Impacts of digitization on real estate sector jobs

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Abstract

Purpose – Previous research on automation and job disruption is only marginally related to the real estate industry and its characteristics. This study investigates the effects of digitization on jobs in German real estate sector, in order to assess the proportion of jobs threatened to be replaced by automation. Since Germany is the largest EU economy insights for the German real estate market allow a first approximation for Europe.

Design/methodology/approach – An extensive database of the German Federal Employment Agency containing job definitions and occupation titles is matched with real estate criteria to create a subset with the relevant real estate occupations. This data is combined with a database of the German Institute of Employment Research reflecting to what extent tasks within jobs can be automated by current technical capabilities.

Findings – For the 286 identified occupations within the real estate sector a weighted average of 47 percent substitution probability through current technological capabilities is derived for tasks within the examined occupations.

Practical implications – This contribution indicates the extent of the structural change the real estate sector has to face due to digitization: One out of two real estate jobs will have to be re-created.

Originality/value – This research quantifies the magnitude of the job killer aspect of digitization in the real estate sector.

Keywords Employment, Digitization, Automation, Structural change, Disruption, Substitution potential

Paper type Research paper

1. The challenge for jobs

When the popular media routinely run article titles like "A World Without Work" (Thompson, 2015), there is a strong indication that an issue has reached a significant level of critical mass. There is no disputing that new technologies (NT) are disrupters to labor and vocational categories, however, the levels of disruption and its impact are not agreed on. At the same time, the utilization of NT's leads to new possibilities and job areas that are being created. These jobs differ in their complexity and demands, and therefore are often better paid.

Innovation and its impact on labor is part of structural change. Pessimistic views in the last year are frequently based on insights from Frey and Osborne (2013) who quantified the impacts of NT's on labor markets in the United States. Accordingly, 47 percent of jobs are subject of being substituted by NT's until 2030. Various studies have used the results of Frey and Osborne by transferring the codes of American occupations to other countries (Bonin *et al.*, 2015; Dengler and Matthes, 2015; Brzeski and Burk, 2015), according to the International Standard Classification of Occupations (ISCO). However, these studies follow the approach that it is not entire professions that can be replaced by NT's, but rather activities leading to a significantly lower share of jobs that are being threatened to be substituted by computers. Arntz *et al.* (2017) maintain that there is evidence to support an impact of a 9 percent to 11 percent job loss in OECD countries caused by digitization. For the purpose of serving as a

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literature review to a wider study that specifically aims at the impact of NT's on real estate, the focus of the following will ask whether there is anything emergent about the current transformations and a long history of previous disruptive phases.

Wage stagnation has been an important economic force that has occurred steadily since the 1980's among Organization for Economic Co-operation and Development (OECD) nations. Stagnation means that wages are relatively flat and do not rise at the rate of inflation. Among these OECD countries, this is a reversal of economic trends that have defined most of the Twentieth Century and was accelerated in particular, during the post-World War Two period. It is a period where the most prominent factor of this trend is that each subsequent generation had more wealth and disposable income than the previous. The consequence of this stagnation is that little growth is occurring and lower relative wages means that capital is not circulating in the economy given that people simply have less disposable income to spend (Picketty, 2014). The economy has stagnated, but capital or profit has increased and this is explained through fewer workers creating more profit and also, a shift toward the financialization of the economy. At the same time, Gregory *et al.* (2016) conclude that from 2000 to 2010 there has been a steady increase in labor demand. In spite of this shift on the other hand, rising unemployment has not been an outcome through the processes of automation that have occurred so far (Arntz *et al.*, 2017). Within the context of Artificial Intelligence (AI), Machine Learning (ML) and robotics, these general factors raise a number of important variables for consideration because they make the impact of these new technologies difficult to measure.

When the data concerning wage stagnation is combined with the analysis of large sets of tax returns in the US and France over a fifty-year period (Picketty, 2014), a number of competing theories emerged as plausible explanation for this. One theory was that through the erosion of the bargaining power of labor wages have stagnated. A second major theory was that outsourcing of tasks and globalization of production are the most significant drivers of stagnation. Manufacturing and then service sector jobs have continually been moved from developed economies to emerging economies because of lower standards for regulation (Addo, 2016). After a period of stagnation being explained by theories about bargaining power shifts and globalization, a new set of evidence began to present NT's as the most important driver to this trend. However, the wider use of NT has various, mutually conflicting consequences. Variables of influence like globalization and political policies, cannot be completely separated from NT's as a factor for job loss and the de-skilling of labor which has resulted in lower wage forms of employment. Frey and Osborne (2017) assert that this creates a greater "polarization" between skilled and unskilled labor and therefore "a hollowing-out of middle-income jobs".

