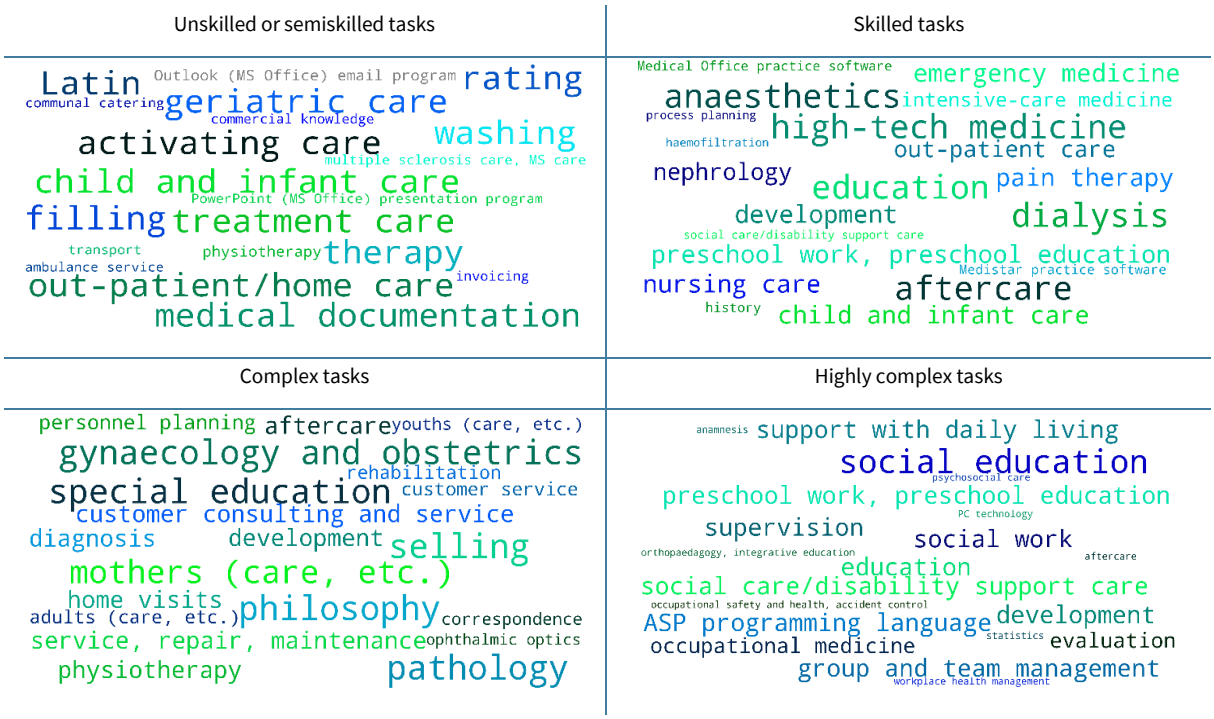


Explanation: Vacancies for Germany and HES occupations. HES occupations refers to medical occupations in health care (occupational main group 81 of the KldB 2010); non-medical occupations in health care, personal hygiene, and well-being, medical engineering (occupational main group 82); education, social and household occupations, theology (occupational main group 83). A different colour was assigned to each skill. A relatively big font size for a skill requirement indicates that the difference in the relative number of occurrences of this skill requirement between the two survey periods is high as compared to skill requirements with a small font size; a comparison of font sizes across different word clouds is not possible.

Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors’ calculations. © IAB

When evaluating the development of hard skill requirements by skill levels, distinct differences between the skill levels can once more be observed (Figure 6.18). While for “unskilled or semiskilled tasks”, more occurrences were counted especially in the nursing sector and also for a few very specific activities (e. g. “washing”), for the “skilled tasks” these were skills from the medical sector (“high-tech medicine, anaesthetics, dialysis”) and from the educational sector (“education”, “preschool work, preschool education”). For the two “complex” skill levels, the range of sectors which the skills with the highest increase belong to was even broader.

Figure 6.18: The 20 hard skill requirements in HES occupations which gained most in importance, according to skill levels



Explanation: Vacancies for Germany and HES occupations. HES occupations refers to medical occupations in health care (occupational main group 81 of the KldB 2010); non-medical occupations in health care, personal hygiene, and well-being, medical engineering (occupational main group 82); education, social and household occupations, theology (occupational main group 83). A relatively big font size for a skill requirement indicates that the difference in the relative number of occurrences of this skill requirement between the two survey periods is high as compared to skill requirements with a small font size; a comparison of font sizes across different word clouds is not possible.

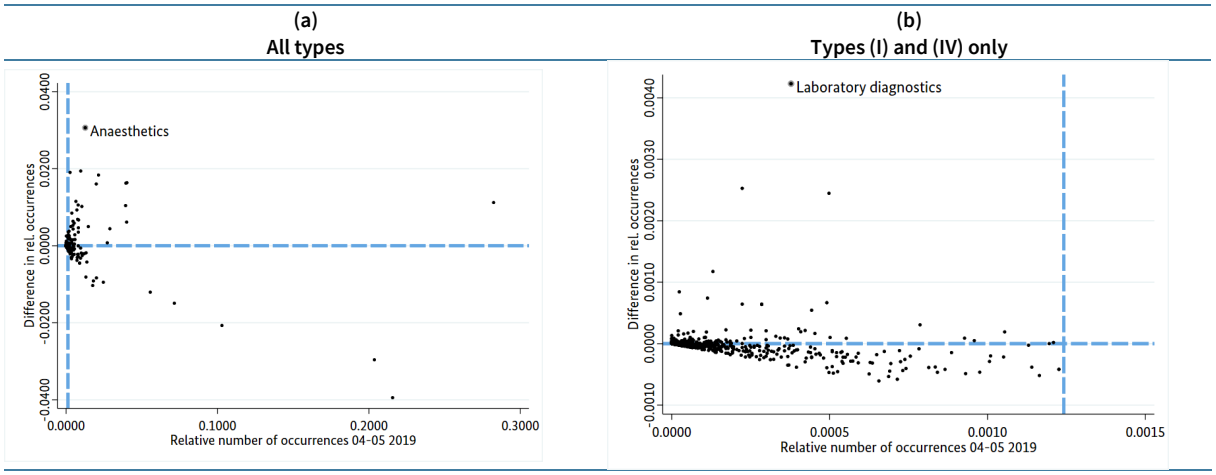
Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

We continued our examination with a sample analysis according to the described analysis framework (Section 6.2) for the HES occupations as well. Again, we limited the examination to one skill level and chose the "skilled tasks" skill level.[55]

For HES occupations, too, a development pattern can be observed that is similar to the previous patterns for MAE and ICT occupations – the frequently mentioned skill requirements were very diverse in their occurrences, and the seldom mentioned ones had a very narrow value range. Within type (I), the "anaesthetics" skill showed the highest increase in the relative number of occurrences, and within type (II), it was the "laboratory diagnostics" skill.

[55] As already noted for MAE and ICT occupations, also in this case, such analysis could be performed for the other skill levels as well.

Figure 6.19: HES occupations, "skilled tasks" skill level: relative number of occurrences of skills in April/May 2019 and their development as compared to October/November 2019

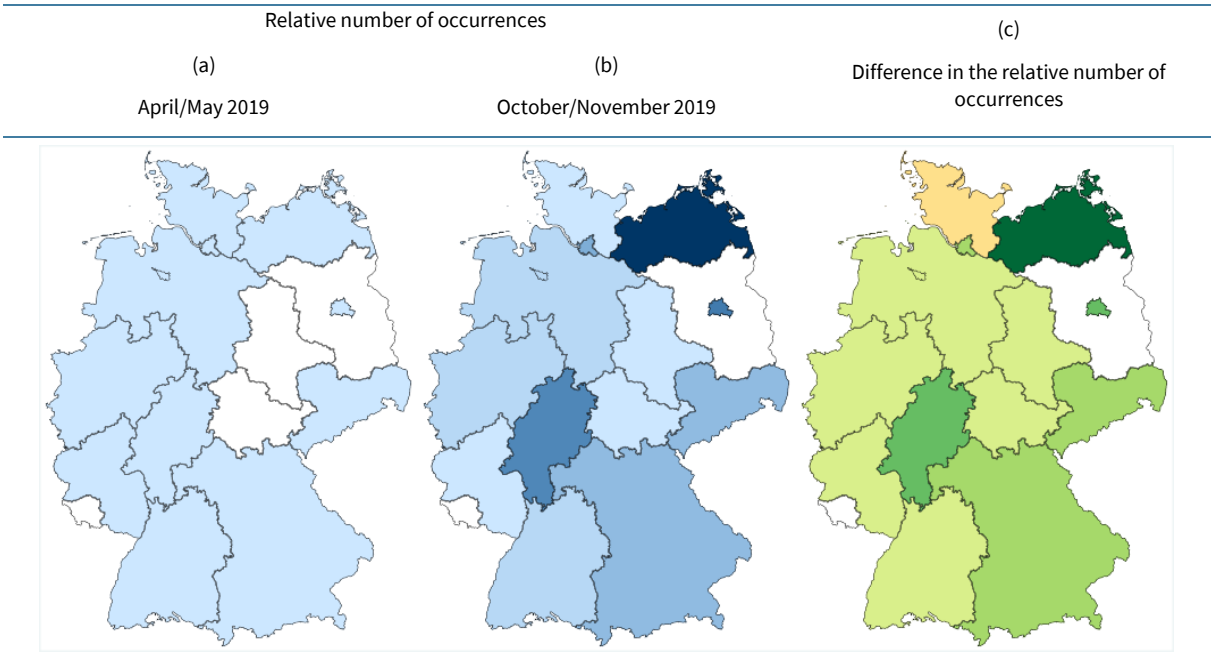


Explanation: Vacancies for Germany and HES occupations, "skilled tasks" skill level. HES occupations refers to medical occupations in health care (occupational main group 81 of the KldB 2010); non-medical occupations in health care, personal hygiene, and well-being, medical engineering (occupational main group 82); education, social and household occupations, theology (occupational main group 83). Each dot in the two panels in the figure corresponds to the difference of relative occurrences of a requirement in October/November 2019 vs. April/May 2019 (vertical axis) and the relative number of occurrences in April/May 2019 (horizontal axis). The horizontal blue dotted line divides the requirements into requirements with an increased and a decreased number of relative occurrences. The vertical blue dotted line is the arithmetic average of the relative number of occurrences of all requirements. It divides the requirements into requirements with "few" and requirements with "many" occurrences. This results in four types; top left corner: type (I), and then clockwise type (II), type (III), and type (IV). The requirements of types (I) and (II), respectively, with the highest increases are highlighted. They are "laboratory diagnostics" (April/May 2019: 0.04 percent occurrences or 110 in 291,168 vacancies; October/November 2019: 0.46 percent or 1,568 in 340,234 vacancies); "anaesthetics" (April/May 2019: 1.27 percent occurrences or 3,684 in 291,168 vacancies; October/November 2019: 4.33 percent occurrences or 14,729 in 340,234 vacancies).

Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

If we look at the regional distribution, we can see for "laboratory diagnostics" that this skill was demanded in almost all federal states in April/May 2019 except for Saarland, Thuringia, Brandenburg, and Saxony-Anhalt (Figure 6.20., left map). In October/November 2019, this skill requirement showed an increase in almost all federal states, only in Saxony-Anhalt and Saarland it was still not required, and in Schleswig-Holstein, the number of occurrences in the job ads decreased slightly. By comparison, Mecklenburg-Western Pomerania and Hesse showed the highest increases, followed by Bavaria, Saxony, and Berlin (Figure 6.20., centre and right maps).

Figure 6.20: Development of the “laboratory diagnostics” skill

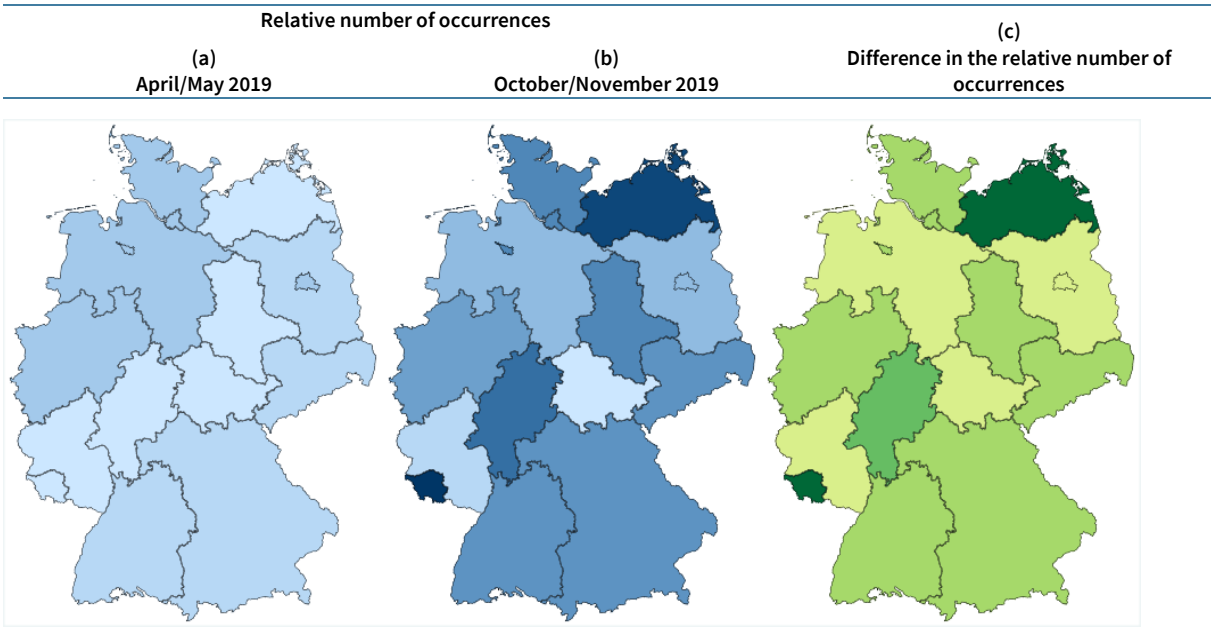


Explanation: Vacancies for Germany and HES occupations, “skilled tasks” skill level. HES occupations refers to medical occupations in health care (occupational main group 81 of the KldB 2010); non-medical occupations in health care, personal hygiene, and well-being, medical engineering (occupational main group 82); education, social and household occupations, theology (occupational main group 83). Centre and left maps: federal states highlighted in blue had corresponding occurrences of skill requirements. The more occurrences were observed, the darker the shade of blue becomes. The value ranges apply to the shades of blue of both maps, so that comparisons of the colour shades are possible. Right map: in federal states with a yellow or red colour, the relative number of occurrences decreased, and in federal states with a green colour, the relative number of occurrences increased. The more distinctive the change is, the more intensive or darker the respective colour shades become. Maps with a detailed legend can be found in Appendix 10.4.

Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors’ calculations. © IAB

The “anaesthetics” skill was demanded in April/May 2019 in job ads for all federal states (Figure 6.21, left map); in Saxony and Thuringia to a greater extent than, for example, in Saarland or Brandenburg. In October/November 2019, the occurrences in job ads of this requirement increased in all federal states. The increases were particularly high in Mecklenburg-Western Pomerania, Hesse, and Saarland (Figure 6.21, centre and right map).

Figure 6.21: Development of the "anaesthetics" skill



Explanation: Vacancies for Germany and HES occupations, "skilled tasks" skill level. HES occupations refers to medical occupations in health care (occupational main group 81 of the KldB 2010); non-medical occupations in health care, personal hygiene, and well-being, medical engineering (occupational main group 82); education, social and household occupations, theology (occupational main group 83). Centre and left maps: federal states highlighted in blue had corresponding occurrences of skill requirements. The more occurrences were observed, the darker the shade of blue becomes. The value ranges apply to the shades of blue of both maps, so that comparisons of the colour shades are possible. Right map: in federal states with a yellow or red colour, the relative number of occurrences decreased, and in federal states with a green colour, the relative number of occurrences increased. The more distinctive the change is, the more intensive or darker the respective colour shades become. Maps with a detailed legend can be found in Appendix 10.4.

Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

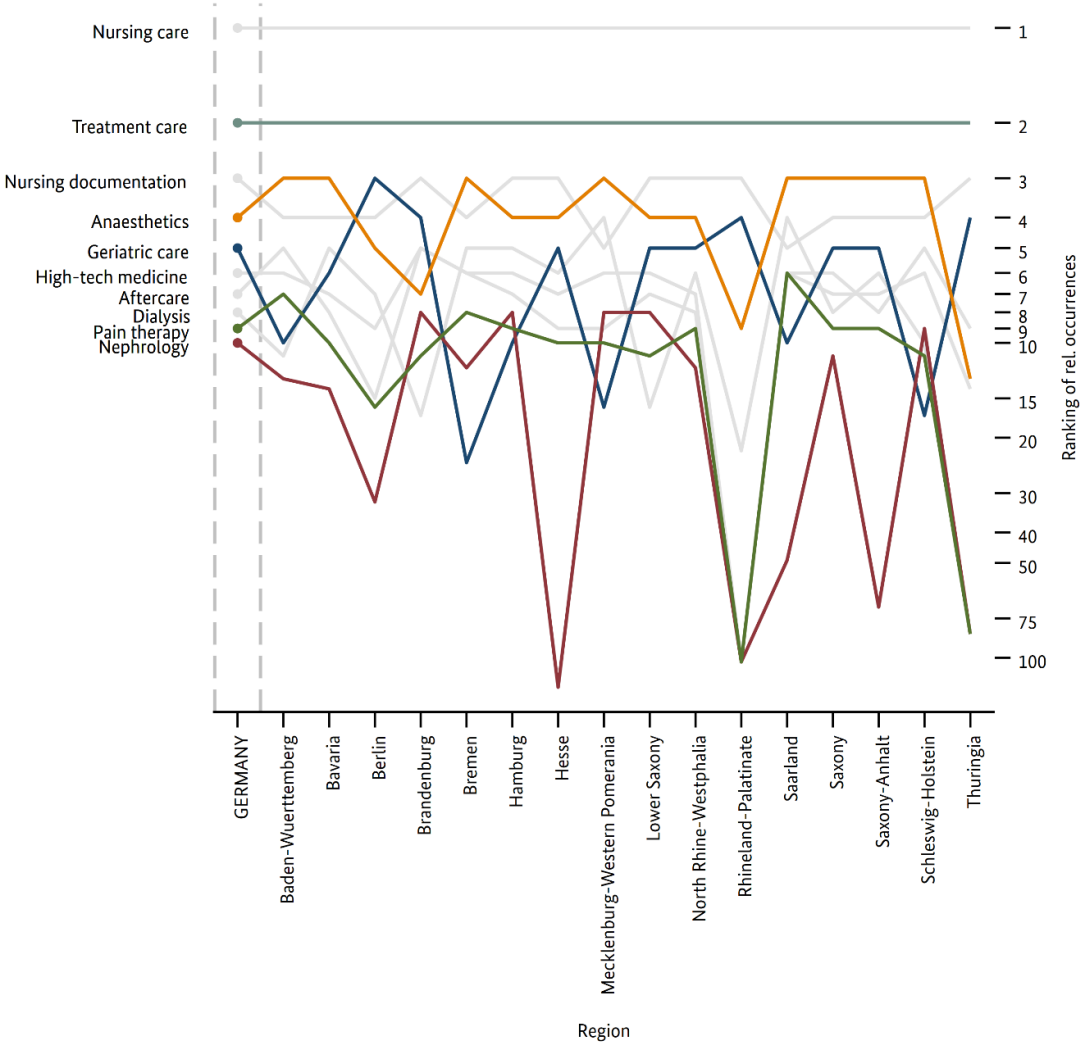
6.3.4.3 Evaluation at the level of individual occupations

For HES occupations, we chose "health and nursing care expert" as the individual occupation.[56] For the second survey period of October/November 2019, a total of 24,579 job ads with 108,644 vacancies were published. The vacancies for this individual occupation constituted almost one third of all evaluable vacancies with the same skill level in the field of HES occupations; see the lower part of Table 6.8 for the "skilled tasks" skill level.

The ten most frequently mentioned hard skill requirements in Germany for "health and nursing care experts" listed in Figure 6.22 (left side) correlated even less with the ten most frequently mentioned skill requirements for all individual occupations for HES occupations with the same skill level (see again Table 6.8 for the "skilled tasks" skill level) as compared to the MAE and ICT occupations. This can also be explained by the probably most pronounced overall heterogeneity of the HES occupations combined by us in this report across the three different occupational main groups.

[56] The occupational type number 81302 according to the classification of occupations 2010 (KldB2010) is assigned to this job title.

Figure 6.22: Order of the number of relative occurrences of hard skills for vacancies for "health and nursing care experts" in Germany and in the federal states, October/November 2019



Explanations: Evaluation at the level of individual occupations. On the left, the ten most frequently mentioned hard skill requirements are listed in the order of their number of occurrences in job ads for "health and nursing care specialists" for all of Germany. The ranking of the skill requirements according to their relative number of occurrences in each federal state can be read from the respective location at the connected lines. In keeping with the explanations in the text, only some of the lines are coloured; the remaining lines are light grey. On the right, the ranking is shown on a logarithmically scaled axis. This has the advantage that large deviations from the first ten ranks can still be visually represented. However, it must be kept in mind that the relative space between the ranks must not be interpreted: although there is no quantitative difference, the space between ranks 1 and 2 seems to be quite large as compared to the gap between ranks 9 and 10.

Source: Data from BA-Jobbörse, access sample, survey period 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

If we examine the occurrences according to federal states, however, fewer differences can be observed in this individual occupation. Many of the ten most frequently used skill requirements showed a quite similar pattern in the ranking of their occurrences in the federal states. "Nursing care" and "treatment care" clearly belonged to this group, but also "nursing documentation" and "anaesthetics" were mentioned in job ads with a relatively similar frequency in all federal states. Some other skill requirements, however, showed considerable variations in their occurrences in job ads for the different federal states even for vacancies for "health and nursing care specialists", e. g. "pain therapy" (see the coloured lines; for reading the respective rank, see the logarithmic axis on the right side of Figure 6.22).

Overall, the picture is somewhat less heterogeneous with regard to the occurrence of skills in job ads for "health and nursing care specialists" than for the examined individual occupations for MAE and ICT occupations.

6.4 Soft skill requirements

In the following, selected evaluations on the soft skill requirements[57] according to Heyse/Erpenbeck (2004) will be shown. We examined the selected occupational sets together in order to be able to better identify similarities and differences. Moreover, we examined the differences between the skill levels.

Table 6.9 lists the relative number of occurrences of the ten most frequently mentioned soft skill requirements for the three selected occupational sets. The upper part is based on the first access sample of April/May 2019, and the lower part is based on the second access sample of October/November 2019.

Seven requirements were continuously mentioned in all three occupational sets and in both access samples: "capacity for team work", "reliability", "self-management", "resilience", "commitment", "communication skills", and "willingness to learn".

In addition to that, there are two skill requirements that were mentioned frequently for MAE and ICT occupations, but not for HES occupations: "project management" and "dialogue ability customer orientation". And there are requirements that occurred in the ranking only for one of the three occupational sets. For both survey periods, these were "mobility" for MAE occupations, "analytical skills" for ICT occupations, and "expertise" and "social commitment" for HES occupations. For April/May 2019, "loyalty" was also included in the ranking for HES occupations, and in October/November 2019 it was "self-responsibility".[58]

[57] We defined this term in Section 4. Detailed information is available in Section 5.2.2.

[58] We can see certain dynamics here as well, which may be further examined by using the procedure described in Section 6.2. Since we already described the procedure for hard requirements by way of example, we will not do this again, but instead examine the skill levels in more detail.

Table 6.9: The ten most frequently mentioned soft skill requirements according to occupational sets

Ranking	MAE occupations		ICT occupations		HES occupations	
	Skill	rF	Skill	rF	Skill	rF
	April/May 2019					
1	Capacity for teamwork	0.2361	Capacity for teamwork	0.1452	Reliability	0.2169
2	Reliability	0.1889	Communication skills	0.0856	Capacity for teamwork	0.1622
3	Self-management	0.1500	Self-management	0.0661	Commitment	0.1111
4	Resilience	0.0704	*Project management*	0.0580	Resilience	0.0777
5	Commitment	0.0395	*Dialogue ability customer orientation*	0.0504	Self-management	0.0385
6	Communication skills	0.0260	Analytical skills	0.0394	Communication skills	0.0185
7	Willingness to learn	0.0182	Reliability	0.0361	Expertise	0.0174
8	*Dialogue ability customer orientation*	0.0169	Resilience	0.0342	Social commitment	0.0102
9	Mobility	0.0168	Commitment	0.0289	Loyalty	0.0053
10	*Project management*	0.0115	Willingness to learn	0.0227	Willingness to learn	0.0048
	Total number of vacancies					
	162,623		98,041		445,377	
	October/November 2019					
1	Capacity for teamwork	0.2257	Capacity for teamwork	0.1275	Reliability	0.1321
2	Reliability	0.1973	Communication skills	0.0815	Capacity for teamwork	0.1209
3	Self-management	0.0959	Self-management	0.0646	Resilience	0.1137
4	Resilience	0.0770	*Project management*	0.0590	Commitment	0.0556
5	Commitment	0.0439	Analytical skills	0.0477	Self-management	0.0537
6	Communication skills	0.0362	*Dialogue ability customer orientation*	0.0373	Communication skills	0.0136
7	Willingness to learn	0.0261	Reliability	0.0309	Expertise	0.0068
8	Mobility	0.0227	Resilience	0.0303	Social commitment	0.0041
9	*Dialogue ability customer orientation*	0.0128	Commitment	0.0257	Willingness to learn	0.0033
10	*Project management*	0.0107	Willingness to learn	0.0128	Self-responsibility	0.0030
	Total number of vacancies					
	124,140		82,833		499,488	

Explanation: Vacancies for Germany and the three selected occupational sets. MAE occupations refers to occupations in mechanical and automotive engineering (occupational main group 25 of the KldB 2010); ICT occupations refers to occupations in computer sciences, information and communication technology (occupational main group 43); HES occupations refers to occupations in health care (occupational main group 81); non-medical occupations in health care, personal hygiene, and well-being, medical engineering (occupational main group 82); education, social and household occupations, theology (occupational main group 83). Unformatted skill requirements are listed in all three occupational sets. Skill requirements in italics are listed in two occupational sets. Underlined requirements are listed in one occupational set only. The "rF" columns contain the respective relative frequency of occurrences of the skills on the left according to skill level.

Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

We will now differentiate according to the classification of soft skill requirements presented in Section 5.2.2 into “personal skills”, “activity and action skills”, “functional and methodical skills”, and “social and communication skills”.

Info box – Explanatory notes on the figures in this section

The following applies to these figures: Due to the broad range of relative occurrences (here from the 0.0001 range to almost 0.2), the scaling in the individual figures was not chosen consistently. This procedure allows for more descriptive diagrams, which can be used to estimate, in particular, how important the individual skills were for the respective occupational set. This estimate can be compared across occupational sets. However, it is important to remember that no direct comparisons with regard to the different basic skills should be made based on the length of the bars. For that purpose, the respective scaling must be taken into account.

Figure 6.23 summarises the evaluation results for “personal skills” according to Heyse/Erpenbeck (2004).[59] The figure shows the relative frequency of occurrences of individual personal skills for each of the three selected occupational sets. Some similarities and differences with regard to the occurrence of personal skills can be discerned between the individual occupational sets.

The similarities are that some skill requirements were mentioned with a higher-than-average frequency; these are, among others, “self-management”, “reliability”, and “commitment” for all three occupational sets. “Willingness to learn” was another one for MAE and ICT occupations. “Self-responsibility” was requested with a relative high frequency only for ICT occupations. The weighting and level of relative occurrences was different, in particular when taking the skill with the highest number of occurrences as a basis. For MAE occupations, the maximum number of relative occurrences was almost 0.2 (“reliability”); for ICT occupations, this number was approx. 0.06 (“self-management”), and for HES occupations, it was 0.13 (“reliability”).

If the relevance of skill requirements for the individual skill levels within the occupational sets is examined, no pattern can be observed across the different occupational sets.[60] For MAE occupations, “commitment” and “reliability” were more often required for vacancies with an “unskilled or semiskilled tasks” skill level, whereas for ICT and HES occupations, these skill requirements were demanded for the intermediate skill levels. In contrast, “holistic thinking” was demanded with a higher-than-average frequency for vacancies for the “highly complex tasks” skill level.

Figure 6.24 shows the results for “activity and action skills” according to Heyse/Erpenbeck (2004). The first striking result is that the “resilience” skill was mentioned most frequently for all occupational sets. However, also in this case it becomes apparent that the level of relative occurrences differed very much; for MAE occupations, it was 0.08, while it was 0.03 for ICT occupations and 0.12 for HES occupations. In the relative comparison, “mobility” and “results-oriented behaviour” stood out for MAE and ICT occupations. In addition to that, “proactivity” must be mentioned for ICT occupations only. For HES occupations, “social commitment” was the second most important activity and action skill, although the level of relative occurrences was very low.

[59] “Personal skills” model explanation according to Heyse/Erpenbeck (2004) on p. 29 (section 5.2.2).

[60] See Figure 10.9 in the Appendix.

Again the picture with regard to the skill levels was likewise heterogeneous:[61] "resilience", for example, was more likely to be demanded for the lower and medium skill levels for MAE and ICT occupations, whereas for HES occupations, this skill requirement was mentioned above all in job ads for the highest skill level "highly complex tasks". In fact, it was generally apparent for HES occupations in particular that the activity and action skills were demanded, above all, in the occupations with the highest skill level. This was only partially applicable to the other two occupational sets.

Figure 6.25 shows the results for "functional and methodical skills" according to Heyse/Erpenbeck (2004). "Analytical skills" and "expertise" were skills mentioned relatively often across all three occupational sets. But here again, the levels of relative occurrences were sometimes different ("analytical skills" for MAE and HES occupations: about 0.002, and for ICT occupations: 0.04; "expertise" for MAE occupations: 0.006; for ICT occupations: 0.01; for HES occupations: 0.007). For MAE occupations, "diligence" was another skill, and for HES occupations, it was "organisational skills". An additional skill for MAE and ICT occupations was "project management", which was mentioned relatively often for both groups; however, there were again considerable differences with regard to the level of relative occurrences (MAE occupations: 0.01 vs. ICT occupations: 0.06).

Moreover, it became evident that "diligence" was a skill requirement mentioned again for the medium skill levels in MAE and ICT occupations, but for the highest skill level in HES occupations. [62] Still: in all three occupational sets, the "functional and methodical skills" were demanded mostly for the highest skill levels.

Summarised evaluations for "social and communication skills" according to Heyse/Erpenbeck (2004) are shown in Figure 6.26. Especially the "capacity for teamwork" and "communication skills" skill requirements had a consistent relatively high relevance across the three occupational sets. "Dialogue ability customer orientation" was another one for MAE and ICT occupations. With regard to the relevance for the skill levels, the results were again very diverse, with many skill requirements being mostly requested for the highest skill level once again.[63] An exception was, for example, "capacity for teamwork", which was almost equally demanded for all skill levels. Another exception was "conscientiousness", which was demanded mostly for the medium or low skill levels.

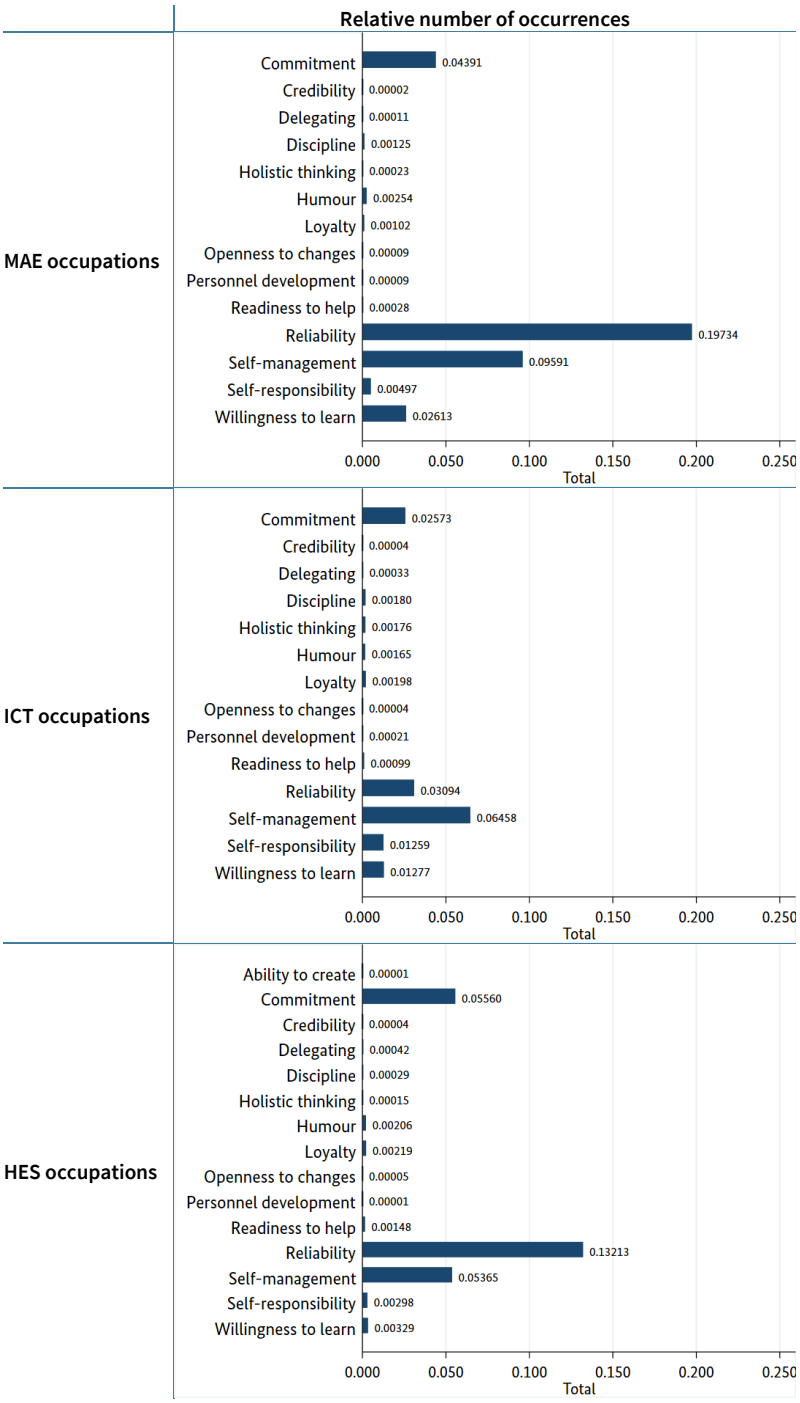
Overall and in comparison with the hard skill requirements, soft skill requirements were mentioned relatively seldom by employers in the job ads. Even the most frequently mentioned requirements such as "capacity for teamwork", "reliability", or "communication skills" were demanded for most different levels. But also generally, we found a high heterogeneity regarding the relative number of occurrences of the individual soft skill requirements between the occupational sets. This heterogeneity can also be observed within the occupational sets along the skill levels; a pattern, as is the case with the skill levels, for example, cannot be observed. Further analyses in this regard could, for example, take potentially interesting soft skill requirements as a basis and examine in which occupations these are predominantly demanded. It might be possible that certain patterns can be derived from this which may explain the decision of employers to include or not include certain soft skill requirements in their job ads.

[61] See Figure 10.10 in the Appendix.

[62] See Figure 10.11 in the Appendix.

[63] See Figure 10.12 in the Appendix.

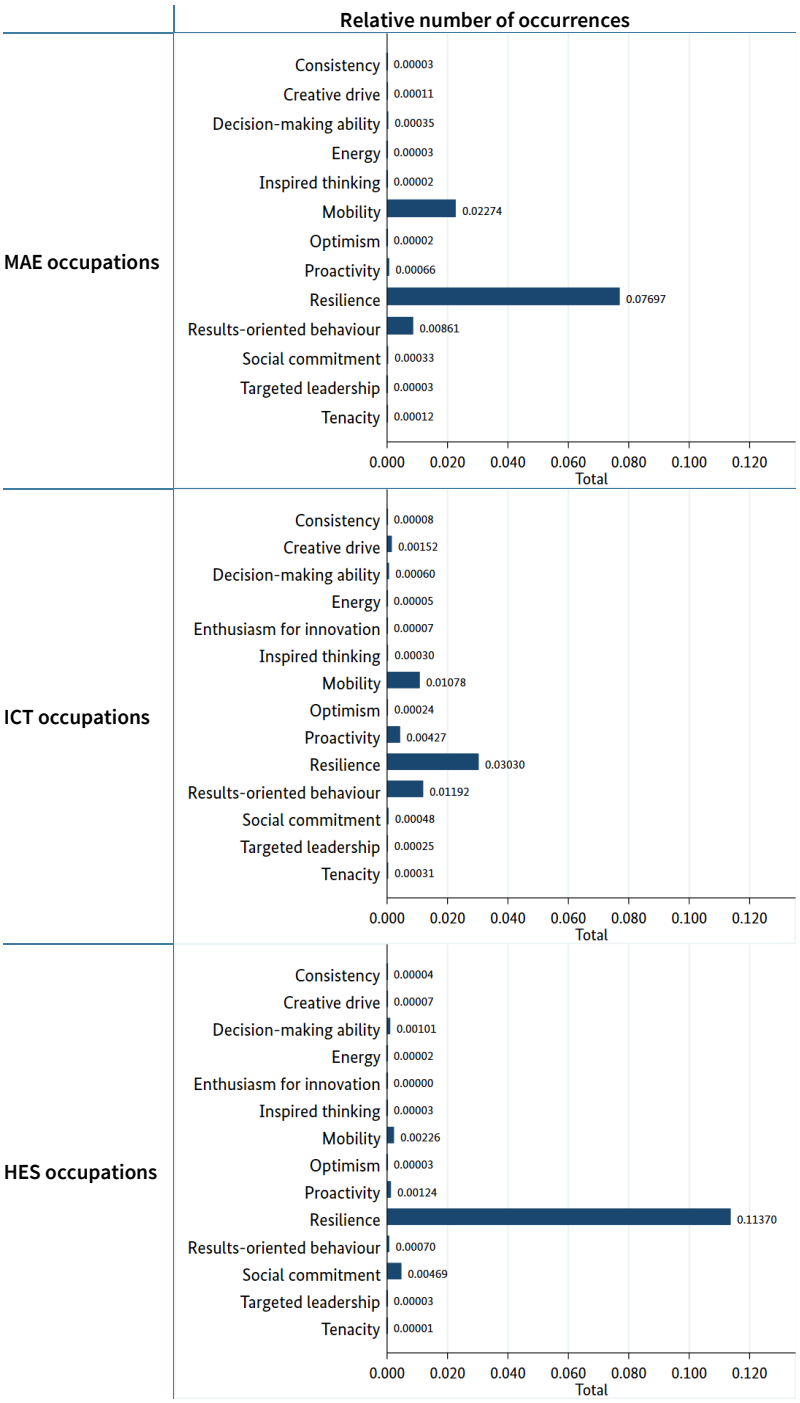
Figure 6.23: Relative number of occurrences of "personal skills" according to Heyse/Erpenbeck (2004) in job ads



Explanations: Vacancies for Germany and the three selected occupational sets. For interpretations, see the info box in this section. MAE occupations refers to occupations in mechanical and automotive engineering (occupational main group 25 of the KldB 2010); ICT occupations refers to occupations in computer sciences, information and communication technology (occupational main group 43); HES occupations refers to occupations in health care (occupational main group 81); non-medical occupations in health care, personal hygiene, and well-being, medical engineering (occupational main group 82); education, social and household occupations, theology (occupational main group 83).

Source: Data from the BA employment website, access sample, period of time: 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

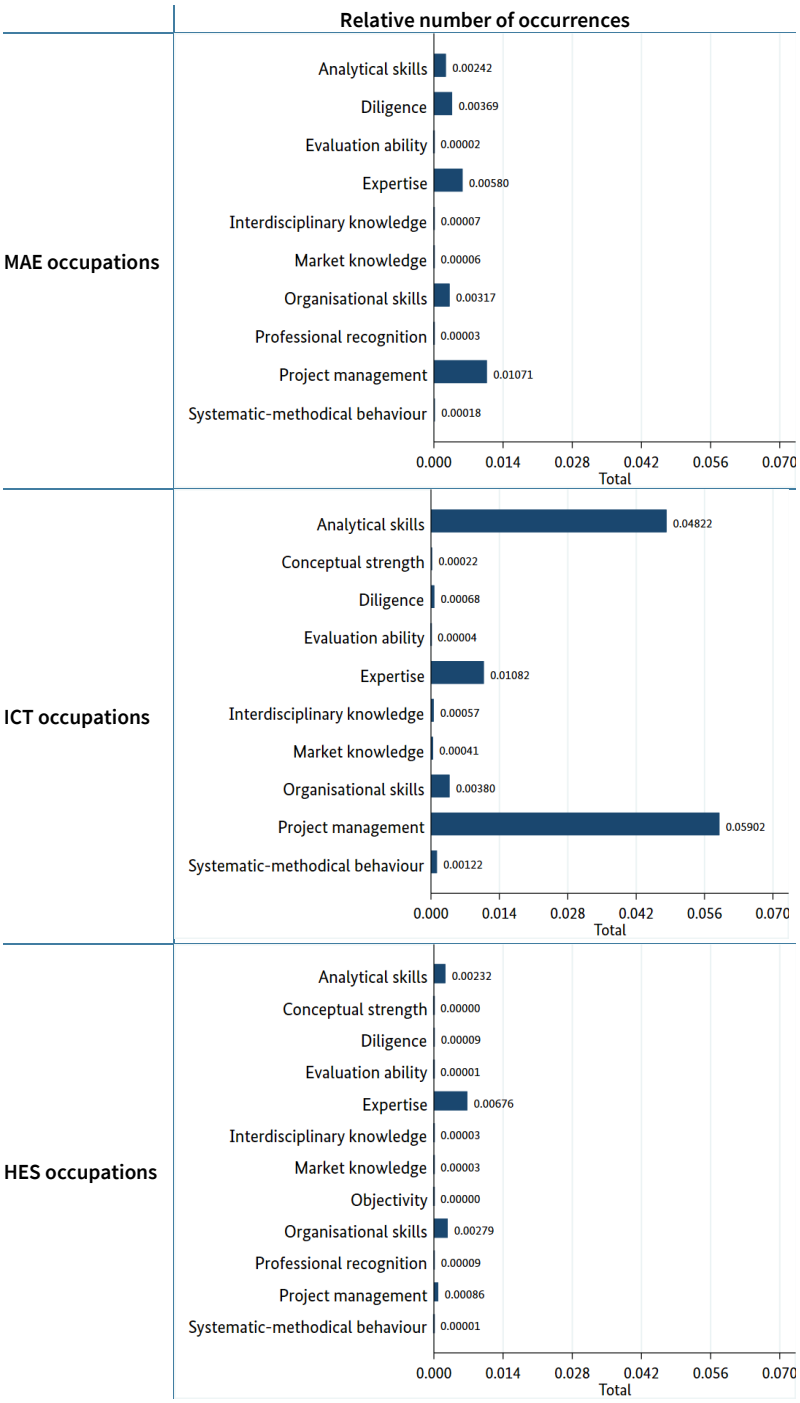
Figure 6.24: Relative number of occurrences of "activity and action skills" according to Heyse/Erpenbeck (2004) in job ads



Explanations: Vacancies for Germany and the three selected occupational sets. For interpretations, see the info box in this section. MAE occupations refers to occupations in mechanical and automotive engineering (occupational main group 25 of the KldB 2010); ICT occupations refers to occupations in computer sciences, information and communication technology (occupational main group 43); HES occupations refers to occupations in health care (occupational main group 81); non-medical occupations in health care, personal hygiene, and well-being, medical engineering (occupational main group 82); education, social and household occupations, theology (occupational main group 83).

Source: Data from the BA employment website, access sample, period of time: 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

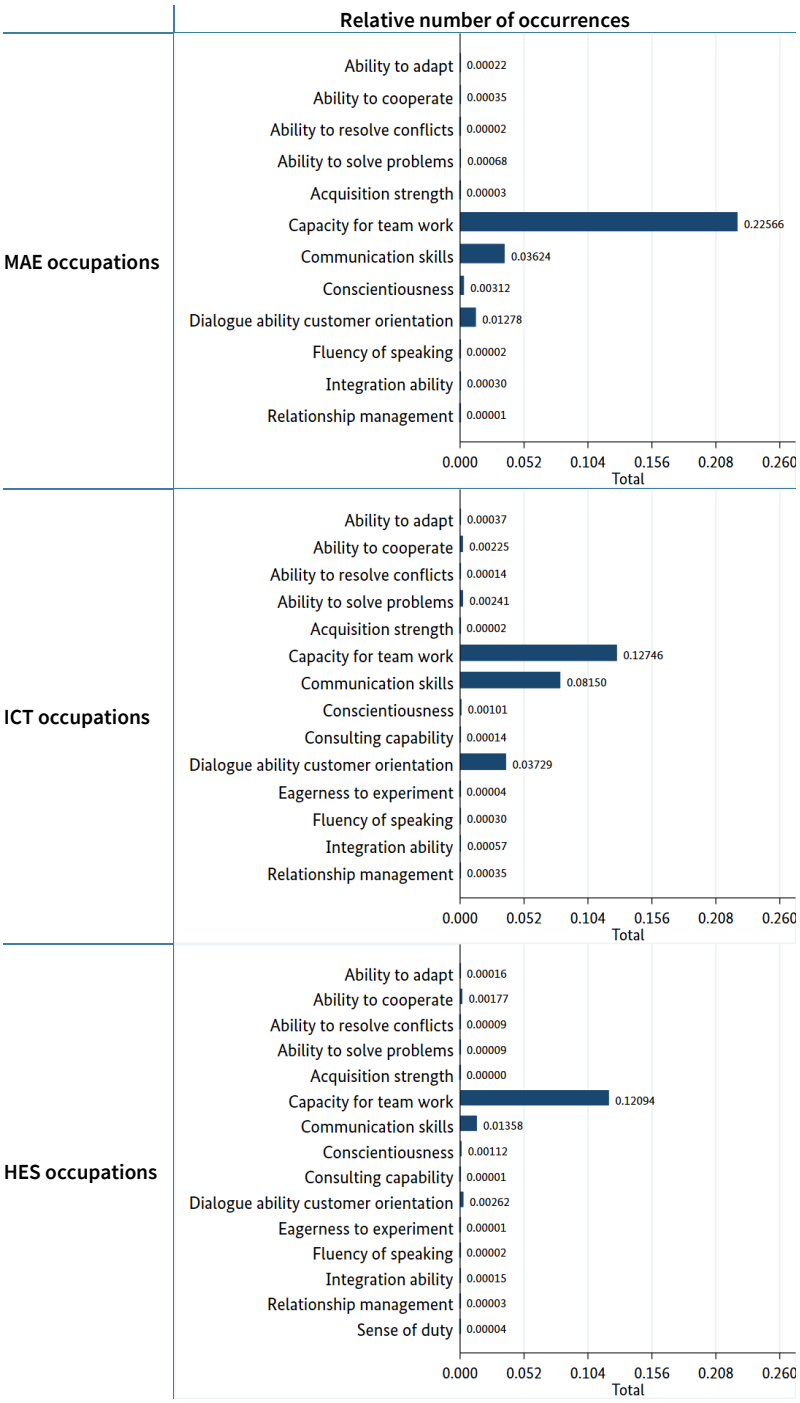
Figure 6.25: Relative number of occurrences of "functional and methodical skills" according to Heyse/Erpenbeck (2004) in job ads



Explanations: Vacancies for Germany and the three selected occupational sets. For interpretations, see the info box in this section. MAE occupations refers to occupations in mechanical and automotive engineering (occupational main group 25 of the KldB 2010); ICT occupations refers to occupations in computer sciences, information and communication technology (occupational main group 43); HES occupations refers to occupations in health care (occupational main group 81); non-medical occupations in health care, personal hygiene, and well-being, medical engineering (occupational main group 82); education, social and household occupations, theology (occupational main group 83).

Source: Data from the BA employment website, access sample, period of time: 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

Figure 6.26: Relative number of occurrences of "social and communication skills" according to Heyse/Erpenbeck (2004) in job ads



Explanations: Vacancies for Germany and the three selected occupational sets. For interpretations of the diagram, see the info box in this section. MAE occupations refers to occupations in mechanical and automotive engineering (occupational main group 25 of the KldB 2010); ICT occupations refers to occupations in computer sciences, information and communication technology (occupational main group 43); HES occupations refers to occupations in health care (occupational main group 81); non-medical occupations in health care, personal hygiene, and well-being, medical engineering (occupational main group 82); education, social and household occupations, theology (occupational main group 83).

Source: Data from the BA employment website, access sample, period of time: 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

7 Conclusion

With this feasibility study, we developed a methodology to perform systematic and content-related analyses of hard and soft skill requirements in job ads.

As a data base for evaluations along occupations, skill levels, and regions, we used job ads published on the employment website of the Federal Employment Agency. Specifically, we used two access samples. These contain all job ads added and published in April/May 2019 as well as November/December 2019.

The feasibility study focuses on three occupational sets which cover the main fields of work of mechanical engineering, information services, and the health and social sector. These three sectors were selected because they gave reason to expect great differences in the occurrence of skill requirements in job ads due to their diversity. Moreover, they are sectors with a relatively high share of employment.

To identify the skill requirements, we used the catalogue of the BERUFENET expert database provided by the BA for hard skills and the skills catalogue („Kompetenzatlas“) by Heyse/Erpenbeck (2004) for soft skills.

We modified both catalogues and transferred them into skill dictionaries where one or more keywords were assigned to the individual skills. Additionally, we also developed and tested a methodology to complement the skill dictionaries with other keywords and new skills. This methodology is based on evaluations of additional job ad text material from the past. For terms not included in the existing skill dictionaries, a word embedding procedure based on a neural network was applied to generate suggestions for the assignment to skills already known. As part of a two-stage, consensual validation procedure, a decision was made as to whether the suggestions were accepted or whether the new terms were really new skill requirements to be added to the skill dictionary.

In total, 284 additional hard skills and a very high number of additional keyword combinations were defined for the hard skill dictionary using this methodology. These additional skills are both “new” skills and skills filling existing gaps in the hard skill dictionary. Generally, the methodology to identify additional, new skills can also be applied to other skill dictionaries.

For the job ad texts, we tested a methodology based on machine learning algorithms which can be used to extract the part of the job ad text that is relevant for the identification. Within the context of this feasibility study, this is the part of the job ad texts where employers describe their requirements expected of the applicants as well as the activities to be performed on the job the job ad refers to. We considered the job description in particular, because even in the skill catalogues, no sharp division can be made between skills and activities on the job, and because the job descriptions can also be understood as implicit requirements by the employers.

On the basis of the processed dictionaries, we were able to identify an average of more than 60 percent of individual terms in the job ad texts. On average, between two and slightly over eight hard and soft skill requirements per job ad can be derived. The number varies between the occupational sets and skill levels. Most requirements, but also relatively per job, were identified for information services occupations, followed by mechanical engineering and the health and social sector occupations. It can be said for all occupational sets that considerably more hard than soft skill requirements were identified. Moreover, the number of hard skill requirements identified increases with a higher skill level, whereas this kind of pattern cannot be observed for soft skill requirements.

The methodology developed by us makes it possible to evaluate skill requirements according to their occurrences along occupations, regions, and skill levels. It is hardly possible and unrewarding to present the results in detail within a report. Therefore, we documented the analysis potential by means of exemplary evaluations for the two survey periods and for the short-term changes between the two periods of time.

The results for hard skills show that the skills most frequently mentioned – hence, in our understanding, the most important skill requirements in the job ads – can be considered to be typical for the respective occupational set under review. For example, the skill requirements “service, repair, maintenance”, “industrial mechanics”, “mechatronics”, “work according to drawings”, and “mechanics” occurred most often in the job ads for mechanical and automotive engineering occupations. For information services occupations, they were “development”, “analysis”, “management”, “software implementation”, and “Java programming language”. For health and social sector occupations, the skills “nursing care”, “geriatric care”, “treatment care”, “nursing documentation”, and “basic nursing” were mentioned most frequently (results for the access wave October/November 2019).

In some cases, we found that the degree of abstraction of the skill requirements mentioned increased with higher skill levels. For mechanical and automotive engineering occupations, very specific, simple activities tended to be frequently required for the “unskilled or semiskilled tasks” skill level (e. g. “loading”, “deburring”, “packing”). In contrast, for the “complex tasks” skill level, for example, terms such as “mechatronics”, “mechanics” or “construction” were mentioned. No such pattern could be observed for the information services occupations. And for the health and social sector occupations, this kind of pattern could be observed to some extent only; for example, “washing” was mentioned frequently as a very specific, simple requirement for “unskilled or semiskilled tasks”, while “supervision/management” was among the most frequently mentioned terms for “highly complex tasks” only.

In order to be able to analyse the development of the importance of skill requirements, we suggest a simple, descriptive framework suitable for the evaluation options which embraces the idea of a “lifecycle” for skill requirements, analogous to product lifecycles. This allows for a classification of changes for skill requirements along their previous relevance and the extent of their change. In the following sections, we described how changes can be further narrowed down, e. g. at a regional level.

By way of example, we applied this framework to the three occupational sets and one selected skill level from each group. In doing so, we reviewed those skill requirements in more detail which showed an increase in occurrences in the job ads between the two survey periods we examined.

For skill requirements with a high increase in occurrences between the two survey waves which were mentioned less frequently at the supra-regional level, we found that these can be quite distinctly located at the federal states level at first. In comparison to the first wave, they then expand, or their regional focus shifts. When looking at the regional distribution of occurrences of the relatively seldom mentioned “laboratory diagnostics” requirement in the job ads for health and social sector occupations, for example, we can see that this skill requirement was required in all federal states except for Saarland, Thuringia, Brandenburg, and Saxony-Anhalt in April/May 2019. In October/November 2019, this skill requirement showed an increase in almost all federal states, only in Saxony-Anhalt and Saarland it was still not required, and in Schleswig-Holstein, the number of occurrences in the job ads decreased slightly. By comparison, Mecklenburg-Western Pomerania and Hesse showed the highest increases, followed by Bavaria, Saxony, and Berlin.

For requirements with a high total increase between the two survey waves and which are frequently mentioned at the supra-regional level, we can see that they are widely used at the regional level, and then either

the number of occurrences increases in all regions or the regional focuses shift as well. For the “industrial mechanics” requirement frequently mentioned in the job ads for mechanical and automotive engineering occupations, it can be said, by way of example, that it was mentioned in job ads for all federal states. There were regional differences: in North Rhine-Westphalia, the skill was mentioned in job ads much more frequently than, for example, in Thuringia. In October/November 2019, however, the relative demand in the job ads decreased in the eastern federal states and in Saarland. Regional differences became apparent here as well. For example, the relative number of occurrences of “industrial mechanics” in job ads decreased to a greater extent in Mecklenburg-Western Pomerania than in Saxony-Anhalt. In contrast, in the western federal states, the relative demand in the job ads even increased, and in Hamburg, for example, it increased to a greater extent than in Bavaria.

At the level of one selected individual occupation per occupational set, respectively, we examined to what extent the ranking of the most frequently mentioned hard skill requirements for all of Germany differs from the ranking in the individual federal states. We found similarities, but also considerable differences. These results again show the importance of evaluations at a regional level. For the individual occupation “computer science specialist”, for example, the “system integration” requirement was almost always the most frequently required skill. In Brandenburg and Saxony, this requirement was in the second place, and in Hesse, it was in the third place of all occurrences. In contrast, the “planning” requirement for the same individual occupation, for example, ranked between the third (Schleswig-Holstein) and 40th place (Bremen) of occurrences.

The exemplary analysis of soft skill requirements showed that only very few of these requirements were mentioned frequently in the job ads across all selected occupational sets. They included, among others, “ability to work in a team”, “reliability”, or “communication skills”. Among the ten most frequently mentioned soft skills in the respective occupational sets were four additional requirements that were mentioned less frequently, but also across all occupational sets: “self-management”, “resilience”, “commitment”, and “willingness to learn”.

In addition to that, there were two skill requirements that were mentioned frequently in the mechanical and automotive engineering occupations and in the information services occupations, but not in the health and social sector occupations: “project management” and “dialogue ability customer orientation”. And there were requirements that occurred only in one of the three occupational sets in the ranking of most frequently mentioned skill requirements. They were “mobility” for mechanical and automotive engineering occupations, “analytical skills” for information services occupations, and “expertise” as well as “social commitment” for health and social sector occupations.

Another striking factor is a relatively high heterogeneity with regard to the level of relative occurrences of the individual soft skill requirements between the three occupational sets, even if the requirements were mentioned relatively often within the occupational sets. With regard to skill levels, no obvious patterns could be observed. There were a lot of soft skill requirements which – measured against the average across all skill levels – were mentioned very often for a low skill level in one occupational set and for a higher skill level in another occupational set.

We conclude that our methodology is able to trace the development of skill requirements in job ads with a high degree of topicality and validity. From a labour demand perspective, this methodology also has the potential to support the selection of specific skills according to their relevance for the design of training and

further training. However, for specific measures, further information would have to be used, especially assessments geared towards a comparison with the available labour supply. We also identified a need for further development of the methodologies, which we will describe in more detail in the following Section 8.

Although a certain but definable effort is needed, our methodologies allow for a valid completion of existing skill dictionaries with new skills and/or additional keyword entries.

Finally, our methodologies can be used to include additional dictionaries, also in the light of current political topics or scientific questions, and evaluate them along the dimensions described.

8 Outlook

With regard to the processing and evaluation methods, we see great potential for further development with the objective of, firstly, providing current, operationalised access to the evaluation results; secondly, increasing the content-related range of evaluations; and thirdly, making improvements to the methodologies. In the following, we will describe what we think are the most important possible development paths for a "skill compass".

8.1 Current, periodic access to the evaluation results

In order to ensure topicality, access samples must be evaluated on a regular basis. The analyses to date show that there are already high dynamics in the occurrences of skills with a survey frequency of six months. With a survey frequency of six months, intra-annual development patterns – which occur, for example, with regard to seasonal effects or economic turning points – could also be recorded at least on a general basis. Moreover, patterns in the development of skill occurrences can be better classified and interpreted only with additional survey waves, also intra-annual.

The analysis potential of the data evaluated was made clear in the previous sections. To use the descriptions of skill occurrences according to their relevance specifically for individual occupations or regions, we think the data can be provided using a business intelligence system with front ends where the simpler evaluations, as presented here to some extent, can be presented graphically.

8.2 Increasing the content-related scope

Besides the hard and soft skill dictionaries, additional dictionaries could be included in the evaluations (list is not conclusive):

- languages
- vocational qualifications
- school qualifications
- licences, permits, driver's licences
- tools (work equipment)

For each of these dictionaries, both data selection and pre-processing must be specifically defined. Besides the information gain, the rate of evaluable text material would also increase further. The quota would also

increase if additional dictionaries on job titles,[64] places of work, or work areas of the vacancies would be evaluated.

Moreover, evaluations of economic sectors would generally be desirable. As described in Section 5.1, information on economic sectors is currently available for roughly two thirds of all vacancies only. Therefore, classification procedures could be tested which use the contents of the job ad texts to identify the economic sector they belong to. Especially those parts of the job ad texts providing the company description would be helpful to achieve this.

An additional classification of the new skills and/or requirements identified according to their degree of innovation could help estimating how important these requirements will be in the future. To achieve this, a methodology would have to be developed first which is also based on qualitative analysis methods.

8.3 Further development of the methodologies

The improvement of the methodologies has the following objectives in particular:

- identifying skill requirements in the text parts not identified to date and, with regard to the skill requirements already identified, further reducing the number of false evaluations (especially text parts incorrectly identified as skill requirements);
- increasing the validity of the criteria developed for the importance of skill requirements.

In order to identify skill requirements in the text parts which have not been identified to date (or will not be identifiable in the future), it is important to apply the methodologies regularly in order to derive new skills and supplement keywords.

Methodologies could also be refined in order to improve text material processing. Our suggestions refer to the current status of international research, i. e., to our knowledge, they have not yet been tested for German job ad texts:

- Methodologies to evaluate the wording in which skill requirements are listed could be tested; this is especially about the identification of these lists and their breakdown.
- We assume that we were able to record most soft skill requirements via a direct identification procedure. When examining the job ads in detail, however, it became apparent that soft skill requirements are sometimes also paraphrased. Therefore, it could be tested to what extent word-embedding procedures can contribute to being able to identify the respective specific skill terms from these paraphrases.

With regard to the validity of the developed criteria for the importance of skill requirements, it must first be kept in mind that it is always about the representativeness of the data material used regarding the aspired usage of evaluations, as was discussed at the end of Section 6.1. In order to improve the assessment of representativeness, research in the following fields would be possible:

- Other job ad text sources (i. e. other job boards, company websites, etc.) can be included in the analysis, and results can be compared; this would at least indirectly address the question of representativeness. Web crawling methods would have to be developed and tested to this end.

[64] These job titles would confirm or complement the available occupational association used here, if applicable, since frequently one or more job titles are described in the job ad texts themselves.

- The job ad data can be compared with survey data which report representative marginal distributions of job ads along characteristics which we also have in our data (e. g. regions or skill levels). These marginal distributions are usually classified quite broadly. However, the information on characteristics of the data material used can be enriched through a comparison at least to some extent.

9 References

Arntz, Melanie; Gregory, Terry; Lehmer, Florian; Matthes, Bitta; Zierahn, Ulrich (2016): Arbeitswelt 4.0—Stand der Digitalisierung in Deutschland Dienstleister haben die Nase vorn. IAB-Kurzbericht 22/2016. Nürnberg: Institut für Arbeitsmarkt- und Berufsforschung (IAB).

Bardmann, Theodor M. (2015): Die Kunst des Unterscheidens: Eine Einführung ins wissenschaftliche Denken und Arbeiten für soziale Berufe. Wiesbaden: Springer Fachmedien.

Bitkom research (2015): Skills Gap Research, LinkedIN. Available at: https://de.slideshare.net/linkedindach/linkedin-dach-skills-gap-studie [Accessed 07 July 2021].

Buchs, Helen; Buchmann, Marlis (2017): Job Vacancies and Unemployment in Switzerland 2006–2014: Labor Market Mismatch and the Significance of Labor Market Tightness for Unemployment Duration. Arbeitsmarktpolitik No. 45 (8. 2017). SECO. Available at: https://www.zora.uzh.ch/id/eprint/149215/1/mismatch-studie.pdf [Accessed 06 July 2021].

Cedefop (2019): Online job vacancies and skills analysis A Cedefop pan-European approach. Luxembourg: European Union. Available at: https://www.cedefop.europa.eu/files/4172_en.pdf [Accessed 29 May 2020.].

Crockett, Tristan; Lin, Eddie; Gee, Matt; Sung, Christina (2018): Skills-ML: An Open Source Python Library for Developing and Analyzing Skills and Competencies from Unstructured Text. Chicago: Center for Data Science and Public Policy, University of Chicago. Available at: http://dataatwork.org/skills-ml/Skills-MLWhitepaper.pdf [Accessed 17 April 2020].

Dengler, Katharina; Matthes, Britta; Paulus, Wiebke (2014): Berufliche Tasks auf dem deutschen Arbeitsmarkt Eine alternative Messung auf Basis einer Expertendatenbank. FDZ Methodenreport 12/2014. FDZ. Nuremberg: Bundesagentur für Arbeit. Available at: http://doku.iab.de/fdz/reporte/2014/MR_12-14.pdf [Accessed 29 May 2020].

Drews, Hanno (2008): Abschied vom Marktwachstums-Marktanteils-Portfolio nach über 35 Jahren Einsatz? Eine kritische Überprüfung der BCG-Matrix. In: Zeitschrift für Planung & Unternehmenssteuerung, 19(1), pp. 39–57.

Güntürk-Kuhl, Betül; Lewalder, Anna Christin; Martin, Philipp (2017): Die Taxonomie der Arbeitsmittel des BIBB. Fachbeiträge im Internet. Bonn: Bundesinstitut für Berufsbildung (BIBB). Available at: https://www.bibb.de/veroeffentlichungen/de/publication/show/8476 [Accessed 21 May 2020].

Hedley, Barry (1977): Strategy and the “business portfolio”. In: Long Range Planning, Vol. 10 No. 2, pp. 9–15.

Hermes, Jürgen; Schandock, Manuel (2016): Stellenanzeigenanalyse in der Qualifikationsentwicklungsforschung. Die Nutzung maschineller Lernverfahren zur Klassifikation von Textabschnitten. Fachbeiträge im Internet. Bonn: Bundesinstitut für Berufsbildung (BIBB). Available at: https://www.bibb.de/veroeffentlichungen/de/publication/show/8146 [Accessed 21 May 2020].

Heyse, Volker; Erpenbeck, John (2004): Kompetenztraining: 64 Informations- und Trainingsprogramme (1st edition). Stuttgart: Schäffer-Poeschel.

Lewis, Phil; Norton, Jennifer (2016): Identification of “Hot Technologies” within the O*NET® System. Raleigh: National Center for O*NET Development. Available at: https://www.onetcenter.org/dl_files/Hot_Technologies.pdf [Accessed 14 May 2020].

Matthes, Britta; Burkert, Carola; Biersack, Wolfgang (2008): Berufssegmente. Eine empirisch fundierte Neuabgrenzung vergleichbarer beruflicher Einheiten. IAB Discussion Paper 35/2008. Nuremberg: Institut für Arbeitsmarkt- und Berufsforschung (IAB).

Mikolov, Tomas; Chen, Kai; Corrado, Greg; Dean, Jeffrey (2013a): Efficient estimation of word representations in vector space. ICLR Workshop, 2013. Available at: https://arxiv.org/abs/1301.3781v3, [Accessed 17 April 2020].

Mikolov, Tomas; Sutskever, Ilya; Chen, Kai; Corrado, Greg S.; and Dean, Jeffrey (2013b): Distributed Representations of Words and Phrases and their Compositionality. In: Burges , Christopher J. C.; Bottou, Léon; Welling, Max; Ghahramani, Zoubin; Weinberger, Kilian Q.: Advances in Neural Information Processing Systems 26. 3111–3119. Curran Associates, Inc. Available at: http://papers.nips.cc/paper/5021-distributed-representations-of-words-and-phrases-and-their-compositionality.pdf (paper), https://proceedings.neurips.cc/paper/2013 (index) [Accessed 07 July 2021].

Rengers, Martina (2018): Internetgestützte Erfassung offener Stellen. Machbarkeitsstudie im Rahmen eines ESSnet-Projekts zu Big Data No. 5/2018. WISTA. Wiesbaden: Statistisches Bundesamt, pp. 11–33. Available at: https://www.destatis.de/DE/Methoden/WISTA-Wirtschaft-und-Statistik/2018/05/internet-gestuetzte-erfassung-052018.pdf?__blob=publicationFile [Accessed 14 May 2020].

Sammut, Claude und Geoffrey I. Webb (Eds.) (2010): Encyclopedia of Machine Learning and Data Mining, Bosten: Springer US. Available at: https://link.springer.com/referencework/10.1007/978-0-387-30164-8 [Accessed 5 May 2020].

Schandock, Manuel (2019): Die Nutzung von Massendaten des Online-Stellenmarktes für Untersuchungen zum Wandel der Arbeitswelt. Lecture as part of the scientific congress of the “Employment/Labour Market” expert committee of the Federal Statistical Office in Wiesbaden with the title “Arbeitsmarkt zwischen Digitalisierung und Wertewandel – neue Indikatoren zur Qualität der Arbeit” on 4/5 June 2019, Wiesbaden: Statistisches Bundesamt. Available at: https://www.destatis.de/DE/Ueber-uns/Kolloquien-Tagungen/Veranstaltungen/FachausschussArbeitsmarkt2019/NutzungMassendatenSchandock.pdf [Accessed 08 July 2021].

Taska, Bledi (14 June 2017): The Value of Real-time Labor Market Data for Macroeconomic Research. NABE Webinar: Using Big Data to Measure Labor Market Trends, burningglass.

Tuggener, Don (2016): Incremental Coreference Resolution for German. Zurich: University of Zurich, Faculty of Arts (Doctoral Thesis).

Weick, Karl E. (1985): Der Prozess des Organisierens. Frankfurt a.M.: Suhrkamp Verlag.

Weinert, Franz E. (ed.). (2014). Leistungsmessungen in Schulen (3rd edition). Weinheim/Basel: Beltz Verlag.

Weissweiler, Leonie; Fraser, Alexandra (2017): Developing a Stemmer for German Based on a Comparative Analysis of Publicly Available Stemmers. In: Rehm, Georg; Declerck, Thierry (eds.): Language Technologies for the Challenges of the Digital Age. GSCL 2017. In: Lecture Notes in Computer Science, vol. 10713. Cham: Springer, pp. 81-94.

WEF (2016): The Future of Jobs: Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution, Global Challenge Insight Report, World Economic Forum. Available at: http://www3.weforum.org/docs/WEF_Future_of_Jobs.pdf [Accessed 14 May 2020].

WEF (2018). The Future of Jobs Report, Centre for New Economy and Society, Insight Report, World Economic Forum. Available at: http://www3.weforum.org/docs/WEF_Future_of_Jobs_2018.pdf [Accessed 14 May 2020].

Zika, Gerd; Helmrich, Robert; Maier, Tobias; Weber, Enzo; Wolter, Marc I. (2018): Arbeitsmarkteffekte der Digitalisierung bis 2035: Regionale Branchenstruktur spielt eine wichtige Rolle. IAB Kurzbericht No. 09/2018. Nuremberg: Institut für Arbeitsmarkt- und Berufsforschung (IAB). Available at: http://doku.iab.de/kurzber/2018/kb0918.pdf [Accessed 14 May 2020].

10 Appendix

10.1 Methods

10.1.1 Pre-processing method

The texts in the job descriptions, the skill terms and keywords were processed as follows (pre-processing procedure):

- Special characters were replaced with spaces by means of a specifically created list. Specific characters were converted into other characters (e. g. “ß” into “ss”, “+” into “plus”, “#” into “hash”). Only valid characters of the German alphabet and Arabic numerals were considered; other characters were not taken into account (e. g. “$pace” was converted into “pace”, “Frie%de” into “Friede”). Moreover, all uppercase letters were converted into lowercase letters. Finally, the characters between two spaces were defined as one token.
- By using a German stop word list,[65] the tokens were cleaned up in regards to linking words and the like. This list contained words which have a linguistic function (such as articles, prepositions, and conjunctions), but were not relevant in terms of content. The list was manually expanded as part of the procedure for consensual validation.[66]
- All remaining tokens were subjected to a stemming procedure. The tokens were shortened to their respective word stems. This procedure ensures, for example, that plural and singular forms of a word can be treated and evaluated the same in terms of content. We used the CISTEM stemmer by Weissweiler/Fraser (2017). This list was also manually post-processed; exceptions were defined in particular.
- Lists existing in the skill catalogues were broken up. We used the CharSplit procedure by Tuggener (2016) to do so. Lists in the job ad texts have not been broken up so far.

10.1.2 Vacancies segmentation

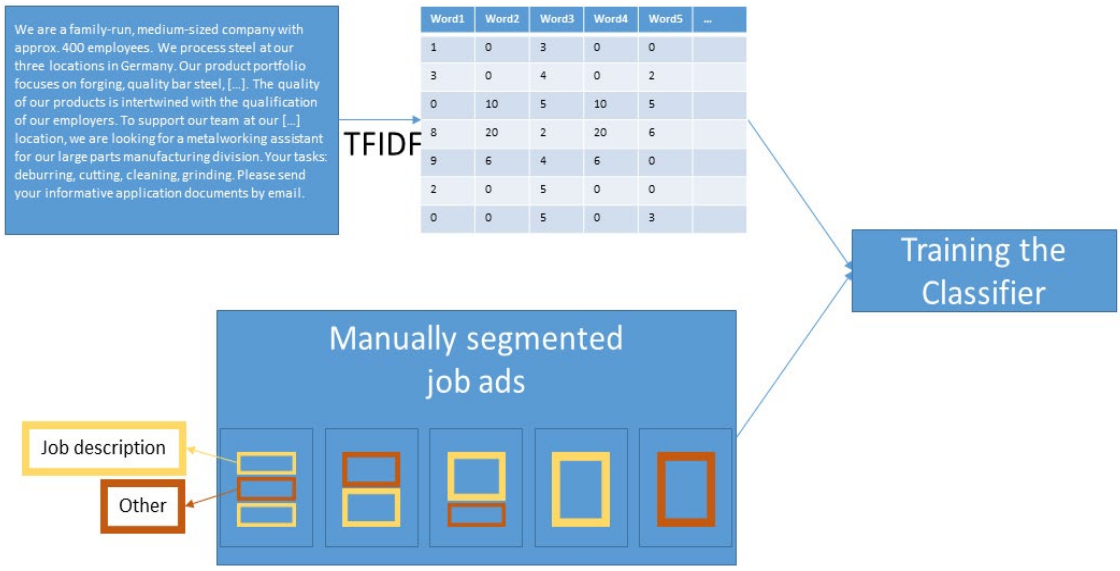
Using a classification procedure (in the following referred to as classifier), we labeled the relevant part of the job ad texts as “job description” and further separated the part “other”, which was irrelevant for the analyses conducted in this study.

This differentiation was done in several stages: first, the job ad texts were transformed by using a so-called term frequency/inverse document frequency algorithm (in the following referred to as TFIDF) such that they were available for further analysis. The TFIDF algorithm “vectorises” the texts by assigning a special vector to each individual token. Afterwards, 1,182 job ad texts were segmented manually. Segment tags for “job description” and “other” were added to the job ad texts and were then used in their vectorised version to train the classifier. During training, the classifier identified differences between the two segments and similarities within the two segments with the help of machine learning (Figure 10.1). Subsequently, the classifier allowed for the application of the “learned” patterns and the segmentation of the texts of all job ads (Figure 10.2).

[65] Source: https://snowballstem.org/algorithms/german/stop.txt, last downloaded on 17 April 2020.

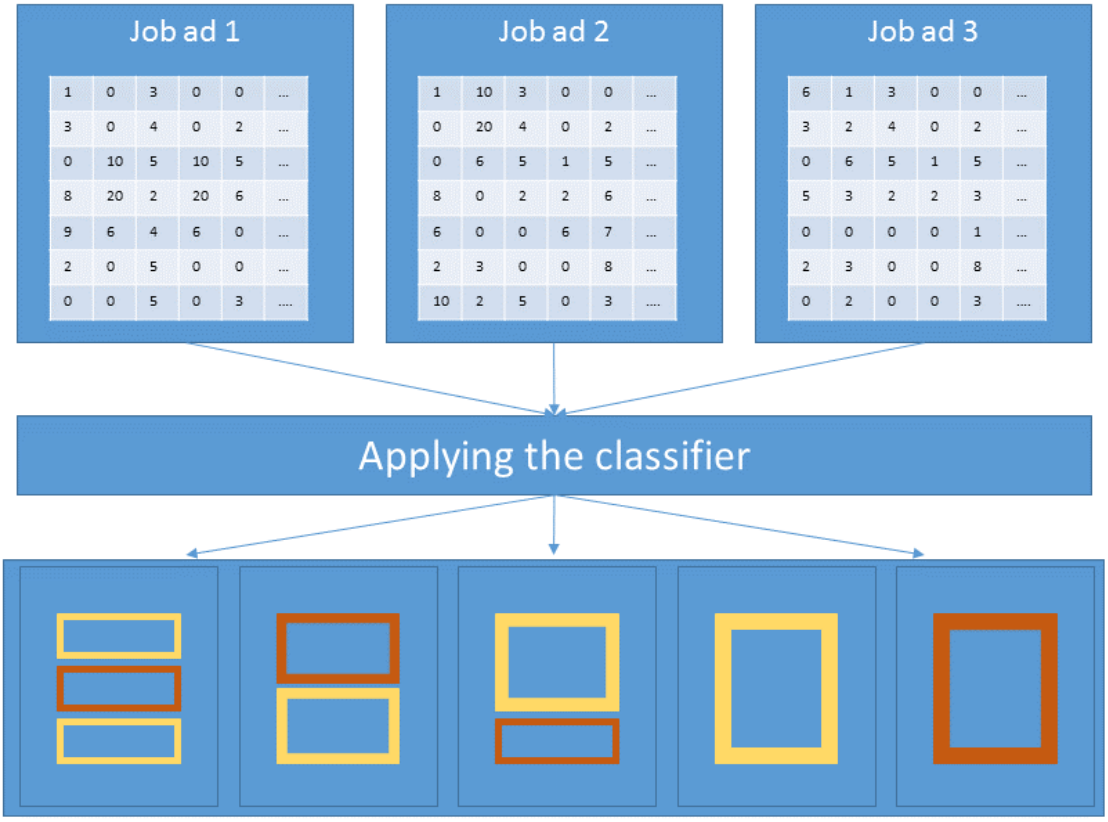
[66] See Section 10.1.3 on the procedure of consensual validation.