The following will examine the level of disruption on the real estate sector in particular. There is an important and conflicting set of assumptions and conclusions that make this difficult to determine. For reasons that will be outlined in the Literature Review, this study will take the task-based approach to automation or substitution potential defined by Dengler and Matthes, 2015, 2016 in order to determine the share of jobs in the German real estate industry that are affected by digitization. The article concludes with a discussion on the remaining tasks for human beings in the real estate industry.

2. Literature review

NT's can be understood as having a long history within the capitalist economy. The mechanization of labor can be traced to the steam powered machines that replaced hand weaving in the clothing industry in the late 1700's and early 1800's. This economic transformation to industrialization also contributed to an early reactionary backlash, which led to protests by workers in England between 1811 and 1816 when these new machines were blamed for unemployment and low wages. Consequently, the manufacturing equipment was damaged by workers (DeCanio, 2016; Frey and Osborne, 2017). Industrialization and

automation were furthered when the Ford model of production was invented and then, quickly adopted by other types of industries. Henry Ford introduced the assembly line model of production whereby individuals become specialized in only one area of manufacturing and this division of labor made production more streamlined and created greater output. The automation of tasks and the deskilling of labor are not new. Like-wise, neither is the criticism of automation that has historically been based on the loss of employment and the de-skilling of existing work tasks. However, the counterweight to this trend has been the economic gains that have emerged as a result. Various areas of employment have been created by the technological change that has led to an expansion of entire sectors such as electronics and computer related fields. For example, Bessen (2016) presented a comprehensive data set of 317 types of jobs that were being replaced by automated technologies driven by computerization and demonstrated that newly created types of employment far exceeded the losses caused by automation. Based on the structure of industrialization within a historical context, DeCanio (2016) presents a data analysis of tasks and substitution potential, and concludes that wage levels will decrease, and that although NT's create new opportunities in fields like engineering, the overall outcome will be the de-skilling of labor.

There are a number of criticisms to this historically driven approach to job market changes. An important criticism of is related to market capitalization and value creation. West (2018) looks at the relationship between market capitalization and employment and compares data taken from 1962 to 2017. In 1962 the two largest companies in terms of market value were AT&T with a value of USD$ 20B (2017) with 564,000 employees and General Motors with a USD$ 12B (2017) value and 605,000. In 2017, Apple had a market capital share of USD$ 800B with 116,000 employees and Google/Alphabet had USD$ 670B and 73,992 workers. In other terms, Apple generated forty times the wealth as AT&T with a fifth of the full-time employees (West, 2018). As a good example of this wealth generation process achieved by few, two individuals developed Android with less than $ 10,000 and then sold this in less than a year to Google for a $ 1B and at the point of sale they employed 50 individuals (Madridakis, 2017). While some maintain that more jobs have been created by the overall computerization (Bessen, 2016), there are important features in current technologies that have to be considered for future projections. Although in the past there was a link between employment growth and innovation, in the future other factors specific to new technologies might generate value without employment growth.

AI can be seen as an example of different value creation in the context of social media and the platform economy. In 2017, Facebook had a market value of USD$ 441B with 18,770 employees (West, 2018). The Facebook revenue was generated through the use of clients' data for the purposes of generating advertising, marketing and market research, and the means for this was the AI employed in data mining/collection and data-analytics. Plat-form models are achieving the same by having algorithms and not humans connect customers with service providers and then, collecting a fee through this human-less transaction. Facebook's market value to employee ratio is significantly greater than either Apple or Google.

Within the real estate industry, the platform economy and the use algorithms is likewise growing. Conway (2018) identifies nine major industry areas where 71 software applications and web-based platforms are emerging that replace human tasks and occupations. A number of these real estate areas include data analytics and platform applications that connect buyers and sellers, borrowers and lenders, customers and legal documents, customers and valuations. These areas are data driven AI applications, thus algorithms rather than people generate value.