Figure 10.1: The manually segmented job ads vectorised by the algorithm serve as input for classifier training



Source: Authors' account. © IAB

Figure 10.2: The classifier can be applied to all job ads for automatic segmentation



Source: Authors' account. © IAB

A similar procedure was used in a study by Hermes and Schandock (2016) for the identification of four segment parts in the job ad texts (referred to as SVM classifier). The same authors also used other procedures, such as a KNN classifier (refers to K nearest neighbor algorithm). In their study, it had the highest accuracy of all procedures (for further information on the quality metrics, see the info box in this section). With reference to the training dataset used by the authors, the SVM classifier achieved slightly poorer results than the KNN classifier, but better results than any other procedure tested. The same authors also indicated that a final evaluation of the procedures was not yet completed, since the results could not be directly transferred to the overall data on the basis of the test data.

Since the KNN algorithm requires long running times, we decided to use the SGD procedure (SVM classifier) for tests as part of the feasibility study. The results on the basis of the training data are quite good. Of the 7,698 manually specified segments, 6,158 segments were used to train the classifier and 1,540 segments were used as a validation set to subsequently determine the quality of the classifier. Different metrics were used for the quality of the classifier; among them in particular accuracy, precision, recall and the F1 score; for further information, see the info box in this section.

Table 10.1 presents these metrics divided into the two segments and as total counts; the latter is a weighted average from the respective metrics for the two segments. According to that, the classifier worked even better for the "other" segment than for the "job description" which we are interested in. Nevertheless, also the values for "job description" are quite good, and the procedure has a high quality in general.

Table 10.1: Quality of the classifier for vacancies segmentation

Segment	Accuracy	Precision	Recall	F1 score
Job description	-	98.02 %	95.43 %	96.71 %
Others	-	98.33 %	99.29 %	98.80 %
Total	98.25 %	98.24 %	98.25 %	98.24 %

Source: Authors' calculations. © IAB

Info box – Metrics on the quality of the classifier (cf. Sammut and Webb 2010)

To measure the quality of the classifier, it is trained only with parts of the manually classified segments. By using the texts "unknown" to the classifier up to that point – the "validation set" – the correct classification of which is known, however, several metrics on the quality of the classifier can be obtained in the next step. Usually, two states – "positive" and "negative" – are distinguished.
For example, we can designate the "job description" classification as "positive" and the "other" classification as "negative" (i. e. if we examine the metrics for the "other" segment, the designations must be chosen the other way round). Each segment was classified as correct (in the following referred to as "true") or incorrect (in the following referred to as "false") with the help of the algorithm. Moreover, a distinction is made between the manual classification (in the following referred to as "actual") and the classification achieved by the classifier (in the following referred to as "predicted").
This results in the four possible states *true positive*, *true negative, false positive*, and false *negative*:

		Actual status (*actual*)		
		Job description (*positive*)	Other (*negative*)	
Status determined by the *classifier* (*predicted*)	Job description (*positive*)	True positive (TP)	False positive (FP)	Predicted positive (PP)
	Other (*negative*)	False negative (FN)	True negative (TN)	Predicted negative (PN)
		Actual positive (AP)	Actual negative (AN)	

Accuracy refers to the share of all correctly classified segments (i. e. the sum of TP and TN) in all segments. Precision and recall are calculated according to the segment class. Precision with regard to "job description" describes, for example, the share of segments correctly classified as "job description" (TP) in all segments classified as "job description" by the classifier (PP), recall with regard to "job description" describes the share of segments correctly classified as "job description" (TP) in all segments manually marked as "job description" (AP), and the F1 score describes the harmonic mean across the two previous values.

A classifier will only have a high quality if it achieves high values for all metrics described. For example, a high accuracy for a dataset with very few actual positives could be achieved if the classifier classified all units exclusively as "negative". This systematic misassessment would manifest in a low recall value in this case.

10.1.3 On the identification of new hard skills

We used two procedures to generate suggestions for the assignment of terms in the job ad texts not yet listed in the skill catalogues of hard skills (BERUFENET, Section 5.2.1). The first procedure is a word embedding procedure and the second procedure is a bidirectional string-in-string search.

The word embedding procedure is based on the assumption that skill requirements in job ad texts are described in close proximity to each other. Other parts of the job ad, in contrast, (such as the presentation of the company or the offers of the company) are further away. Starting from a skill term already known, all terms are listed which are within a to-be-defined maximum distance (threshold) from the known term. Since these terms can also exist in pairs far apart from each other in the text but are now listed together by means of a third term, the method promises a collection of terms which have a semantic relation.

As a basis, the entire corpus of job ad texts of approx. 7.2 million different job ads available in October 2018 was used. The relatively high number results, among others, from the utilisation of job ads already deactivated or marked for deletion. That is acceptable in this case, since the texts served as a material collection for skill occurrences, and thus a distinction such as the validity of a job ad for a specific point of time was not required. For the same reason, we also refrained from applying a segmentation (for information on segmentation, see Appendix 10.1.2). In order for a term to be considered at all, it had to occur in the texts of at least 50 job ads.

We used a method based on the "Continuous Bag of Words" model (CBOW, Mikolov et al. 2013a, 2013b). Based on the evaluation of all possible word distances, first the relative word distance is determined for each term pair. Term pairs are pairs of word stems in this case. This means that those job ad texts and entries in the dictionaries are considered which were subjected to the pre-processing procedures described in Appendix 10.1.1.

The lowest possible value of relative word distance is zero, and the highest possible value is one. To generate the list of suggestions for new skills, the threshold had to be defined in this range. Therefore, it corresponds to the maximum relative word distance beyond which terms are no longer taken into account. The higher

the value, the larger is the number of suggested terms, and – as it is assumed – the weaker is the semantic relation to the skill term already known. In the current project state, we decided for a maximum relative distance of 0.6 and limited the number of words suggested this way to a maximum of six. If the terms found in this way did not correspond exactly to the already known hard skill terms and/or keywords, they were included in the list of suggestions together with the known skill terms (in close proximity).

To be sure that the terms would not have to be assigned to certain skills in the existing catalogue of hard skills, a parallel bidirectional "string-in-string search" was performed. This procedure determines whether the string of the term found is included in one or more skill terms from the existing catalogue or whether the terms found contain the string of a skill term from the existing catalogue. In these cases, the list of suggestions was expanded by the skill term found for the corresponding term.

These suggestions were manually reviewed as part of a consensual validation procedure (see the info box below). They were assigned to one of the three following categories:

- The terms can be assigned to existing skills in accordance with the generated suggestion or based on additional research.
- The terms describe new and/or not yet recorded skills and complement the existing skill catalogue.
- The terms are not important for further evaluation.

Info box – The consensual validation method

The assignment of the individual terms in the list of suggestions for new skills must be done in a manual process. We assume that there is not always a unique solution for the assignment, but that a consensus can be achieved between different researchers for each assignment, and that this consensus can bear further intersubjective reviews.
This kind of procedure is referred to as a consensual validation procedure and is established and recognised in qualitative social research (for the basics, see e. g. Weick 1985, Bardmann 2015).

The procedure was applied in a two-stage process. In the first stage, a total of 1,475 different word stems not yet included in the dictionaries for hard skills were reviewed manually. The original words from which the word stem resulted as well as the generated assignment suggestions were also presented for each word stem. Each word stem was assigned to one or more categories. Besides the acceptance of the generated assignment suggestion or the assignment to another skill included in the dictionaries, assignment to other categories was also possible, e. g. to the "stop word list".

Three specialists made the assignments independently of each other. In total, the specialists arrived at the same result for almost half of the terms. The most fundamental reasons for the deviating results of the specialists were:

- varying degrees of knowledge of BERUFENET as a source for the occupational skill catalogue;
- different assessment with regard to the accepted/desired degree of substantiation of the skills (therefore frequently assignment to "superordinate" skills vs. specification as individual skill);
- different assessment of whether contextualisation would make sense vs. term is not suited to describe a skill;
- handling of licences as a separate category vs. occupational skill.

The terms for which no consistent result could be achieved were subjected to moderated discussions between the specialists, where the consensual validation was performed.

For approx. one third of the assignments to be made, the specialists requested further contextualisation. This required a second stage for the procedure. In the second stage, the original words for the list of word stems to be contextualised were embedded in the correct section of the job ad text. This list was limited to a maximum of ten most frequently used combinations of the original word and preceding or subsequent words. This selection was again presented to the same specialists. More than half of the terms to be reviewed again could be assigned unambiguously.

For approx. one quarter of the assignments to be made, it could be expected that skills could be identified if they appeared together with certain terms in the job ads. This concerned the handling of certain materials or products; functional areas in establishments which might allow for drawing conclusions about skills and occupations as well as adjectives being indicative of a skill if certain nouns follow. These groups were reviewed again in more detail with the aim of determining general rules for the generation of keywords to assign them to skills already listed or new skills. To this end, also specific excerpts from job ad texts or a selection of entire job ad texts were examined to comprehend the structures behind the utilisation of these terms in the text material.

Eventually, part of the terms (about 20 percent of the assignments to be made in the second stage) could still not be assigned unambiguously despite contextualisation and thus remained unsolved. An analysis would be required for these terms which goes even deeper than our analyses performed here. All in all, the methodology in the second stage is reasonable in our view, since the kind of contextualisation chosen here alone was sufficient to achieve 60 percent of the assignments to be made. For another approx. 20 percent, systematic rework was required to generate keywords for existing skills or to define new skills and their keywords.

10.2 Individual skills according to Heyse/Erpenbeck (2004)

Table 10.2: Individual skills according to Heyse/Erpenbeck (2004)

Code	Individual skill
PP1	Loyalty
PP2	Normative-ethical attitude
PP3	Credibility
PP4	Self-responsibility
PA1	Commitment
PA2	Self-management
PA3	Creativity
PA4	Openness to changes
PS1	Humour
PS2	Readiness to help
PS3	Personnel development
PS4	Delegating
PF1	Willingness to learn
PF2	Holistic thinking
PF3	Discipline
PF4	Reliability
AP1	Decision-making ability
AP2	Creative drive
AP3	Enthusiasm for innovation
AP4	Resilience
AA1	Energy
AA2	Mobility
AA3	Willingness to perform

Code	Individual skill
AA4	Proactivity
AS1	Optimism
AS2	Social commitment
AS3	Inspired thinking
AS4	Quick-wittedness
AF1	Results-based behaviour
AF2	Targeted leadership
AF3	Tenacity
AF4	Consistency
SP1	Ability to resolve conflicts
SP2	Integration ability
SP3	Capacity for teamwork
SP4	Dialogue ability customer orientation
SA1	Acquisition strength
SA2	Ability to solve problems
SA3	Eagerness to experiment
SA4	Consulting capability
SS1	Communication skills
SS2	Ability to cooperate
SS3	Relationship management
SS4	Ability to adapt
SF1	Fluency of speaking
SF2	Willingness to understand
SF3	Sense of duty
SF4	Conscientiousness
FP1	Knowledge-oriented
FP2	Analytical skills
FP3	Objectivity
FP4	Evaluation ability
FA1	Conceptual strength
FA2	Organisational skills
FA3	Diligence
FA4	Systematic-methodical behaviour
FS1	Project management
FS2	Awareness of consequences
FS3	Teaching ability
FS4	Professional recognition
FF1	Expertise
FF2	Market knowledge
FF3	Planning behaviour
FF4	Interdisciplinary knowledge

Source: Skills catalogue („Kompetenzatlas“) according to Heyse/Erpenbeck (2004). Own translation from German into English.

10.3 New skills found

Table 10.3: New skills

New skills	Description	Skill group
Farm animal welfare and housing	Forms of animal farming that align with the original, natural habitat conditions and species-specific needs of the animals.	Agriculture, forestry, and horticulture
Mowing operations		Agriculture, forestry, and horticulture
8D report	Name of a document in the field of quality management. Used for internal and external complaints between supplier and customer to unveil process steps to facilitate the complaint.	Production, processing, technology
Advanced product quality planning (APQP)	Refers to advance quality planning in the product development process. Errors in planning and manufacturing are to be avoided from the beginning by specific measures, e. g. cross-departmental collaboration.	Production, processing, technology
Machining and processing aluminium	Refers to the machining and processing of aluminium in various ways, e. g. sawing or seaming.	Production, processing, technology
Diecast aluminium	Die casting technique to press aluminium in a liquid or doughy state into a heated steel mould by applying high pressure.	Production, processing, technology
Aluminium casting	Casting of aluminium alloys, used to deliberately influence material characteristics such as hardening, robustness, and absorption of vibrations.	Production, processing, technology
Instruction list (IL)	IL is one of the methods for programming programmable logic controllers standardised in IEC 6113-3 and used for logical connections of controller inputs and outputs.	Production, processing, technology
ARM architecture	Refers to one of the globally most widely used microprocessors used, for example, in small electronic devices such as smartphones and tablets.	Production, processing, technology
Order monitoring	As part of production planning/controlling, order monitoring forms part of the optimisation process of production systems. It is based on factory data collection, which is important to determine quality and servicing and maintenance planning as well as for production calculation, project monitoring, and post calculation.	Production, processing, technology
Automated optical inspection (AOI)	System of the “machine viewing” category which can find and report errors in production by means of image processing.	Production, processing, technology
Batch record review	Is a review or proof used after the manufacturing of a batch to prove that it was manufactured according to the procedural and regulatory requirements.	Production, processing, technology
Installation space analysis	Installation space analysis is used for collision-free (de)installation of parts; nowadays, it is often performed by means of digital CAD systems.	Production, processing, technology
Construction steel machining and processing	Refers to the machining and processing of low-alloy steel with partial heat treatment frequently used in structural and mechanical engineering.	Production, processing, technology
Operating an elastomer extruder press	Refers to the operation of a machine that uses pressure to force elastomer (plastics of good dimensional stability that can be deformed) into different moulds.	Production, processing, technology
Construction of equipment	This includes the handling, transportation, and storage of parts and assemblies with the main focus on protecting and safely using products.	Production, processing, technology
Current Good Manufacturing Practice (cGMP)	This refers to guidelines for the quality assurance of production processes and the production environment in the manufacturing of pharmaceuticals.	Production, processing, technology
Design for assembly (DFA)	Refers to a type of production engineering aimed at developing products such that a time-saving and cost-efficient installation is possible, e. g. with a low number of parts.	Production, processing, technology

New skills	Description	Skill group
Digital radio network 4G	4th-generation network standard subject to international guidelines and regulations. This network standard is often also referred to as LTE. However, from a technical point of view, it is the successor of LTE, since LTE is a 3rd-generation network standard (as version 3.9xG). The version "LTE Advanced" is an exact equivalent of the 4G radio network standard.	Production, processing, technology
DIN 14675	DIN standard 14675 describes the expert installation and operation of a fire alarm system automatically alerting the fire brigade.	Production, processing, technology
Print finishing	Includes the inspection of printed sheets, the selection of suitable processing technologies, and the installation and configuration of processing systems.	Production, processing, technology
Processing and handling elastomer	Refers to the handling and processing of elastomer. Elastomers are plastics of good dimensional stability that can be deformed, e. g. sealing rings.	Production, processing, technology
Electrical design	Optimises the process flow of electrical installation and network technology for efficient and documented planning, often using CAD software.	Production, processing, technology
Functional safety of machine controls (DIN ISO 13849)	Refers to a standard for the safety requirements of machine controls, including the development of corresponding software.	Production, processing, technology
Failure mode and effects analysis (FMEA)	This fault probability analysis is part of quality management. It aims at identifying, avoiding, and correcting failures in manufacturing to reduce costs.	Production, processing, technology
Fine chemistry	Commercial category for chemical pure substances the processing and production of which is the responsibility of speciality chemicals companies, because common characteristics of fine chemicals production are complex syntheses, low volumes, and a high degree of purity.	Production, processing, technology
Landline telephony	The sum of wired networks used for voice and data communication.	Production, processing, technology
Functional safety	Refers to an aspect of system security used to review the safety function of electronic and/or programmable systems. The objective is to detect and eliminate failures at an early stage.	Production, processing, technology
Logic diagram (LD)	Refers to a standardised, graphically oriented programming language for programmable logic controllers.	Production, processing, technology
Health, safety, environment (HSE)	HSE management is about planning, implementing, controlling, and optimising operational processes in the fields of health protection, occupational safety, and environmental management.	Production, processing, technology
IATF	The International Automotive Task Force is a purpose-built working group consisting of representatives from automotive manufacturers and associations which deals with the harmonisation of quality management.	Production, processing, technology
IATF 16949	Is a standards collection of the IATF and contains general requirements for quality management systems in the automotive industry.	Production, processing, technology
IEC 61508	Refers to an international standards series for systems with safety functions and their development.	Production, processing, technology
Industrial electronics	Describes the installation, inspection, and maintenance of electronic systems. Industrial electronics is a sub-area of industry electrics and refers to solid-state technology in the industrial context.	Production, processing, technology
Industrial painting	The objective is to protect a variety of materials, including metal, plastics, wood, glass, paper, leather, and textiles, against external damages such as rust and decay by painting them in spray booths or painting lines.	Production, processing, technology
Industrial electrics	Industrial electrics deals with anything associated with electricity and power in the industrial context.	Production, processing, technology
Industrial mechanics	Manufacturing of parts and assemblies for machines and production systems as well as monitoring and optimising manufacturing processes and performing repair and maintenance tasks.	Production, processing, technology
ISO 9001	Describes a standard from quality management and its premises valid across industries.	Production, processing, technology
Kaizen	Methodical concept; often describes the field of innovation management which focuses on continuous improvement.	Production, processing, technology
Air-conditioning service	General functional tests of air-conditioning systems, pressure and tightness tests, visual check, and filter and coolant exchange.	Production, processing, technology

New skills	Description	Skill group
Mechanical construction	Manufacturing of steel and metal constructions; this also includes manual and machine processing of parts and their installation.	Production, processing, technology
Creating construction plans		Production, processing, technology
Reading construction plans		Production, processing, technology
Construction technology	Comprises knowledge from manufacturing engineering, materials science, engineering mechanics, and control engineering.	Production, processing, technology
Coordinate measuring technology	Coordinate measuring systems and data processors are used to measure spatial coordinates from specific points to the workpiece surface and convert them into geometrical quantities.	Production, processing, technology
Corundum blasting	Corundum, crystallised aluminium oxide, is a sharp-edged blasting medium which can be used in various ways, frequently to remove paint and rust, but also for targeted surface deformation.	Production, processing, technology
Painting preparation	Is a sub-area of surface technology to ensure that the paint can be properly processed.	Production, processing, technology
Agricultural machinery mechanics	Repair and maintenance of agricultural vehicles, machines, systems, and equipment.	Production, processing, technology
Circuit board placement	Describes the process of placing and soldering electronic devices; may be done by machines or manually. There are two methods: the pin-through hole (PTH) and the through-hole technology placement (THT).	Production, processing, technology
Process control technique	Refers to a number of methods and processes to manage and monitor technical processes.	Production, processing, technology
Machine-to-machine (M2M) technologies	This technology is located between information and communication technologies. It is used for the communication, monitoring, and maintenance of terminals.	Production, processing, technology
Machine installation	Comprises all partial tasks to be performed prior to the commissioning of a machine.	Production, processing, technology
Machining and processing brass	Refers to the machining and processing of brass in various ways, e. g. turning or milling.	Production, processing, technology
Measurement system analysis (MSA)	As part of quality management, the measuring capability is analysed for various metrics, e. g. measurement errors or accuracy.	Production, processing, technology
Mixed-signal technique	Is the generic term for processing analogous and digital signals.	Production, processing, technology
Mobile hydraulics	Comprises the entirety of hydraulic systems installed in mobile work machines.	Production, processing, technology
OHSAS 18001	Occupational Health and Safety Assessment Series refers to an occupational health and safety management system as a standard for occupational health and safety, to avoid accidents at work or occupational diseases.	Production, processing, technology
Oil change	Exchange of consumed lubricants in order to protect machine gearboxes, motors, or machines with circulatory lubrication.	Production, processing, technology
Machining and processing panel materials	Refers to the machining and processing of panel materials, e. g. by painting.	Production, processing, technology
Poka-yoke (error proofing)	Technical provisions or installations are supposed to lead to the immediate detection and prevention of errors.	Production, processing, technology
Production process and product approval (PPA)	Is part of quality assurance and refers to an interface between suppliers and companies. PPA is based on the IATF 16949 of the automotive industry but is also used increasingly in other industries. PPA is to ensure that the delivery of goods produced meets the expectations of the companies.	Production, processing, technology
Programming (industrial robots)	Industrial robots are increasingly programmed for complex tasks in manufacturing processes. Two types of programming are distinguished: offline and online programming.	Production, processing, technology

New skills	Description	Skill group
Inspection technology	Inspection technology is guided by quality standards, i. e. inspection is performed against a direct guideline. Therefore, it must be differentiated from measurement technology.	Production, processing, technology
Quality of Service (QoS)	Describes quality requirements and/or measures and processes for specific communication services from the user's point of view, e. g. packet loss, jitter, propagation delays, and transmission capacity.	Production, processing, technology
Robot programming	For example, robot programming is supposed to enable companies to automate their production. Robots electronics and mechanics are to be controlled by means of software programming.	Production, processing, technology
Circuit simulation	Circuit simulation with circuit simulation programs is an accepted standard in the development of electronic devices. By means of simulation, verification, and testing without realisation, it will be ensured that the function is fulfilled.	Production, processing, technology
Machining and processing steel	Refers to the machining and processing of steel, e. g. by milling (among others with CNC machines) and drilling.	Production, processing, technology
Welding steel	Refers to the permanent fusion of several steel workpieces by means of welding techniques, such as tungsten inert gas welding (TIG).	Production, processing, technology
Standard operating procedure (SOP)	Is a textual description of procedures and risk assessment (e. g. health, environment, and safety) for regulatory approval of industrial, aerial, and military products.	Production, processing, technology
Control device testing	The functional tests of control devices require testing of the actual functionality and the most important failure events.	Production, processing, technology
Supervisory control and data acquisition (SCADA)	SCADA are computer systems used to monitor and control technical processes.	Production, processing, technology
Unified communications	Is used to ensure the integration of communication media in a uniform application environment.	Production, processing, technology
Verification testing	A verification test [...] can detect any type of error source, but cannot identify them separately. This means that the verification test detects problems in the machine regardless of the error source. It is thus a quick alternative to traditional calibration.	Production, processing, technology
Non-destructive testing	Is a procedure to check materials for their resilience with the help of mechanical, chemical, and thermal substances.	Production, processing, technology
Owner representation	Name of the agent between the owner and the project team in construction organisation.	Construction, architecture
Construction site supervision	Coordination between establishment and construction site. This also includes consultation on site and ensuring construction site safety, so that the building process can be effected safely and without complications.	Construction, architecture
Design planning	Design planning is the phase in the planning process in which a design is created (often in the building industry).	Construction, architecture
Approval planning	Part of construction planning to create buildings and the fourth phase after HOAI; comprises all tasks in connection with the building application with the aim of receiving a building licence.	Construction, architecture
Geomatics	Deals with spatial reference systems and the modelling and analysis of spatial data. Combines disciplines such as: geodetics, geoinformatics, surveying.	Construction, architecture
Turnkey construction	If a building project is to be delivered to the customer ready for occupation by the contractor, is must be kept in mind that the contractor can be held liable by the customer.	Construction, architecture
Structural engineering	Generally deals with the physical forces of non-moving systems. Structural engineering is used in mechanics and constructional engineering.	Construction, architecture
Section 57b StVZO (German road traffic licensing regulation)	Section on the inspection of tachographs and control devices.	Economy, administration
AHO	AHO is a professional association of engineers and architects for the representation of fee- and competition-related interests. With regard to skills, this term refers to performance profiles and remuneration recommendations for building project control which were prepared by this association.	Economy, administration
Bid solicitation	Describes that part of commercial purchasing which deals with the specification of enquiries. For example, information about vendors, bid sum, subject of the contract, and payment terms must be obtained.	Economy, administration
Job tracking	Is a sub-area of job controlling and can be ascribed to the controlling, sales, and production divisions.	Economy, administration

New skills	Description	Skill group
Building regulations law	Is a sub-area of public building law besides construction planning law and contains provisions on the construction licensing procedure and construction supervision. The focus is on construction-technical requirements on the building project and the regulations on risk prevention due to the construction.	Economy, administration
Building contract law	Is part of the legal field that, for example, deals with claims for compensation in case of faulty goods of companies against the suppliers.	Economy, administration
Investment controlling	Coordination of complex company structures geared towards the overall objective, the responsibility of which is controlling, planning, and managing cross-establishment structures.	Economy, administration
Ordinance on Industrial Safety and Health	Refers to the ordinance regulating the provision of means of production by the employer and their usage by the employers in accordance with health protection.	Economy, administration
BGV A3	Former version of DGUV (see DGUV).	Economy, administration
Cross-selling	Is a marketing strategy to sell additional products or services by using existing customer networks.	Economy, administration
DGUV regulations	Describes the regulations specified by the German umbrella association of institutions for statutory accident insurance and prevention and accident insurers (Spitzenverband der gewerblichen Berufsgenossenschaften und der Unfallkassen) (founded in 2007).	Economy, administration
e-government	Describes a process simplification by digital information and communication technologies (ICT) in the organisation of political institutions such as authorities and municipalities.	Economy, administration
Reception services	Supports companies and customers with questions of communication and finding a contact person.	Economy, administration
Creating fire protection statements	Dealing with problems and questions with regard to issues outside the fire protection concept, which is part of the building project in most cases.	Economy, administration
Financial controlling	Control measures for coordination within the financial sector and between [other] divisions […] with the aim of maintaining solvency and maximising the value of equity capital claims.	Economy, administration
Capacity planning	Determination of the plan benchmarks on grounds of existing capacity based on theoretical maximum capacity.	Economy, administration
SGB II knowledge	Knowledge of the German Social Code II (Basic Security for Jobseekers).	Economy, administration
SGB III knowledge	Knowledge of the German Social Code III (Employment Promotion).	Economy, administration
SGB V knowledge	Knowledge of the German Social Code V (Statutory Health Insurance).	Economy, administration
SGB VI knowledge	Knowledge of the German Social Code VI (Statutory Pension Insurance).	Economy, administration
SGB VIII knowledge	Knowledge of the German Social Code VIII (Children and Youth).	Economy, administration
SGB IX knowledge	Knowledge of the German Social Code XI (Social Care).	Economy, administration
Key performance indicator (KPI)	KPIs are also known as performance ratio and are used by companies to get an overview of performance and activities. Sub-areas of management and controlling can analyse and adjust processes accordingly in order to streamline the company.	Economy, administration
Keyword advertising	Refers to an online marketing strategy in which certain keywords are paid for by advertisers, based on search requests, to display an ad to the user.	Economy, administration
Supplier support	To maintain business relationships between companies and suppliers.	Economy, administration
Market strategy	Is a business strategy to open up and use markets. Market analyses and data evaluations are used to achieve this. In contrast to the marketing strategy, the aim here is to keep or gain additional market shares to make profits.	Economy, administration
Material disposition	Is a process stage in manufacturing which comprises material requirements planning, acquisition, and warehousing following ascertainment of production.	Economy, administration
Merchandising	The entirety of promotional measures in trade, mostly activities around the shelf space, such as placing products, stocking shelves with goods, or labelling, which are supposed to increase the added value.	Economy, administration
Native advertising	Is a type of paid online advertising the content and visual appearance of which are similar to the editorial environment of a website. Advertisers can configure contents such that they attract attention by using the concept of concealment.	Economy, administration
Personnel placement management	Part of management in public administrations to streamline costs in the personnel area.	Economy, administration
Personnel administration	Is responsible for a number of areas in a company, e. g. personnel planning, recruiting, management, and development as well as wage and salary administration.	Economy, administration
Personnel statistics	Refers to the collection of all relevant personnel data required for planning and controlling within a company.	Economy, administration

New skills	Description	Skill group
Preferential right	Preferences are preferential treatments under customs law for goods from certain countries and regions having a positive impact on the delivery costs and thus a pro-competitive effect.	Economy, administration
Product lifecycle management (PLM)	A management process to seamlessly integrate all information which is obtained during the lifecycle of a product and which defines and represents it.	Economy, administration
Process optimisation	Entirety of measures for improved resource utilisation and for a more efficient and effective company organisation.	Economy, administration
Process planning	Process planning deals with the planning of the production process. It consists of process, batch size, and schedule planning.	Economy, administration
Invoice management	This refers to the processing of incoming invoices, including invoice recording, archiving, auditing, and approval of invoices.	Economy, administration
Accounting principles	These cover a variety of fields. Generally, every company is required to keep accounts; the principles specify whether singe-entry or double-entry accounting is required. The accounting principles contain both internal and external accounting, so that the financial situation can be visualised depending on the target group.	Economy, administration
Social advertising	Is a strategy in digital marketing to distribute advertising messages and communications in social networks by means of bought advertising space.	Economy, administration
Daily closing	Identifying the actual and nominal cash balance the difference of which must be determined at daily closing.	Economy, administration
The Open Group Architecture Framework (TOGAF)	Supports companies with the development but also the maintenance of their architecture; various approaches are applied to this end, e. g. iterative processes to ensure best practices.	Economy, administration
Business planning	Is part of the management and controlling divisions to enable targeted management control and planning of structures in the company.	Economy, administration
Upselling	Providing a superior product variant or service instead of less expensive alternatives.	Economy, administration
Vergabeordnung für freiberufliche Leistungen (VOF, Regulation on the Awarding of Contracts for Freelance Services)	The VOF was replaced by the VgV. It used to regulate the awarding procedures of freelance services, e. g. architects and engineers.	Economy, administration
Vergabeverordnung (VgV, Public Tender Regulation)	Comprises the entirety of regulations and provisions a public authority must observe when purchasing equipment and services it requires to perform its public tasks.	Economy, administration
Packaging regulations	These are to ensure undisturbed material flow between suppliers and companies. Among others, it is about the choice of suitable packaging for the selected type of delivery, so that the product can be transported without damage.	Economy, administration
Residential property management	Description of the tasks of the caretaker determined by the Condominium Act. Management must take place according to organised standards, so that the requirements of home owners can be met.	Economy, administration
Vehicle inspection according to ADR	Vehicle equipment according to the guidelines (ADR) and the inspection of vehicles are required to check the hazardous materials transported and the regulations applying to the persons involved.	Transport, traffic
-	-	Hotels, restaurants, tourism
Disposal of pharmaceutical waste		Services
Disposal of radioactive waste		Services
AMPscript	AMPscript is a script language and is frequently used in HTML emails, and text or push messages.	IT, DP, computers
Amtliches Liegenschaftskatasterinformationssystem (ALKIS, Official Real Estate Registry Information System)	In Germany, ALKIS replaces the ALK (Automatisierte Liegenschaftskarte, Automated Land Register Map) and the ALB (Automatisiertes Liegenschaftsbuch, Automated Real Estate Book). The aim is to combine all information in one data system.	IT, DP, computers
CANalyzer analysis software	Analysis software to analyse the data traffic in serial bus systems.	IT, DP, computers
Apache HBase	Non-relational, distributed open-source database modelled according to Google Bigtable and written in Java.	IT, DP, computers
Apache Spark	Framework for cluster computing which deals with machine learning and big data.	IT, DP, computers
Application server	Refers to a server or software in a computer network that runs application programs.	IT, DP, computers
Autodesk Vault	PDM software for the data management tool integrated with the Autodesk Inventor Series, Autodesk Inventor Professional, AutoCAD Mechanical, AutoCAD Electrical, Autodesk Revit, and Civil 3D products.	IT, DP, computers
AVEVA Diagrams	Enables the creation and provision of intelligent P&IDs and other circuit diagrams.	IT, DP, computers
BabtecQ	Software with a modular structure to support quality management. Processes can be streamlined, and information can be provided by continuous data collection.	IT, DP, computers
BlackBerry OS operating system	Is the name of a multitasking operating system by Blackberry; its successor is called Blackberry 10.	IT, DP, computers

New skills	Description	Skill group
Big data architecture	Data volumes the complexity and size of which overload traditional databases are collected in big data architectures which are able to perform data processing and analysis.	IT, DP, computers
Image synthesis/rendering	Creating an image or a diagram from raw data (e. g. geometric description in the 2D or 3D space).	IT, DP, computers
BlackBerry Enterprise Server (BES)	Refers to middleware by Blackberry which synchronises message contents between servers and terminals.	IT, DP, computers
BlackBerry Unified Endpoint Manager	Is used to manage a number of terminals, e. g. notebooks, smartphones, and tablets.	IT, DP, computers
Border Gateway Protocol (BGP)	Refers to a routing protocol connecting autonomous systems.	IT, DP, computers
Accounting software	Is used by companies to facilitate the profit assessment process. Information on revenues and expenses can be tracked, so that unnecessary costs and losses of time can be avoided.	IT, DP, computers
Tableau business intelligence software	Visualisation software by Tableau used to collect, evaluate, and present data.	IT, DP, computers
hyperMILL CAD/CAM application	A modular CAM software solution enabling CAM programmers to create numeric control programs.	IT, DP, computers
HyperWorks CAE application	Open architecture simulation platform.	IT, DP, computers
Certified Ethical Hacker	This certificate allows a person to hack into computer system security to perform a targeted search for weaknesses in the target system, point them out, and initiate the improvement of computer system security.	IT, DP, computers
CISM certificate	A certificate for IT professionals for planning, implementation, controlling, and monitoring IT security concepts.	IT, DP, computers
CISSP certificate	Certificate of IT security knowledge for IT specialists.	IT, DP, computers
Citrix XenApp	An extension of the Windows terminal services; facilitates application by virtualisation and IT management (e. g. centralised administration and management console).	IT, DP, computers
Citrix XenDesktop	Is the name of a software platform developed by Citrix which allows multiple users to remotely access Microsoft Windows desktop computers.	IT, DP, computers
Cloudogu EcoSystem (CES)	A platform for software development with a modular structure. Integration of services, functions, and applications takes place via docker containers.	IT, DP, computers
Composer (package management)	Refers to an application-oriented package manager for the PHI script language.	IT, DP, computers
Computer graphics	Sub-area of computer sciences dealing with computer-aided image generation […] and image editing.	IT, DP, computers
Firstspirit content management system (CMS)	Commercial content management system […] managing contents for websites and other output channels.	IT, DP, computers
Cross-platform development	Refers to the development of programs to be run on different platforms; this is also referred to as platform independence.	IT, DP, computers
Data vault modelling technique	Is a modelling technique and centralised database (data warehouses) optimised for analysis purposes which can act flexibly with extensions and records the time data are saved.	IT, DP, computers
Database query	Refers to a query of the database system by performing a logical operation to obtain specific information from a database.	IT, DP, computers
Database structures	By using, for example, entity relationship models, a scheme for the conception of database structures is to be created.	IT, DP, computers
Data integration	Description of the process of merging several data sources in one view.	IT, DP, computers
Data conversion	Converting a file from one file format into another by using a file converter.	IT, DP, computers
Data modelling	Information system modelling attributes of several entities and the relationship between entities.	IT, DP, computers
Data maintenance	Is part of a company's information management and describes a process continuously ensuring automated processes. The information in the data must be current, reliable, and duplicate-free, so that the quality and processes of a company can be enabled.	IT, DP, computers
Data transfer	Methods to transfer information from a sender to a recipient.	IT, DP, computers
Debugging	Is an optimisation method for systems and programs. Procedures and processes are to be tracked, and failures are to be diagnosed. The aim is to improve the application process.	IT, DP, computers
Device Enrollment Program (DEP)	The Device Enrollment Program helps companies to easily provide and configure Apple devices.	IT, DP, computers
Digital speech processing	Digital processing of audio signals via sound cards.	IT, DP, computers
Domain Name System (DNS)	Refers to a network service used to convert or translate queries into addresses that can be processed by computers.	IT, DP, computers
draw.io	draw.io is a free online charts software to create flow charts, process charts, organisation charts, UML, ER, and network charts.	IT, DP, computers
Printing systems	Software accepting and processing a file to be printed as a print job, and sending it to a printer.	IT, DP, computers
Dynamic Host Configuration Protocol (DHCP)	Is a process used to automate the assignment of network configurations (e. g. IP addresses) to clients through a server.	IT, DP, computers

New skills	Description	Skill group
Oxid eCommerce software	Software by Oxid which helps companies getting started with eCommerce. Interfaces are integrated with all important ERP systems.	IT, DP, computers
ECMAScript 6 (ES6)	Refers to the standardised language core of JavaScript, which is objectified and classless. ECMAScript is a declaration which is also used in class-based programming languages.	IT, DP, computers
Empirum Client Management	Matrix42 Empirum is a centralised, user-friendly system which integrates and automates all processes and tasks related to the management of physical workplaces, from provision to decommissioning.	IT, DP, computers
EPLAN P8	Computer support by EPLAN for projecting, documenting, and managing electrotechnical automation projects. Production processes are to be improved and streamlined.	IT, DP, computers
Vehicle bus systems	The objective is to facilitate the replacement of control units and/or electronics within a bus system; this includes diagnostics, the integration of sensors, and flash programming.	IT, DP, computers
Graphic user interface	The graphic user interface is part of the operating system and is supposed to facilitate the application and handling of the system by the user. Icons and controls (e. g. the mouse) enable the execution of commands for the applications.	IT, DP, computers
Group Policy Object (GPO)	For Windows operating systems; refers to a collection of digital settings having a positive impact on data security.	IT, DP, computers
Embedded programming	This type of programming is required in the field due to the limitation of resources for the configuration of peripheral elements, adjustment to hardware conditions, and real-time programming at low computing performance.	IT, DP, computers
IDocs	Is used to facilitate the exchange and transmission of information and data from SAP to other systems.	IT, DP, computers
IEC 62304	Is a Europe-wide standard specifying the minimum requirements on the most important medical devices software lifecycle processes. It focuses on the development, maintenance, and risk management of the software.	IT, DP, computers
IMDS	Is a global, standardised exchange and management system for material data in the automotive industry.	IT, DP, computers
Security (Ipsec) internet protocol	Refers to a protocol extension which can ensure secure communication in IP networks by certain measures (e. g. encryption).	IT, DP, computers
Ionic	Is a web framework to develop interactive apps authored in JavaScript and TypeScript.	IT, DP, computers
ISO/IEC 2700x	Refers to a number of standards for information security, e. g. risk analysis and management as well as instructions.	IT, DP, computers
IT service management (ITSM)	Refers to the usage of IT services to meet the requirements of complex business processes by increasing the efficiency and improving customer and service orientation.	IT, DP, computers
Java Message Service (JMS)	Is a programming interface (API) to control middleware which communicates between two or more clients.	IT, DP, computers
Junos OS	A network operating system developed by Juniper Networks.	IT, DP, computers
Calculation program	Is frequently used in construction and crafts sectors. The objective is the exact calculation of material consumption and price and cost analyses to ensure predictability for companies.	IT, DP, computers
Kibana (open-source analysis platform)	Is the name of a browser-based open-source analysis platform which enables the search and visualisation of data.	IT, DP, computers
Konstanz Information Miner (KNIME)	Free software for interactive data analysis. By applying a modular pipeline concept, the integration of different processes of machine learning and data mining is enabled.	IT, DP, computers
Design applications	Is a general term for CAD programs. These support the manufacturing of products (e. g. aircrafts, cars, buildings, clothing) by computer-aided design.	IT, DP, computers
Continuous integration	This term originates from software development and refers to the process of continuously merging components in an application instead of daily work with daily integration. Continuous integration is to be applied until the software quality improves.	IT, DP, computers
Kubernetes	A system developed by Google to facilitate container usage, which automatically provides, scales, and manages containers.	IT, DP, computers
Legacy code	Is an established, historically grown application in the field of business software. It often refers to the source code of operating systems no longer supported.	IT, DP, computers
MagicDraw	MagicDraw is a visual UML, SysML, BPMN, and UPDM modelling tool which supports team collaboration. This dynamic and versatile development tool was developed for business analysts, software analysts, programmers, and QA engineers and facilitates the analysis and design of object-oriented (OO) systems and databases.	IT, DP, computers
Malware	Malicious software designed to run undesired and malicious functions.	IT, DP, computers
Microservices	Complex applications; in software development they are defined in a variety of modules and act in an uncoupled way with other modules. The individual modules communicate via simple interfaces.	IT, DP, computers

New skills	Description	Skill group
Microsoft Dynamics Nav	Software for business administration; supports the planning and control of operating resources (e. g. capital and personnel resources).	IT, DP, computers
Middleware	A type of distribution platform between application and operating system, used to facilitate communication and management across applications. Examples for the tasks performed by middleware are contact forms, subscriptions, and registrations.	IT, DP, computers
Mixed reality	Refers to a mixture of two systems: natural and artificial (computer-based) perception. Mixed reality is often used also in the arts or in some media areas.	IT, DP, computers
Model–view–controller (MVC)	Is a threefold pattern division of software into the following components: model, view/presentation, and control. The model component mostly describes the status management of objects, e. g. during communication with databases. View refers to the representation of the model. Model and view are connected by the third part, control.	IT, DP, computers
NHibernate framework	Used to enable object-relational representation, which can be saved in relational databases and shown as objects.	IT, DP, computers
NI-TestStand	Test management software to develop automated test and validation systems and to expand functionalities of systems.	IT, DP, computers
Nvidia Hairworks	Software plug-in for 3ds Max and Maya by Nvidia for the realistic representation of fur and hair.	IT, DP, computers
Object-oriented analysis and design (OOAD)	Necessary phase in the software development process which ensures that the system requirements are disclosed by an object-oriented analysis, and the object-oriented design is used to model how the system solves the tasks and requirements.	IT, DP, computers
Open Shortest Path First (OSPF)	A link state routing protocol developed by IETF which promotes quick convergence and better scalability in larger networks.	IT, DP, computers
OpenShift (cloud computing)	A container application platform for cloud computing.	IT, DP, computers
Platform as a service (PaaS)	Refers to a cloud environment service. An internet-based platform is to be provided for the development of web applications.	IT, DP, computers
DOCexpert practice software	Software for medical information systems, provides EDP systems for medical practices.	IT, DP, computers
Prototype class library	Is used to facilitate the usage by different programming aids, also as an option for JavaScript source text shortening.	IT, DP, computers
Prototype testing	Prototypes are used in the conception phase […] for the new and further development of web applications and websites. As part of a usability test, prototype tests […] are to be performed by the user to optimise the function and avoid any undesirable developments.	IT, DP, computers
PTC Windchill (PLM software)	Product lifecycle management software released by PTC in 1998.	IT, DP, computers
Qlik Sense	Business intelligence software that works with an in-memory technology and has been equipped with a cognitive engine since 2018 (based on the machine learning concept).	IT, DP, computers
Red Hat Enterprise Linux (RHEL)	A Linux distribution whose operating system is aligned with the requirements of large companies.	IT, DP, computers
Redis (database system)	Is part of non-relational database systems (NoSQL) and is characterised by a simple key value data structure.	IT, DP, computers
Redux	Name of a JavaScript library to manage the information of a web application.	IT, DP, computers
Release update	Refers to updating and installing standard software by applying an update by the vendor.	IT, DP, computers
Remote Function Call (RFC) process	Refers to a process to retrieve functions in a remote system and to enable communication between the applications of different systems.	IT, DP, computers
RESTful API	Based on a REST technology the architectural style and communication strategy of which is frequently used for the development of web services.	IT, DP, computers
SAP Business Planning and Consolidation (SAP BPC)	SAP Business Planning and Consolidation is s software for business planning and consolidation. It comprises functions for planning, budgeting, estimations, and financial consolidation.	IT, DP, computers
SAP Enhancement Packages (EHP)	Refers to the SAP extension of the core package; it has a modular design and supports specific process optimisations.	IT, DP, computers
SAP Fiori	Fiori is the general term for new UX guidelines. […] A sub-category is SAPUI5. Is used to facilitate the utilisation of SAP software.	IT, DP, computers
Script languages	In contrast to programming languages, these are translated via an interpreter. Examples for the application of script languages are pop-up windows and advertisement on websites.	IT, DP, computers
Selenium	Free auxiliary software for test automation of software and web applications.	IT, DP, computers
Siemens control	An electronic procedure by Siemens to control machine tools by means of a computer.	IT, DP, computers
SINUMERIK 840d	An electronic procedure (CNC control) by Siemens to control machine tools by means of a computer.	IT, DP, computers
SoapUI	Refers to a software test tool in the SOA field, mostly to test web services.	IT, DP, computers
Software as a service (SaaS)	A specific area of cloud computing providing software and the IT infrastructure through a service provider or web browser.	IT, DP, computers

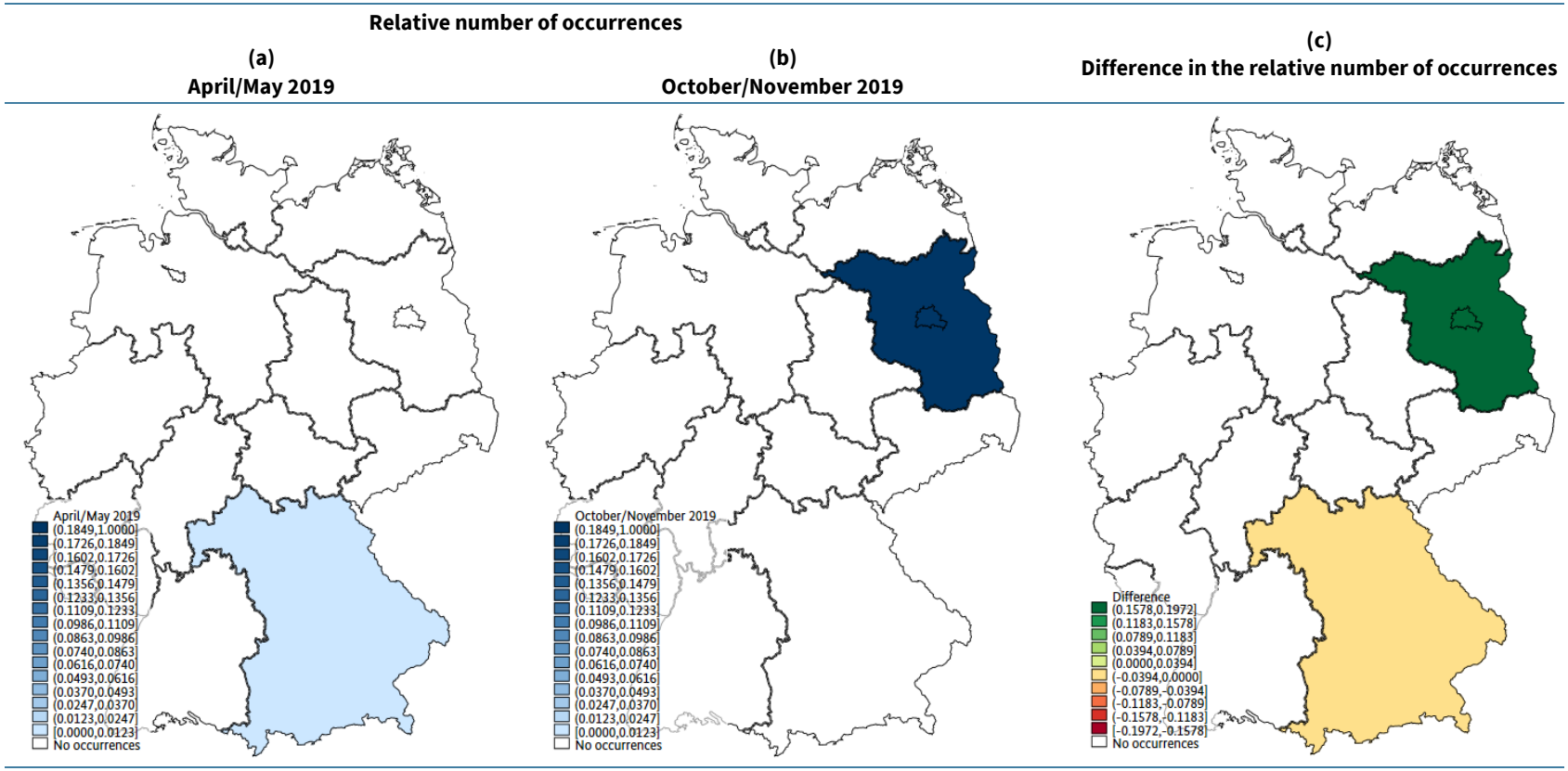
New skills	Description	Skill group
Software deployment	Processes to install software on a usually large number of computers; this also includes their configuration and maintenance.	IT, DP, computers
Software-in-the-Loop simulation (SIL)	Is used in aerospace and traffic engineering to test partially integrated software in a simulated environment.	IT, DP, computers
Software-defined data centre	Refers to a marketing term for IT infrastructure which has completed virtualisation and can be provided as an IT service.	IT, DP, computers
Software-defined networking (SDN)	Strategy to build computer network devices and software separating and abstracting the two essential components of such devices. DS SDN is an essential part of virtualisation.	IT, DP, computers
Software-defined storage (SDS)	A marketing term for computer data storage software to manage data repositories regardless of the underlying hardware.	IT, DP, computers
Solaris	An operating system distribution by Oracle.	IT, DP, computers
Sophos Unified Threat Management (UTM)	Refers to a software and hardware package with a modular design. It is used for comprehensive protection as part of IT security by means of applications such as firewalls, VPN, ATP, etc.	IT, DP, computers
SPOT (data management)	The single point of truth (SPOT) is a data pool which is driven by the objective of being universally valid, reliable, and correct. The term is often used with regard to data warehousing, which frequently consists of redundant data.	IT, DP, computers
Stored procedure	Is a function in database management systems which can be used to access entire command strings in the form of saved commands from the database client.	IT, DP, computers
SUSE Linux Enterprise Server (SLES)	A modular operating system which is part of the Linux distributions. It focuses on the optimisation and increase in efficiency of internal company information technology (e. g. servers, mainframe computers).	IT, DP, computers
TargetLink	Software for automatic series code generation.	IT, DP, computers
TensorFlow	Open-source platform by Google used, for example, to apply machine learning.	IT, DP, computers
Test harness	Is part of quality assurance for software programs; programs are systematically automated, tested, and checked for different environments.	IT, DP, computers
Test management	Contains process analyses and process optimisation to determine the system quality. Risk reductions, such as securing system failures, and an optimised cost-benefit calculation are to guarantee predictability for companies.	IT, DP, computers
Ubuntu	Ubuntu is a Linux distribution which is based on Debian in terms of architecture and infrastructure. The Ubuntu distribution is aimed at providing a user-friendly operating system and software.	IT, DP, computers
Version management	Is used for project logging and enables users to recover, track, and undo data changes.	IT, DP, computers
GitLab version management program	Refers to a web application by GitLab for version management (see Version management).	IT, DP, computers
Virtualisation	Description of a process of abstraction from hardware and software to virtual IT resources, e. g. cloud computing. Resources are to be optimised by means of virtualisation.	IT, DP, computers
Process model	An essential part of system development and software engineering. Activities and procedures in the process are to be ordered and described.	IT, DP, computers
Web analysis	Refers to the collection and evaluation of user behaviour data on websites.	IT, DP, computers
Algorithm	Description of unique command strings for problem solving often referring to software problems. These strings must be finite and formulated in a specific syntax.	Science, research, development
Data collection	Frequently describes the process of collecting information by different methods, e. g. surveys, examinations, and experiments.	Science, research, development
Genome editing	Umbrella term for molecular biological techniques to purposefully change the DNA, including the genome of plants, animals, and human beings.	Science, research, development
High-fidelity prototyping	Refers to a computer-aided interactive presentation of the product (prototype) which has the greatest similarity to the final design with regard to details and functionality.	Science, research, development
Conception		Science, research, development
Method validation	Part of the approval process; in scientific areas, part of analytics. It refers to the proof of suitability of specific methods in these areas.	Science, research, development
Molecular imaging	Refers to the representation of physiological processes, which improves the diagnosis of diseases through early detection of, for example, increased cell activity.	Science, research, development
Regression analysis	Refers to a number of statistical analysis processes to model relationships of two or more variables.	Science, research, development

New skills	Description	Skill group
Time series analysis	This special form of regression analysis deals with the inferential statistical analysis of chronological data points. The objective is the prediction of trends and/or developments.	Science, research, development
Aligner therapy	Using hardly visible plastic rails, malocclusion can be treated in orthodontics.	Social affairs, education, health, sports
Literacy training	Teaching how to read and write.	Social affairs, education, health, sports
Labour market integration	Refers to a number of tasks occurring as part of the integration of people in the labour market and requiring specific knowledge, such as consulting or placement of job-seekers.	Social affairs, education, health, sports
Arthroscopy	Using an endoscope, joints can be treated by means of minimally invasive surgery by making small incisions (arthrotomies).	Social affairs, education, health, sports
Aseptic way of working	Refers to a sterile way of working required to avoid infections.	Social affairs, education, health, sports
DIN EN 60601	Refers to a number of safety standards for medical equipment and systems.	Social affairs, education, health, sports
Ergometry	Different ergometers can be used to document the individual physical fitness as part of performance diagnostics via step and fatigue tests as well as cross-sectional and longitudinal examinations.	Social affairs, education, health, sports
Joint surgery	Refers to a medical area which focuses on curing injured or failing natural joints. This is not about the replacement of specific joints, but about salvage and reconstruction.	Social affairs, education, health, sports
Instrument preparation	Refers to the process of cleaning and disinfecting medical instruments to protect people against infections and injuries.	Social affairs, education, health, sports
Paediatrics	Is that part of medicine dealing with the development of children and adolescents with regard to the prevention and treatment of diseases.	Social affairs, education, health, sports
Paediatric cardiology	Refers to the science of congenital and acquired diseases of the heart in children.	Social affairs, education, health, sports
Physiotherapy with training tools	Refers to individual medical training therapy following a phase of illness.	Social affairs, education, health, sports
Laparoscopic surgery	Refers to a sub-area of surgery where surgery in the abdominal cavity is performed with the help of an optical instrument (endoscope) and by using clamps and surgical knives which are operated indirectly via extensions.	Social affairs, education, health, sports
Molecular pathology	Processes and causes of physical conditions are examined by means of molecular biological methods, e. g. in the personalised treatment of cancer.	Social affairs, education, health, sports
Parenteral feeding	Refers to feeding via the vein; patients receive all important nutrients, such as carbohydrates, fats, fluids, and proteins.	Social affairs, education, health, sports
Rehabilitation sports	Is a programme with the objective of permanently integrating people with disabilities or threatened to develop a disability in professional life and society.	Social affairs, education, health, sports
Reintegration	Refers to the ability to support different groups of people with their reintegration in various contexts, such as pupils and students in a school class, or family reintegration.	Social affairs, education, health, sports
Stereotaxis	A minimally invasive treatment method which enables precise localisation control via image-driven and computer-aided route guidance systems. It is mainly used in radiotherapy and for surgeries.	Social affairs, education, health, sports
Strand technique		Social affairs, education, health, sports
Spine surgery	Is the surgical discipline specialising in operative treatment of spine and bone marrow diseases.	Social affairs, education, health, sports
Seating	Arrangement of chairs in a room for various events.	Media, art, design
Moving image	Sequence of images generating the illusion of movement by displaying them in short intervals […].	Media, art, design

Source: Authors' calculations and classifications. © IAB

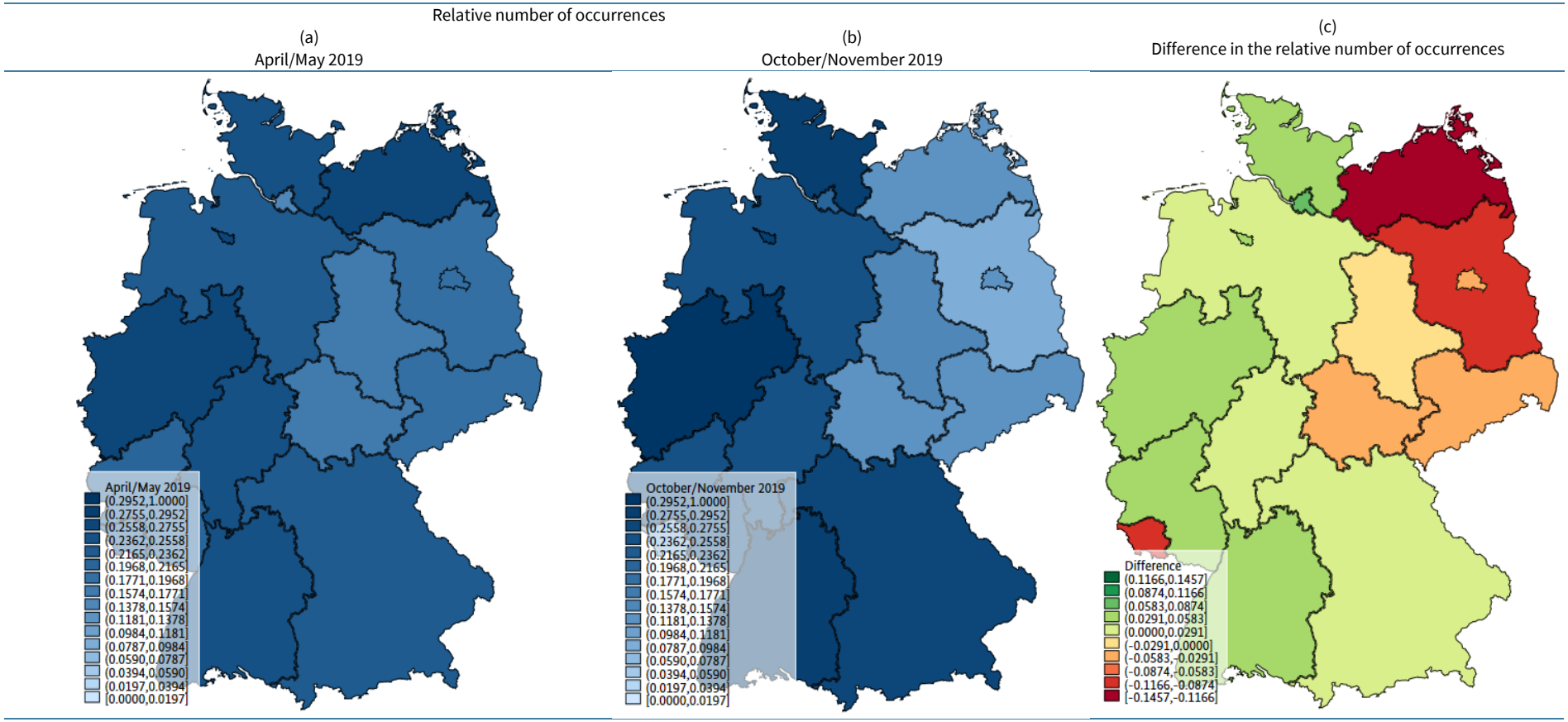
10.4 Regional development of selected skill requirements

Figure 10.3: Development of the "photolithography" skill



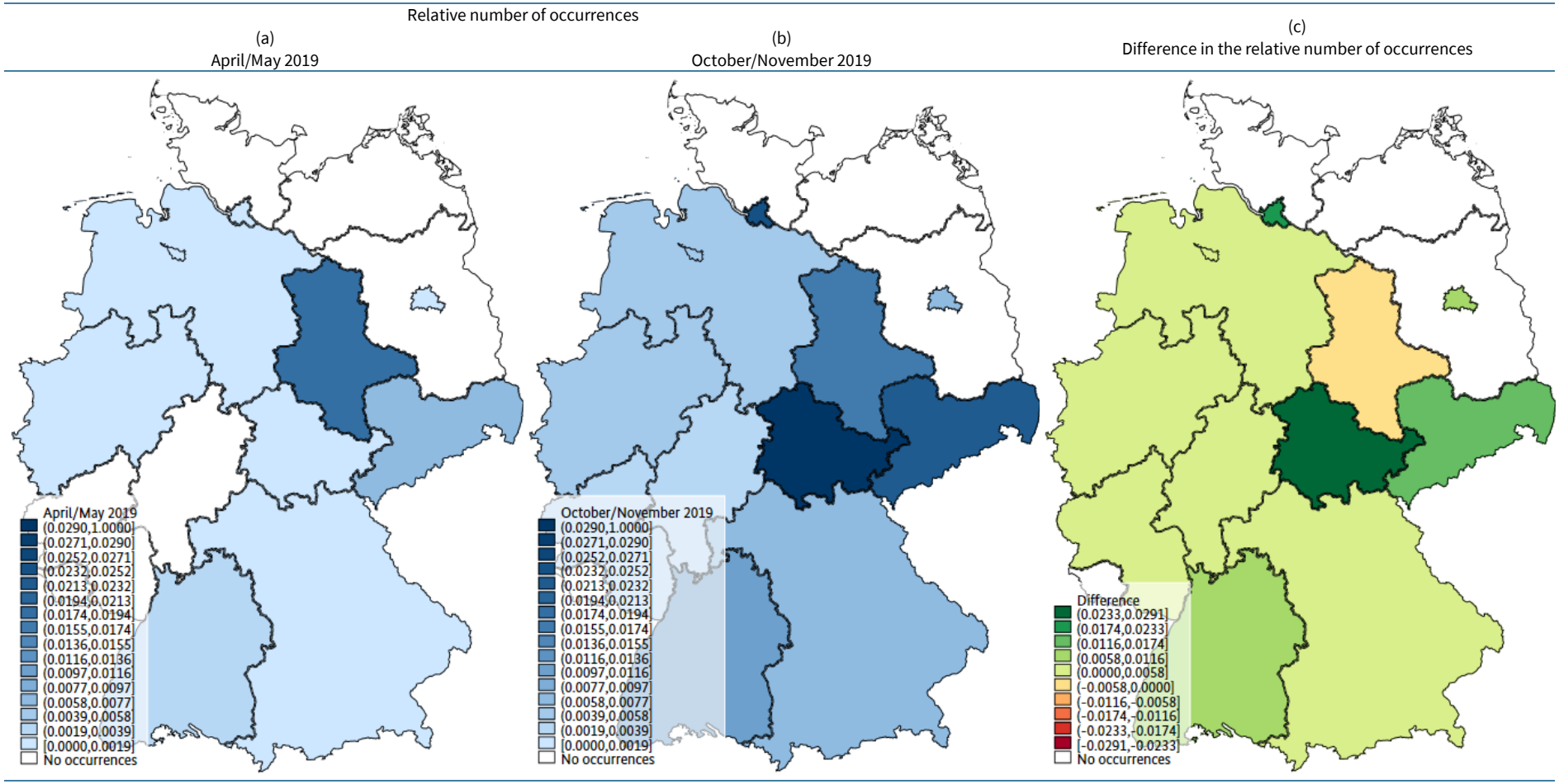
Source/explanation: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Vacancies for Germany and MAE occupations. Intervals in the legends: the number of relative occurrences assigned to an interval for each federal state is always higher than the smallest specified value of the interval and may range up to the highest specified value of the interval. Authors' calculations. © IAB

Figure 10.4: Development of the “industrial mechanics” skill



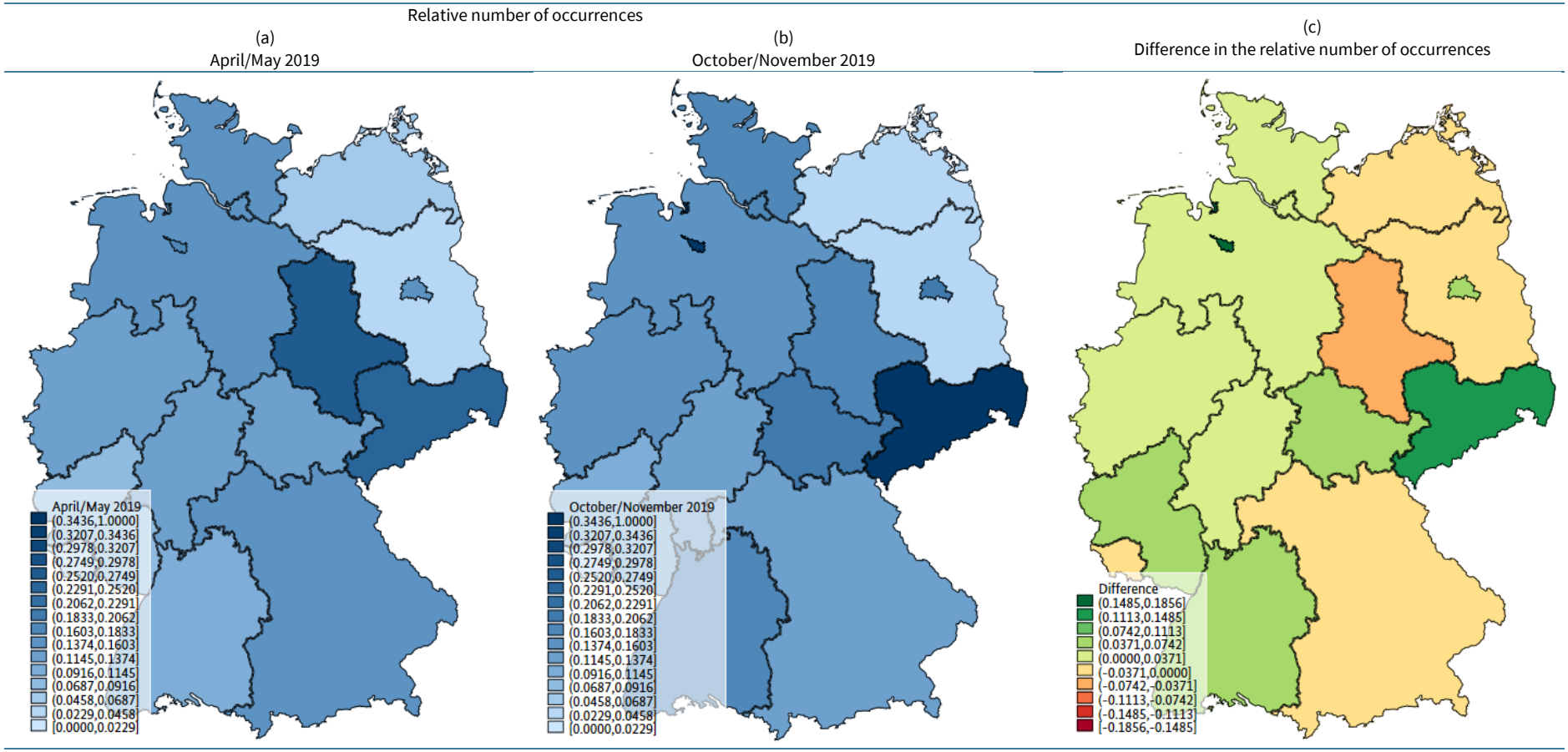
Source/explanation: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Vacancies for Germany and MAE occupations. Intervals in the legends: the number of relative occurrences assigned to an interval for each federal state is always higher than the smallest specified value of the interval and may range up to the highest specified value of the interval. Authors’ calculations. © IAB

Figure 10.5: Development of the “design patterns” skill



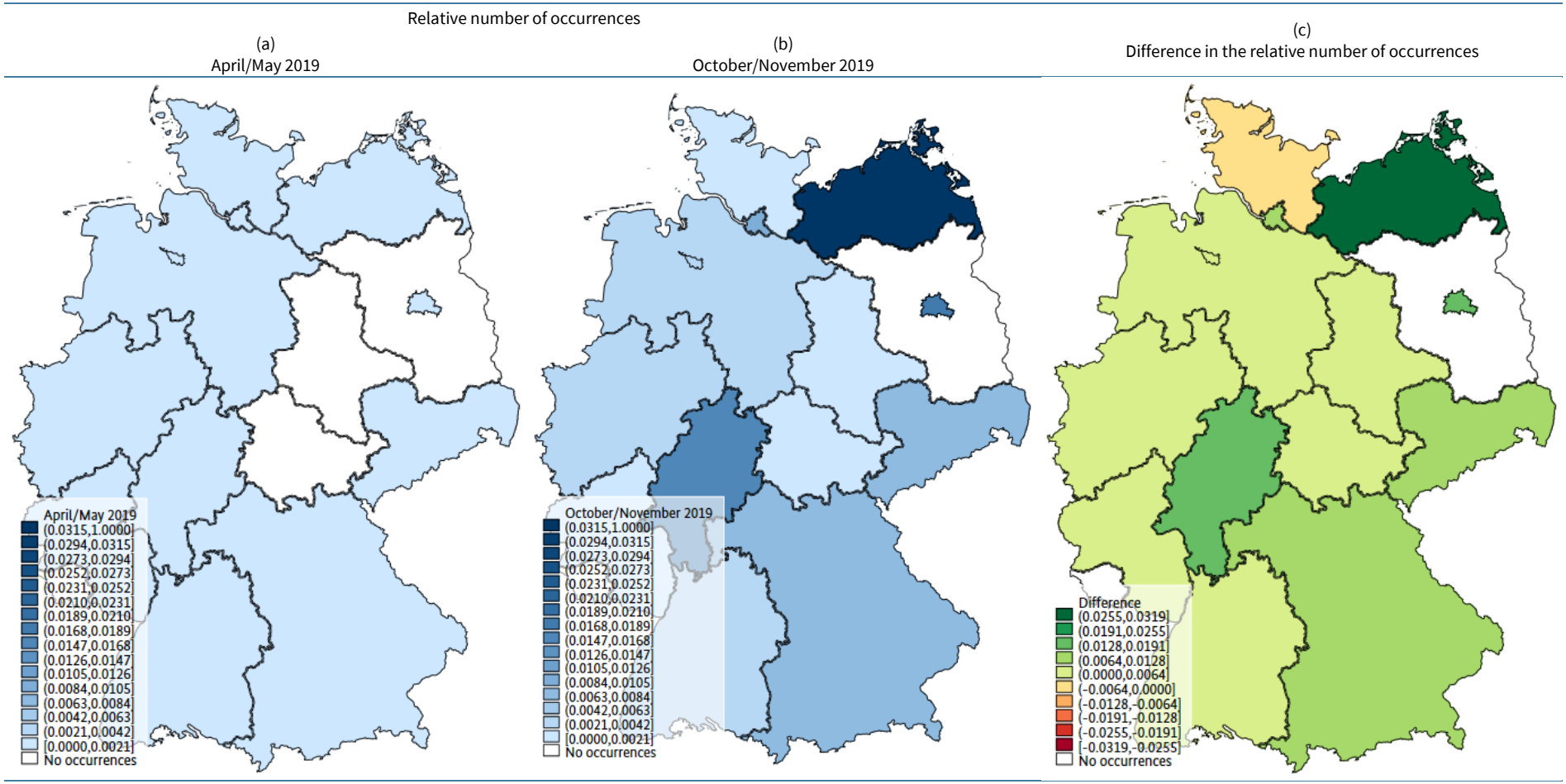
Source/explanation: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Vacancies for Germany and ICT occupations. Intervals in the legends: the number of relative occurrences assigned to an interval for each federal state is always higher than the smallest specified value of the interval and may range up to the highest specified value of the interval. Authors’ calculations. © IAB

Figure 10.6: Development of the "development" skill



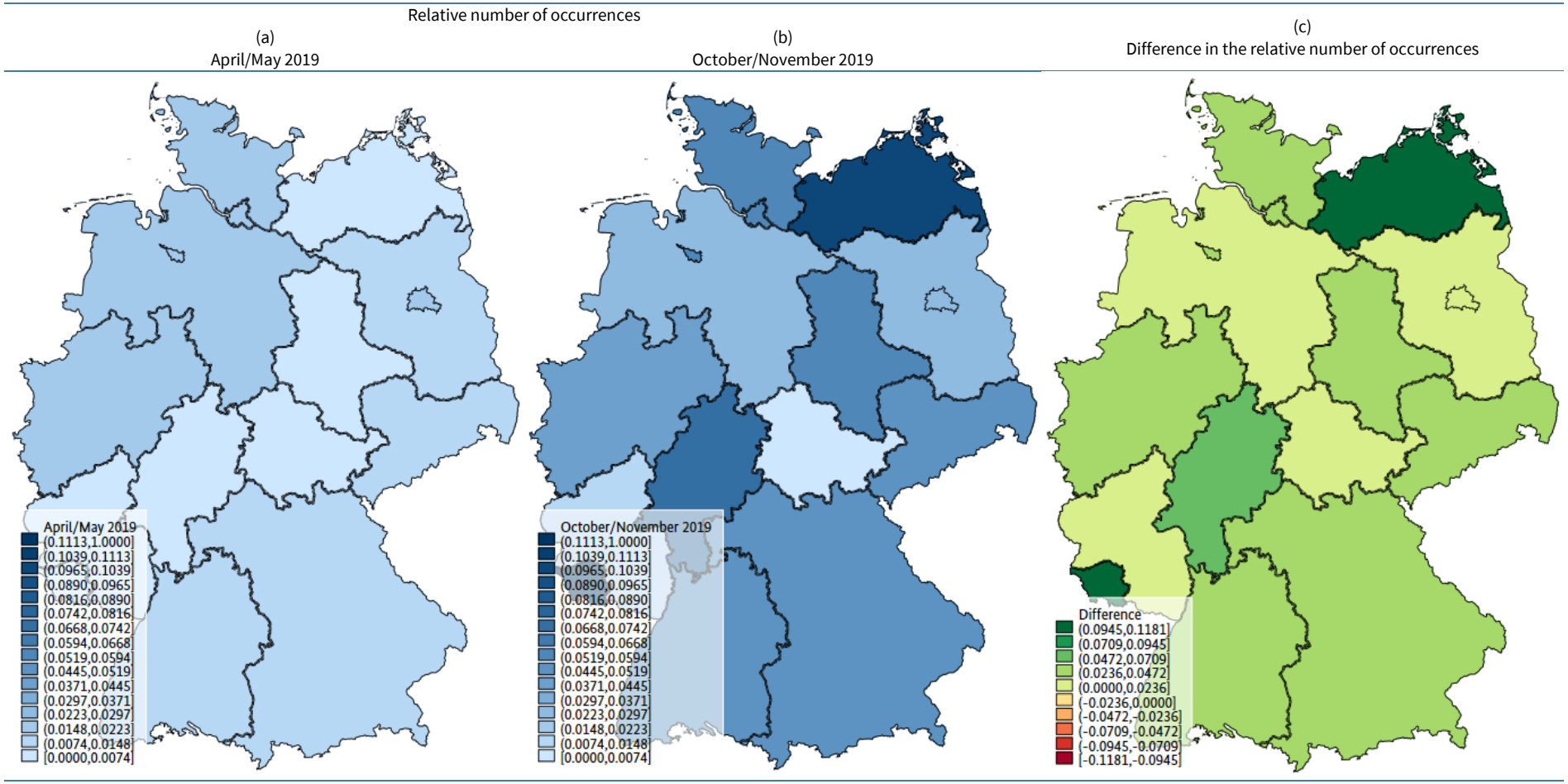
Source/explanation: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Vacancies for Germany and ICT occupations. Intervals in the legends: the number of relative occurrences assigned to an interval for each federal state is always higher than the smallest specified value of the interval and may range up to the highest specified value of the interval. Authors' calculations. © IAB

Figure 10.7: Development of the "laboratory diagnostics" skill



Source/explanation: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Vacancies for Germany and HES occupations. Intervals in the legends: the number of relative occurrences assigned to an interval for each federal state is always higher than the smallest specified value of the interval and may range up to the highest specified value of the interval. Authors' calculations. © IAB

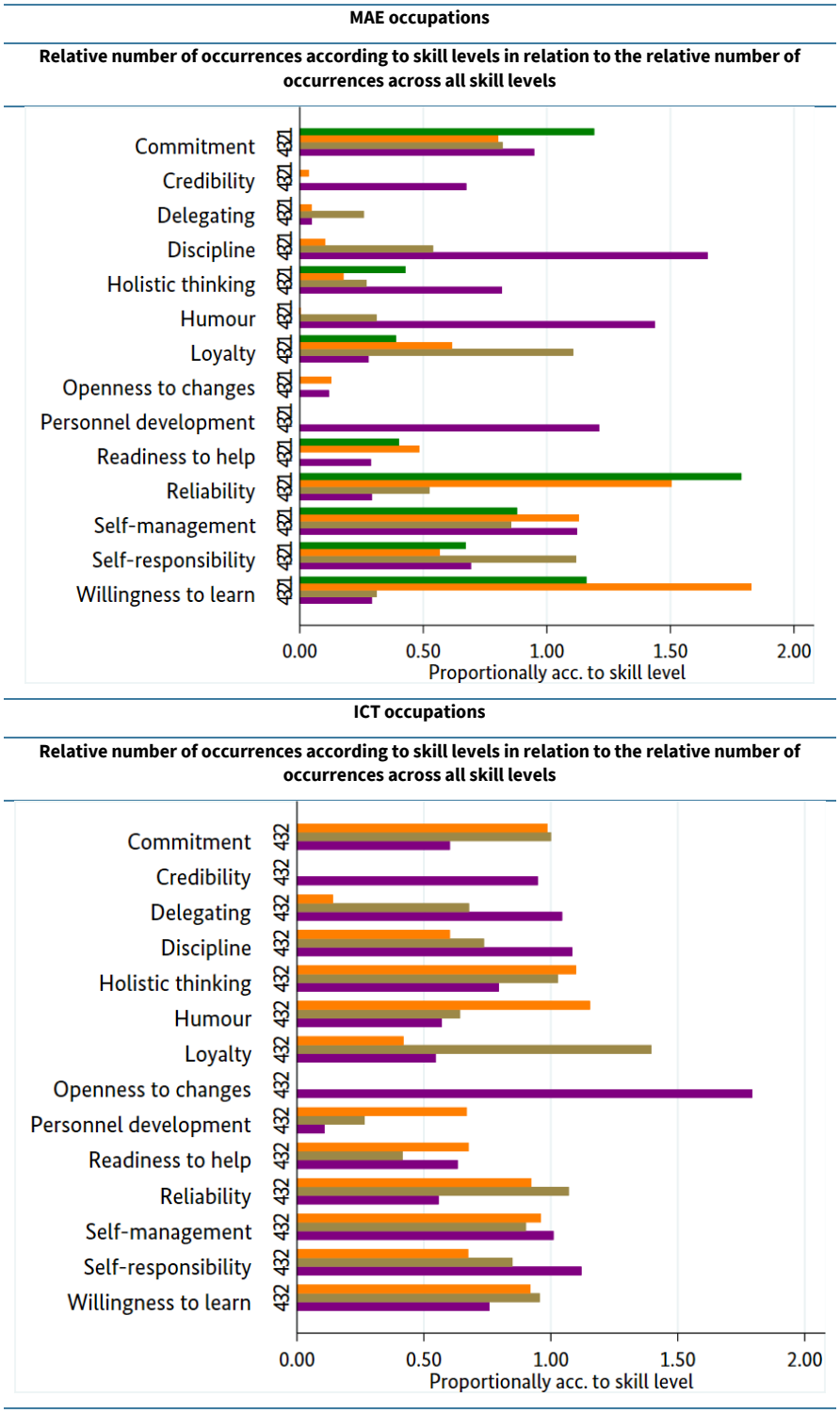
Figure 10.8: Development of the "anaesthetics" skill



Source/explanation: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Vacancies for Germany and HES occupations. Intervals in the legends: the number of relative occurrences assigned to an interval for each federal state is always higher than the smallest specified value of the interval and may range up to the highest specified value of the interval. Authors' calculations. © IAB

10.5 Additional results for soft skills

Figure 10.9: Total relative number of occurrences and relation of the relative number of occurrences between the different skill levels for personal skills according to Heyse/Erpenbeck (2004), October/November 2019

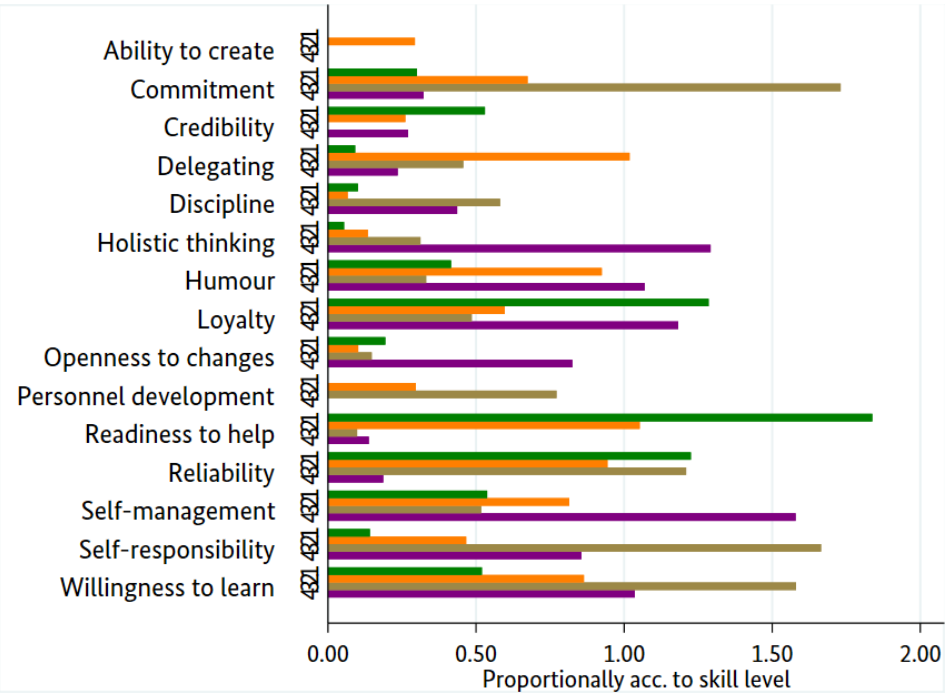


To be continued on the next page

Continued from the previous page

HES occupations

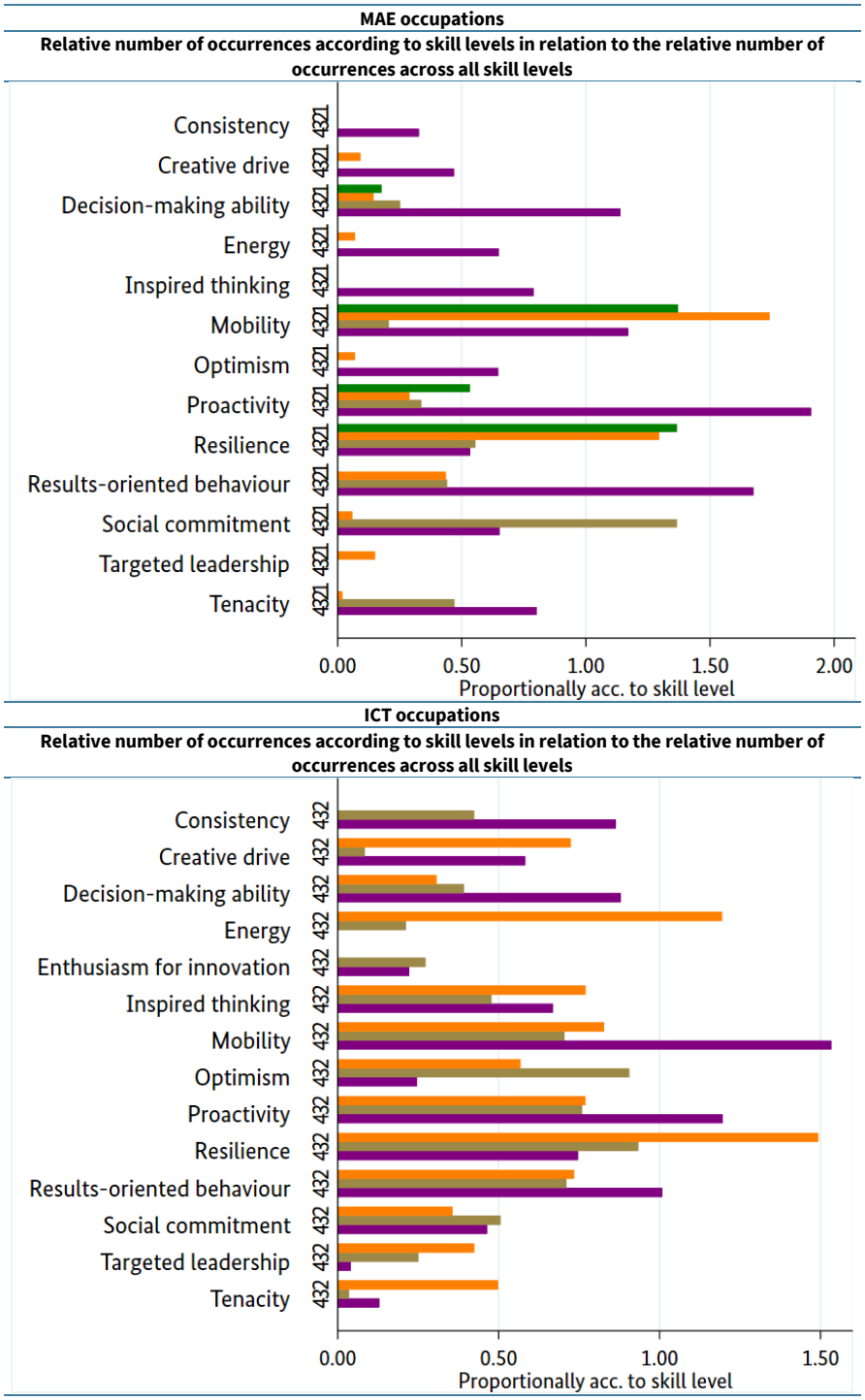
Relative number of occurrences according to skill levels in relation to the relative number of occurrences across all skill levels



Explanations: Vacancies for Germany and the selected occupational sets. The diagrams show the relevance of the individual skills for each skill level. The relative number of occurrences in the skill levels were examined in relation to the (average number of) relative occurrences across all skill levels. The diagrams cannot and are not supposed to give evidence about whether the relative number of occurrences of one skill for a certain skill level is higher than the relative number of occurrences of another skill for the same skill level. First (green) bar: “unskilled or semiskilled tasks”; second (orange) bar: “skilled tasks”; third (brown) bar: “complex tasks”; fourth (purple) bar: “highly complex tasks”. MAE occupations refers to occupations in mechanical and automotive engineering (occupational main group 25 of the KldB 2010); ICT occupations refers to occupations in computer sciences, information and communication technology (occupational main group 43); it must be kept in mind that there is no “unskilled or semiskilled tasks” skill level for ICT occupations; HES occupations refers to occupations in health care (occupational main group 81); non-medical occupations in health care, personal hygiene, and well-being, medical engineering (occupational main group 82); education, social and household occupations, theology (occupational main group 83).

Source: Data from the BA employment website, access sample, period of time: 1 October 2019 to 30 November 2019. Authors’ calculations. Explanation: All vacancies for Germany. © IAB

Figure 10.10: Relation of the relative number of occurrences between the different skill levels for activity and action skills according to Heyse/Erpenbeck (2004)

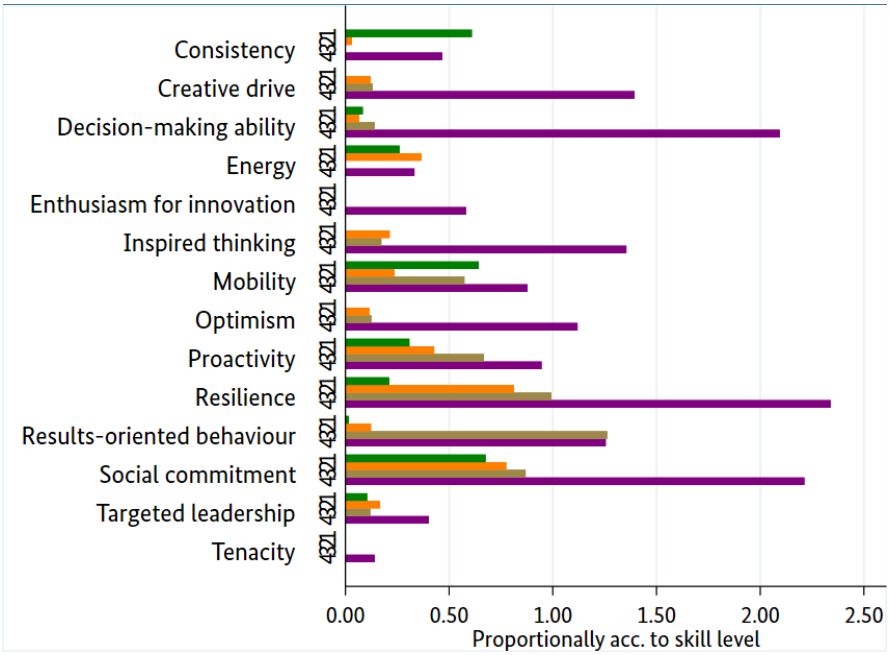


To be continued on the next page

Continued from the previous page

HES occupations

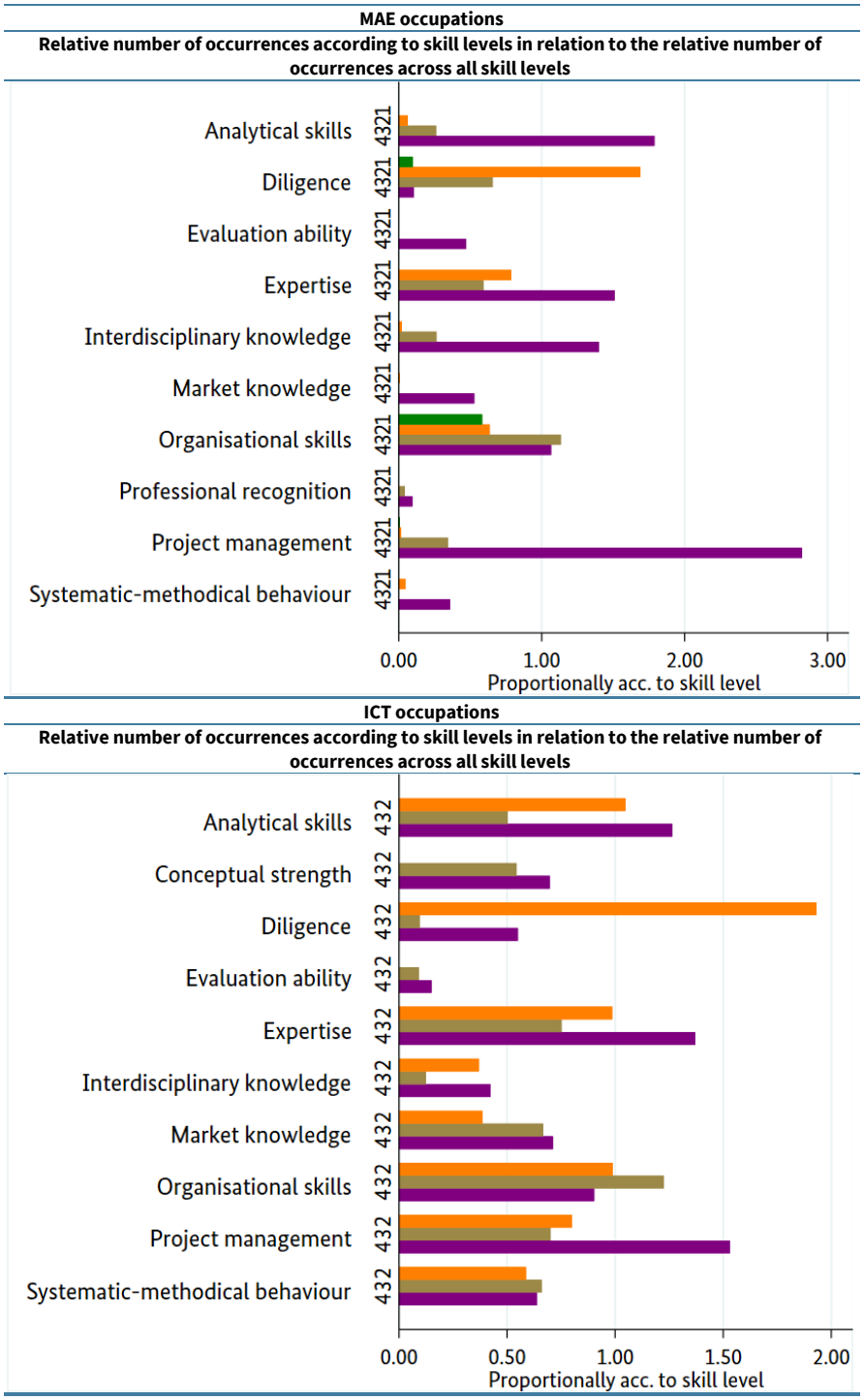
Relative number of occurrences according to skill levels in relation to the relative number of occurrences across all skill levels



Explanations: Vacancies for Germany and the selected occupational sets. The diagrams show the relevance of the individual skills for each skill level. The relative number of occurrences in the skill levels were examined in relation to the (average number of) relative occurrences across all skill levels. The diagrams cannot and are not supposed to give evidence about whether the relative number of occurrences of one skill for a certain skill level is higher than the relative number of occurrences of another skill for the same skill level. First (green) bar: “unskilled or semiskilled tasks”; second (orange) bar: “skilled tasks”; third (brown) bar: “complex tasks”; fourth (purple) bar: “highly complex tasks”. MAE occupations refers to occupations in mechanical and automotive engineering (occupational main group 25); ICT occupations refers to occupations in computer sciences, information and communication technology (occupational main group 43); it must be kept in mind that there is no “unskilled or semiskilled tasks” skill level for ICT occupations; HES occupations refers to occupations in health care (occupational main group 81); non-medical occupations in health care, personal hygiene, and well-being, medical engineering (occupational main group 82); education, social and household occupations, theology (occupational main group 83).

Source: Data from the BA employment website, access sample, period of time: 1 October 2019 to 30 November 2019. Authors’ calculations. Explanation: All vacancies for Germany. © IAB

Figure 10.11: Relation of the number of relative occurrences between the different skill levels for functional and methodical skills according to Heyse/Erpenbeck (2004)

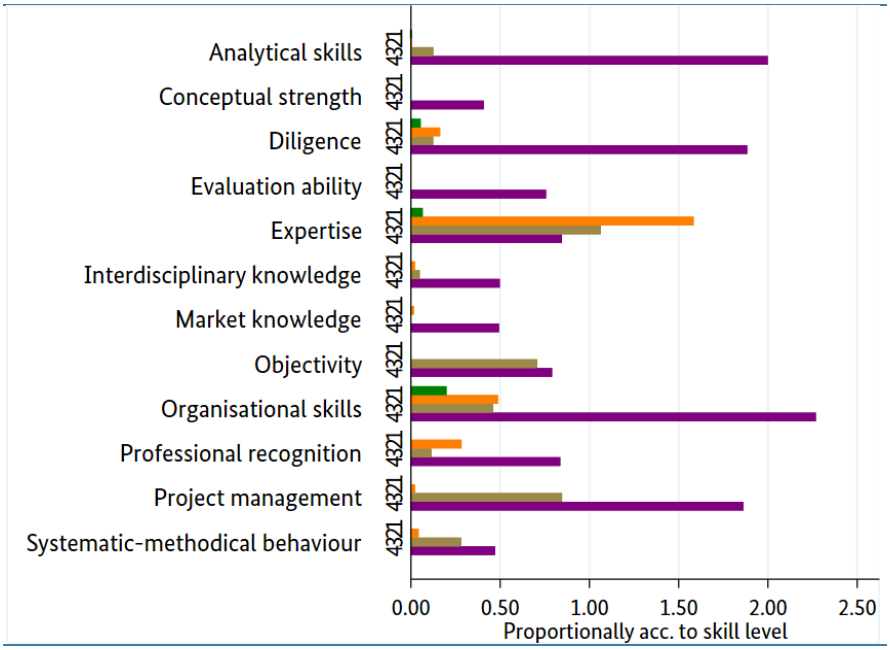


To be continued on the next page

Continued from the previous page

HES occupations

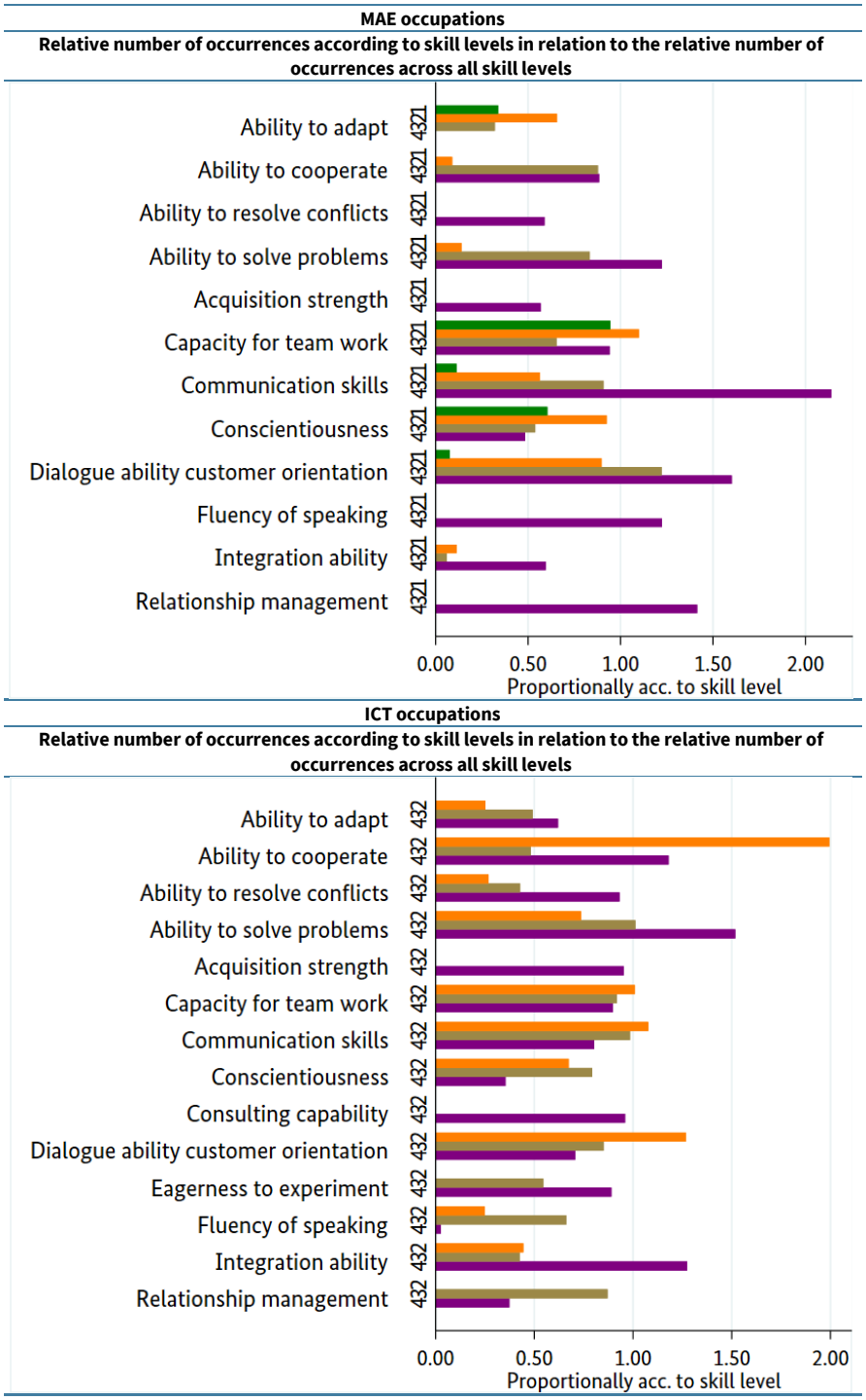
Relative number of occurrences according to skill levels in relation to the relative number of occurrences across all skill levels



Explanations: Vacancies for Germany and the selected occupational sets. The diagrams show the relevance of the individual skills for each skill level. The relative number of occurrences in the skill levels were examined in relation to the (average number of) relative occurrences across all skill levels. The diagrams cannot and are not supposed to give evidence about whether the relative number of occurrences of one skill for a certain skill level is higher than the relative number of occurrences of another skill for the same skill level. First (green) bar: “unskilled or semiskilled tasks”; second (orange) bar: “skilled tasks”; third (brown) bar: “complex tasks”; fourth (purple) bar: “highly complex tasks”. MAE occupations refers to occupations in mechanical and automotive engineering (occupational main group 25 of the KldB 2010); ICT occupations refers to occupations in computer sciences, information and communication technology (occupational main group 43); it must be kept in mind that there is no “unskilled or semiskilled tasks” skill level for ICT occupations; HES occupations refers to occupations in health care (occupational main group 81); non-medical occupations in health care, personal hygiene, and well-being, medical engineering (occupational main group 82); education, social and household occupations, theology (occupational main group 83).

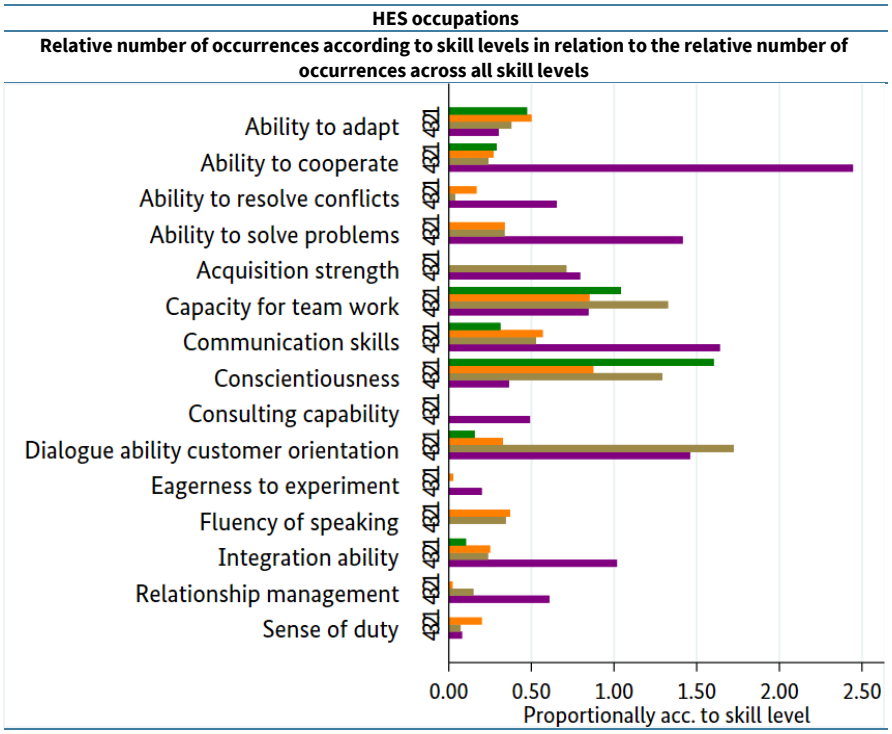
Source: Data from the BA employment website, access sample, period of time: 1 October 2019 to 30 November 2019. Authors’ calculations. Explanation: All vacancies for Germany. © IAB

Figure 10.12: Relation of the relative number of occurrences between the different skill levels for social and communication skills according to Heyse/Erpenbeck (2004)



To be continued on the next page

Continued from the previous page



Explanations: Vacancies for Germany and the selected occupational sets. The diagrams show the relevance of the individual skills for each skill level. The relative number of occurrences in the skill levels were examined in relation to the (average number of) relative occurrences across all skill levels. The diagrams cannot and are not supposed to give evidence about whether the relative number of occurrences of one skill for a certain skill level is higher than the relative number of occurrences of another skill for the same skill level. First (green) bar: “unskilled or semiskilled tasks”; second (orange) bar: “skilled tasks”; third (brown) bar: “complex tasks”; fourth (purple) bar: “highly complex tasks”. MAE occupations refers to occupations in mechanical and automotive engineering (occupational main group 25 of the KldB 2010); ICT occupations refers to occupations in computer sciences, information and communication technology (occupational main group 43); it must be kept in mind that there is no “unskilled or semiskilled tasks” skill level for ICT occupations; HES occupations refers to occupations in health care (occupational main group 81); non-medical occupations in health care, personal hygiene, and well-being, medical engineering (occupational main group 82); education, social and household occupations, theology (occupational main group 83).

Source: Data from the BA employment website, access sample, period of time: 1 October 2019 to 30 November 2019. Authors’ calculations. Explanation: All vacancies for Germany. © IAB

10.6 Number of skills found per job ad

Table 10.4 shows the number of hard and soft skill requirements counted. Column (3) of the table contains the sum of skill categories mentioned. When interpreting these figures, attention must be paid to the fact that we did not exclude job ad text which, for example, contained very few text lines, because even these job ad texts may contain valuable information, even if we have not (yet) evaluated it.

In general, most hard skill requirements per job ad were found for ICT occupations. This number was between 5.4 and 7.4 requirements within the skill levels and for both survey periods. For MAE occupations, it was between 1.3 and 5.4 requirements; for HES occupations, between 1.5 and 2.7 requirements. Table 10.4 also shows that the number of hard skill requirements found increased with the skill level.

In contrast, the number of soft skill requirements found was much lower. It was comparable between the occupational sets and within the skill levels and was between 0.6 and 0.9 requirements

per job ad. We could not identify any pattern suggesting that the number of soft skill requirements per job ad varies systematically with the skill levels.

There may be a number of reasons for very low numbers or undetected skill requirements. On the basis of random examinations of the job ad text material, we assume that these reasons vary.

For hard skill requirements, we cannot (yet) assume that we were able to acquire the entirety of requirements mentioned. Repeated sequences to identify additional, new skills (Section 5.2.1) based on job ad texts and using the latest data, if possible, are required to this end.

However, for soft skill requirements, we would tend to assume that the keyword corpus must be complemented to be able to identify the extensive soft skill requirements already recorded. An expansion of this catalogue seems not appropriate; however, a differentiation or generating additional search words may be useful.

Table 10.4: Number of skills found per job ad

Access sample	Occupational group	Skill level	(1) Hard skills	(2) Soft skills	(3) Sum of (1)-(2)
April/ May 2019	MAE occupations	Unskilled or semiskilled tasks	1.38	0.72	2.10
		Skilled tasks	2.89	0.80	3.69
		Complex tasks	4.06	0.76	4.82
		Highly complex tasks	5.44	0.83	6.27
	ICT occupations	Skilled tasks	5.42	0.71	6.13
		Complex tasks	5.94	0.67	6.61
		Highly complex tasks	7.24	0.78	8.02
	HES occupations	Unskilled or semiskilled tasks	1.57	0.69	2.26
		Skilled tasks	2.08	0.66	2.74
		Complex tasks	2.16	0.78	2.94
		Highly complex tasks	2.52	0.66	3.18
October/November 2019	MAE occupations	Unskilled or semiskilled tasks	1.29	0.76	2.05
		Skilled tasks	2.86	0.79	3.65
		Complex tasks	4.03	0.73	4.76
		Highly complex tasks	5.33	0.85	6.18
	ICT occupations	Skilled tasks	5.75	0.73	6.48
		Complex tasks	6.34	0.66	7.00
		Highly complex tasks	7.41	0.70	8.11
	HES occupations	Unskilled or semiskilled tasks	1.46	0.63	2.09
		Skilled tasks	2.13	0.64	2.77
		Complex tasks	2.40	0.69	3.09
		Highly complex tasks	2.73	0.78	3.51

Explanation: Vacancies for Germany and the selected occupational sets. MAE occupations refers to occupations in mechanical and automotive engineering (occupational main group 25 of the KldB 2010); ICT occupations refers to occupations in computer sciences, information and communication technology (occupational main group 43); it must be kept in mind that there is no "unskilled or semiskilled tasks" skill level for ICT occupations; HES occupations refers to occupations in health care (occupational main group 81); non-medical occupations in health care, personal hygiene, and well-being, medical engineering (occupational main group 82); education, social and household occupations, theology (occupational main group 83).

Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

10.7 Alternative data differentiations

The evaluations shown in the main text always refer to all job ads found in the BA-Jobbörse, taking into account the number of vacancies per job ad for the three occupational sets and the two survey periods. By way of example, we would like to examine here if and to what extent alternative data differentiations may lead to other evaluation results.

First of all, the BA-Jobbörse data allow for the identification of vacancies created for the purpose of temporary employment. And indeed it becomes apparent that large parts of the vacancies in the BA-Jobbörse are designed for temporary employment; see Table 10.5 for the second access sample October/November 2019.

Table 10.5: Number of vacancies related to vacancies without temporary employment and all vacancies, October/November 2019

Occupational group	Number of vacancies		Difference (1)-(2)
	(1) Without temporary employment	(2) All	
MAE occupations	58,855	124,140	-65,285
ICT occupations	63,704	82,833	-19,129
HES occupations	354,745	499,488	-144,743
Total	477,304	706,461	-229,157

Explanation: Vacancies for Germany and the selected occupational sets. Without temporary employment. MAE occupations refers to occupations in mechanical and automotive engineering (occupational main group 25 of the KldB 2010); ICT occupations refers to occupations in computer sciences, information and communication technology (occupational main group 43); HES occupations refers to occupations in health care (occupational main group 81); non-medical occupations in health care, personal hygiene, and well-being, medical engineering (occupational main group 82); education, social and household occupations, theology (occupational main group 83).

Source: Data from the BA employment website, 1 access sample, period of time: 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

Generally, our data can also be used to perform a separate analysis of vacancies with and without temporary employment. In the vacancies without temporary employment, we generally find fewer skill requirements as compared to all vacancies. This applies to hard skills in particular; see Table 10.6

Table 10.6: Number of skill requirements identified in job ads without temporary employment

Dictionaries	April/May 2019				October/November 2019			
	Total	including by selected occupational main groups			Total	including by selected occupational main groups		
		MAE occupations	ICT occupations	HES occupations		MAE occupations	ICT occupations	HES occupations
Hard skills	3,280 (-193)	1,609 (-157)	2,072 (-96)	1,808 (-55)	3,227 (-128)	1,566 (-135)	1,997 (-66)	1,762 (-58)
Soft skills	56 (0)	46 (0)	53 (0)	55 (0)	56 (0)	46 (-2)	52 (0)	56 (0)

Explanation: Vacancies without temporary employment for Germany and the selected occupational sets. Difference of the number of requirements found with regard to all job ads, including temporary employment, in parentheses and highlighted in red. MAE occupations refers to occupations in mechanical and automotive engineering (occupational main group 25 of the KldB 2010); ICT occupations refers to occupations in computer sciences, information and communication technology (occupational main group 43); HES occupations refers to occupations in health care (occupational main group 81); non-medical occupations in health care, personal hygiene, and well-being, medical engineering (occupational main group 82); education, social and household occupations, theology (occupational main group 83).

Source: Data from the BA employment website, two access samples, periods of time: 1 April 2019 to 31 May 2019 and 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

One reason for this result may be that vacancies for temporary employment are advertised with a broader requirement profile, since the employees wanted are to work flexibly with different employees. To validate this hypothesis, however, an in-depth analysis would be required.

Moreover, we examined the hard skill requirements from the second survey wave of October/November 2019 to determine to what extent the combination of the 25 most frequently mentioned requirements in all vacancies differs from the vacancies without temporary employment. We noted that the ranking of skill requirements according to the frequency of occurrences changed slightly; their combination, however, remained almost the same, as shown in Table 10.7 to Table 10.9.

Therefore, we conclude that the requirements for vacancies without temporary employment differ only slightly when compared to all vacancies, at least for the skill requirements mentioned most frequently. The identification of detailed differences must be subject to further examinations.

Another option to obtain a different data differentiation result is the evaluation of job ads without considering the number of vacancies. One of the disadvantages is that the location of a vacancy can only be determined if a job ad is actually published for one specific vacancy and that one place of work is known. Furthermore, the scope of labour demand would not be considered, at least as presented in BA-Jobbörse.

Nevertheless, such evaluation may be appropriate if the analyses focuses on the examination of preferences with regard to requirements by employers relating to specific characteristics of the employer. The consideration of the number of vacancies would then have no added value. We compared the results for hard skill requirements in vacancies without consideration of the number of vacancies with the results for the vacancies with consideration of the number of vacancies.

The results show that indeed the combination of the most frequently mentioned skill requirements differs in this case, and more considerably than for the above-mentioned comparison of all vacancies with vacancies without temporary employment. Hence, it depends on the research question whether this kind of data differentiation is appropriate. For this feasibility study, which

focuses on the (quantitative) relevance of skill requirements, a consideration of the number of vacancies is reasonable.

Table 10.7: The 25 most frequently mentioned hard skill requirements in MAE occupations for vacancies without temporary employment vs. all vacancies, October/November 2019

Skill	Vacancies without temporary employment			All vacancies			Differences in ranking
	Ranking	Number of occurrences	Relative frequency	Ranking	Number of occurrences	Relative frequency	
Service, repair, maintenance	1	13,318	0.23	1	27,948	0.23	0
Mechatronics	2	11,282	0.19	3	21,136	0.17	-1
Industrial mechanics	3	10,940	0.19	2	24,601	0.20	1
Mechanics	4	6,437	0.11	5	13,194	0.11	-1
Technical understanding	5	5,644	0.10	6	12,116	0.10	-1
Work according to drawings	6	5,208	0.09	4	13,377	0.11	2
Operation/putting into service	7	4,506	0.08	7	8,475	0.07	0
Development	8	3,257	0.06	15	4,421	0.04	-7
Production, manufacture	9	2,944	0.05	10	6,165	0.05	-1
Hydraulics	10	2,926	0.05	8	6,928	0.06	2
Planning	11	2,835	0.05	16	4,314	0.03	-5
Welding	12	2,708	0.05	9	6,188	0.05	3
Construction	13	2,425	0.04	20	3,780	0.03	-7
Pneumatics	14	2,370	0.04	12	5,044	0.04	2
Electrical engineering	15	2,322	0.04	21	3,459	0.03	-6
Electronics	16	2,218	0.04	17	4,046	0.03	-1
Metalworking	17	2,169	0.04	11	5,066	0.04	6
Car manufacturing, vehicle technology	18	2,146	0.04	22	2,999	0.02	-4
Loading	19	1,873	0.03	13	4,630	0.04	6
Machine control/operation, system/device operation	20	1,716	0.03	14	4,501	0.04	6
Diagnosis	21	1,669	0.03	25	2,818	0.02	-4
Metal construction	22	1,619	0.03	18	4,042	0.03	4
Analysis	23	1,584	0.03	26	2,645	0.02	-3
Quality control, quality assurance	24	1,484	0.03	19	3,896	0.03	5
Agricultural machinery mechanics	25	1,470	0.02	28	2,371	0.02	-3
Drilling	31	1,115	0.02	24	2844	0.02	7
Mechanical construction	35	894	0.02	23	2896	0.02	12
	Total number of vacancies						
	58,855 (Divergence from all vacancies: -65,285)			124,140			

Explanation: Vacancies without temporary employment for Germany and MAE occupations. MAE occupations refers to occupations in mechanical and automotive engineering (occupational main group 25 of the KldB 2010). Skills that belong to the 25 most frequently mentioned skills in one of the two variants of data sets but not to this group of the other variant are highlighted in red.

Source: Data from the BA employment website, access sample, period of time: 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

Table 10.8: The 25 most frequently mentioned hard skill requirements in ICT occupations for vacancies without temporary employment vs. all vacancies, October/November 2019

Skill	Vacancies without temporary employment			All vacancies			Differences in ranking
	Ranking	Number of occurrences	Relative frequency	Ranking	Number of occurrences	Relative frequency	
Development	1	19,766	0.31	1	24,260	0.29	0
Analysis	2	9,000	0.14	2	11,960	0.14	0
Management	3	8,961	0.14	3	11,305	0.14	0
Software implementation	4	8,715	0.14	4	10,627	0.13	0
Java programming language	5	8,534	0.13	5	10,510	0.13	0
Planning	6	7,682	0.12	6	9,890	0.12	0
SQL database	7	6,900	0.11	7	9,156	0.11	0
LINUX operating system	8	6,218	0.10	9	7,887	0.10	-1
Business information systems	9	5,777	0.09	11	6,874	0.08	-2
Architecture	10	5,592	0.09	14	6,489	0.08	-4
HTML, XML, XHTML, XAML, XSLT	11	5,509	0.09	12	6,735	0.08	-1
Configuring	12	5,335	0.08	8	7,996	0.10	4
JavaScript programming language	13	5,283	0.08	15	6,387	0.08	-2
Electrical engineering	14	5,178	0.08	13	6,587	0.08	1
System integration	15	4,793	0.08	10	7,223	0.09	5
Scrum project management and development method	16	3,572	0.06	19	4,112	0.05	-3
Monitoring	17	3,141	0.05	20	3,903	0.05	-3
Operation/putting into service	18	2,914	0.05	18	4,207	0.05	0
Active Directory service	19	2,762	0.04	17	4,396	0.05	2
First-level support	20	2,738	0.04	16	4,783	0.06	4
IM SAP module (investment management)	21	2,665	0.04	22	3,215	0.04	-1
Oracle database	22	2,612	0.04	21	3,331	0.04	1
git version management program	23	2,563	0.04	23	3,072	0.04	0
Python programming language	24	2,335	0.04	27	2,887	0.03	-3
VMware virtualisation software	25	2,323	0.04	24	3,045	0.04	1
Enterprise resource planning (ERP)	30	2,110	0.03	25	2,996	0.04	5
	Total number of vacancies						
	63,704 (Divergence from all vacancies: -19,129)			82,833			

Explanation: Vacancies without temporary employment for Germany and ICT occupations. ICT occupations refers to occupations in computer sciences, information and communication technology (occupational main group 43 of the KldB 2010 Skills that belong to the 25 most frequently mentioned skills in one of the two variants of data sets but not to the group of the other variant are highlighted in red.

Source: Data from the BA employment website, access sample, period of time: 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

Table 10.9: The 25 most frequently mentioned hard skill requirements in HES occupations for vacancies without temporary employment vs. all vacancies, October/November 2019

Skill	Vacancies without temporary employment			All vacancies			Differences in ranking
	Ranking	Number of occurrences	Relative frequency	Ranking	Number of occurrences	Relative frequency	
Nursing care	1	73,753	0.21	1	117,474	0.24	0
Treatment care	2	50,885	0.14	3	74,987	0.15	-1
Geriatric care	3	49,075	0.14	2	75,873	0.15	1
Education	4	21,693	0.06	7	24,847	0.05	-3
Preschool work, preschool education	5	21,483	0.06	9	24,454	0.05	-4
Development	6	21,153	0.06	6	25,562	0.05	0
Basic nursing	7	16,735	0.05	5	29,281	0.06	2
Nursing documentation	8	16,570	0.05	4	35,318	0.07	4
Activating care	9	16,364	0.05	12	18,296	0.04	-3
Anaesthetics	10	16,163	0.05	8	24,506	0.05	2
Social care/disability support care	11	13,814	0.04	13	17,536	0.04	-2
High-tech medicine	12	12,580	0.04	14	14,523	0.03	-2
Social education	13	11,679	0.03	15	13,292	0.03	-2
Aftercare	14	11,667	0.03	17	11,971	0.02	-3
Child and infant care	15	11,587	0.03	16	13,289	0.03	-1
Planning	16	9,830	0.03	11	20,889	0.04	5
Children (care, etc.)	17	9,181	0.03	10	21,217	0.04	7
Dialysis	18	7,327	0.02	19	7,417	0.01	-1
Gynaecology and obstetrics	19	7,238	0.02	18	7,733	0.02	1
Out-patient care	20	6,439	0.02	21	7,094	0.01	-1
Emergency medicine	21	6,348	0.02	23	6,451	0.01	-2
Taking blood samples	22	6,010	0.02	22	6,817	0.01	0
Pain therapy	23	5,894	0.02	25	6,332	0.01	-2
Nephrology	24	5,575	0.02	29	5,609	0.01	-5
Social work	25	5,339	0.02	28	5,617	0.01	-3
People with disabilities (care, etc.)	32	4,137	0.01	20	7,123	0.01	12
Supervision, management	46	2,471	0.01	24	6,333	0.01	22
	Total number of vacancies						
	354,745 (Divergence from all vacancies: -144,743)			499,488			

Explanation: Vacancies without temporary employment for Germany and HES occupations. HES occupations refers to medical occupations in health care (occupational main group 81 of the KldB 2010); non-medical occupations in health care, personal hygiene, and well-being, medical engineering (occupational main group 82); education, social and household occupations, theology (occupational main group 83). Skills that belong to the 25 most frequently mentioned skills in one of the two variants of data sets but not to the group of the other variant are highlighted in red.

Source: Data from the BA employment website, access sample, period of time: 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

Table 10.10: The 25 most frequently mentioned hard skill requirements for MAE occupations in the job ads without considering the number of vacancies vs. all vacancies, October/November 2019

Skill	All job ads			All vacancies			Differences in ranking
	Ranking	Number of occurrences	Relative frequency	Ranking	Number of occurrences	Relative frequency	
Service, repair, maintenance	1	14,951	0.22	1	27,948	0.23	0
Industrial mechanics	2	13,704	0.20	2	24,601	0.20	0
Mechatronics	3	11,973	0.18	3	21,136	0.17	0
Mechanics	4	6,800	0.10	5	13,194	0.11	-1
Technical understanding	5	6,300	0.09	6	12,116	0.10	-1
Work according to drawings	6	6,015	0.09	4	13,377	0.11	2
Operation/putting into service	7	4,776	0.07	7	8,475	0.07	0
Hydraulics	8	3,717	0.05	8	6,928	0.06	0
Development	9	3,654	0.05	15	4,421	0.04	-6
Welding	10	3,614	0.05	9	6,188	0.05	1
Production, manufacture	11	3,492	0.05	10	6,165	0.05	1
Planning	12	3,331	0.05	16	4,314	0.03	-4
Pneumatics	13	3,211	0.05	12	5,044	0.04	1
Construction	14	2,740	0.04	20	3,780	0.03	-6
Electrical engineering	15	2,591	0.04	21	3,459	0.03	-6
Electronics	16	2,541	0.04	17	4,046	0.03	-1
Metalworking	17	2,354	0.03	11	5,066	0.04	6
Car manufacturing, vehicle technology	18	2,340	0.03	22	2,999	0.02	-4
Loading	19	2,205	0.03	13	4,630	0.04	6
Machine control/operation, system/device operation	20	2,072	0.03	14	4,501	0.04	6
Metal construction	21	2,038	0.03	18	4,042	0.03	3
Quality control, quality assurance	22	1,923	0.03	19	3,896	0.03	3
Diagnosis	23	1,921	0.03	25	2,818	0.02	-2
Analysis	24	1,859	0.03	26	2,645	0.02	-2
Process engineering	25	1,604	0.02	33	1,842	0.01	-8
Mechanical construction	30	1,233	0.02	23	2,896	0.02	7
Drilling	31	1,185	0.02	24	2,844	0.02	7
	Number of job ads			Number of vacancies			
	68,129			124,140			

Explanation: Job ads for Germany and MAE occupations. MAE occupations refers to occupations in mechanical and automotive engineering (occupational main group 25 of the KldB 2010). Skills that belong to the 25 most frequently mentioned skills in one of the two variants of data sets but not to the group of the other variant are highlighted in red.

Source: Data from the BA employment website, access sample, period of time: 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

Table 10.11: The 25 most frequently mentioned hard skill requirements for ICT occupations in the job ads without considering the number of vacancies vs. all vacancies, October/November 2019

Skill	All job ads			All vacancies			Differences in ranking
	Ranking	Number of occurrences	Relative frequency	Ranking	Number of occurrences	Relative frequency	
Development	1	20,428	0.32	1	24,260	0.29	0
Analysis	2	9,027	0.14	2	11,960	0.14	0
Software implementation	3	8,549	0.13	4	10,627	0.13	-1
Management	4	8,333	0.13	3	11,305	0.14	1
Java programming language	5	8,037	0.13	5	10,510	0.13	0
Planning	6	7,522	0.12	6	9,890	0.12	0
SQL database	7	7,279	0.11	7	9,156	0.11	0
LINUX operating system	8	6,205	0.10	9	7,887	0.10	-1
Configuring	9	6,094	0.10	8	7,996	0.10	1
Electrical engineering	10	6,082	0.10	13	6,587	0.08	-3
HTML, XML, XHTML, XAML, XSLT	11	5,721	0.09	12	6,735	0.08	-1
Business information systems	12	5,568	0.09	11	6,874	0.08	1
JavaScript programming language	13	5,281	0.08	15	6,387	0.08	-2
System integration	14	5,192	0.08	10	7,223	0.09	4
Architecture	15	5,073	0.08	14	6,489	0.08	1
Operation/putting into service	16	3,446	0.05	18	4,207	0.05	-2
Scrum project management and development method	17	3,309	0.05	19	4,112	0.05	-2
First-level support	18	3,301	0.05	16	4,783	0.06	2
Active Directory service	19	3,199	0.05	17	4,396	0.05	2
Monitoring	20	2,923	0.05	20	3,903	0.05	0
Python programming language	21	2,570	0.04	27	2,887	0.03	-6
git version management program	22	2,538	0.04	23	3,072	0.04	-1
PHP programming language	23	2,478	0.04	26	2,980	0.04	-3
Computer engineering	24	2,472	0.04	30	2,641	0.03	-6
Oracle database	25	2,459	0.04	21	3,331	0.04	4
VMware virtualisation software	26	2,443	0.04	24	3,045	0.04	2
IM SAP module (investment management)	28	2,357	0.04	22	3,215	0.04	6
Enterprise resource planning (ERP)	29	2,342	0.04	25	2,996	0.04	4
	Number of job ads			Number of vacancies			
	63,709			82,833			

Explanation: Job ads for Germany and ICT occupations. ICT occupations refers to occupations in computer sciences, information and communication technology (occupational main group 43 of the KldB 2010). Skills that belong to the 25 most frequently mentioned skills in one of the two variants of data sets but not to the group of the other variant are highlighted in red.

Source: Data from the BA employment website, access sample, period of time: 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

Table 10.12: The 25 most frequently mentioned hard skill requirements for HES occupations in the job ads without considering the number of vacancies vs. all vacancies, October/November 2019

Skill	All job ads			All vacancies			Differences in ranking
	Ranking	Number of occurrences	Relative frequency	Ranking	Number of occurrences	Relative frequency	
Nursing care	1	29,227	0.18	1	117,474	0.24	0
Treatment care	2	20,737	0.13	3	74,987	0.15	-1
Geriatric care	3	19,765	0.12	2	75,873	0.15	1
Nursing documentation	4	14,839	0.09	4	35,318	0.07	0
Planning	5	9,655	0.06	11	20,889	0.04	-6
Basic nursing	6	8,380	0.05	5	29,281	0.06	1
Development	7	7,328	0.05	6	25,562	0.05	1
Children (care, etc.)	8	6,640	0.04	10	21,217	0.04	-2
Education	9	4,704	0.03	7	24,847	0.05	2
Preschool work, preschool education	10	4,412	0.03	9	24,454	0.05	1
Social care/disability support care	11	4,223	0.03	13	17,536	0.04	-2
Activating care	12	4,069	0.03	12	18,296	0.04	0
Anaesthetics	13	3,858	0.02	8	24,506	0.05	5
Supervision, management	14	3,373	0.02	24	6,333	0.01	-10
Social education	15	3,164	0.02	15	13,292	0.03	0
Therapy	16	2,638	0.02	31	5,425	0.01	-15
Quality management	17	2,604	0.02	27	5,717	0.01	-10
Hygiene	18	2,576	0.02	38	4,275	0.01	-20
Child and infant care	19	2,531	0.02	16	13,289	0.03	3
High-tech medicine	20	2,367	0.01	14	14,523	0.03	6
Taking blood samples	21	2,174	0.01	22	6,817	0.01	-1
Social work	22	1,937	0.01	28	5,617	0.01	-6
Customer consulting and service	23	1,910	0.01	26	5,848	0.01	-3
Wound treatment	24	1,732	0.01	37	4,544	0.01	-13
Patient care	25	1,727	0.01	42	3,770	0.01	-17
Aftercare	28	1,579	0.01	17	11,971	0.02	11
Gynaecology and obstetrics	36	1,215	0.01	18	7,733	0.02	18
People with disabilities (care, etc.)	39	1,111	0.01	20	7,123	0.01	19
Out-patient care	51	888	0.01	21	7,094	0.01	30
Dialysis	55	837	0.01	19	7,417	0.01	36
Pain therapy	56	836	0.01	25	6,332	0.01	31
Emergency medicine	61	797	0.00	23	6,451	0.01	38
	Number of job ads			Number of vacancies			
	63,709			82,833			

Explanation: Job ads for Germany and HES occupations. HES occupations refers to medical occupations in health care (occupational main group 81 of the KldB 2010); non-medical occupations in health care, personal hygiene, and well-being, medical engineering (occupational main group 82); education, social and household occupations, theology (occupational main group 83). Skills that belong to the 25 most frequently mentioned skills in one of the two variants of data sets but not to the group of the other variant are highlighted in red.

Source: Data from the BA employment website, access sample, period of time: 1 October 2019 to 30 November 2019. Authors' calculations. © IAB

Imprint

IAB-Forschungsbericht 7|2021

Date of publication
6 August 2021

Publisher
Institute for Employment Research
of the Federal Employment Agency
Regensburger Str. 104
90478 Nürnberg Germany

Download of this IAB-Forschungsbericht
http://doku.iab.de/forschungsbericht/2021/fb0721.pdf

All publications in the series „IAB-Forschungsbericht“ can be downloaded from
http://www.iab.de/en/publikationen/forschungsbericht.aspx

Website
www.iab.de

ISSN
2195-2655

Corresponding author
Michael Stops
Phone: +49 911 179-4591
Email: michael.stops@iab.de