Other areas are using more NT's and change the tasks performed by the human employees. The fastest growing area is buildings and operations management where remote security systems, smart home technologies and robotics used in cleaning and maintenance are already having a significant impact. Further, new possibilities emerge through 3D

technologies employed in viewing properties and through 3D printing. Thus an image can be quickly generated into an entire model of a building or a neighborhood area. Companies-like Doxel, OpenSpace, and Airworks specialize in digital photo-capturing buildings and construction sites by having cameras that are fixed, mounted on robots, on drones and construction worker hats (Conway, 2018). Conway identifies how NT's including AI, machine learning and big data create opportunities in the real estate sector because of their positive results in data-gathering, distribution, and analytics, automated valuation models, risk assessment, communications, and business processes. Furthermore, that are additional emergent areas such as Augmentation and Space Planning, Geospatial Analytics, and the internet of Things (IoT). Augmentation and Space Planning is the use of video capturing to create accurate 3D-ready spatial/building information. Geospatial Analytics includes how this data is processed into 3D-models, drawings, or animated formats. Conway (2018) defines this emerging real estate processes in the following terms: "Geospatial analysis is the gathering, display, and manipulation of imagery, GPS, satellite photography and historical data, described explicitly in terms of geographic coordinates or implicitly, in terms of a street address, postal code, or forest stand identifier as they are applied to geographic models" (Conway, 2018, p. 47).

Deloitte (2018) shows that the real estate service of the future must move away from the pure operational management of the buildings to a holistic approach that ensures that the customers are able to function.

Where some tasks such as a telephone dispatcher who would have conventionally connected a taxi driver with a customer have been replaced by the AI contained in phone apps, other tasks such as building maintenance, construction, and manufacturing will continue to require human participation. All of these areas are significant to the real estate business in particular. These discrepancies in drivers of automation versus job growth, significantly impact the theories that underpin future predictions in employment (Arntz, 2017; DeCanio, 2016). By contrast, the literature as a whole identifies variables such as hand precision and human to human contact as areas that will continue to be decisive for human employment. These tasks cover front line health care and surgery, hair cutting, cultural production and the arts. Furthermore, areas with soft skills like creative and social intelligence will be the types of non-routine tasks that cannot be replaced (Frey and Osborne, 2017).

There are a number of considerations regarding automation and gender. Dengler and Matthes (2015) demonstrate that male dominated vocations will be significantly more impacted than conventionally female jobs; however, it does not follow that the demand will increase for women because of this shift given that gender roles have determined both career choices, but also the social value placed on certain areas of work. A study of Pricewaterhouse Coopers LLP (PricewaterhouseCoopers LLP, 2017) reveals similar findings, stating that female workers could be more affected by automation in the short term, but male jobs are more at risk of being automated in the long term. Males have dominated areas like manufacturing and facility related production occupations, and these are among the highest in terms of substitution potential (Dengler and Matthes, 2015). There is a limitation of looking at the change in supply and demand terms, given that there are considerations about how value is determined, and where women's work has been subject to the devaluing caused by patriarchy. This raises the important issue about how a job is evaluated and how consistent the automation design systems are when they are broken down into specific tasks (Arntz *et al.*, 2016).

In the existing literature, there is a wide range of the effects of NT on employment numbers. At the high end of the predicted numbers are studies like Bowles (2014) who predict a loss of 60 percent of jobs due to NT and the Frey and Osborne study (Frey and Osborne, 2013, 2017), cited over 3,500 times, that predicts that by 2030 47 percent of analyzed 730

occupations will disappear through automation. By contrast, on the low end of the scale, Arntz *et al.* (2017) take a different approach by measuring automated tasks against full occupations, predict that only 9 percent to 11 percent of all jobs in OECD countries will be lost. To demonstrate the importance of tasks as opposed to isolating the automation of whole occupations, Arntz *et al.* (2017) use the data for the Frey and Osborne (2013) study that concluded that 47 percent of all jobs will be lost and reduced it to 9 percent by isolating the tasks within the jobs rather than the jobs themselves. The occupations defined by the substitution potential based on five tasks that include: manual non-routine tasks, interactive non-routine tasks, manual routine tasks, cognitive routine tasks and analytical non-routine task (Dengler and Matthes, 2015). Another international comparison is carried out by Nedelkoska and Quintini (2018). According to this, 14 percent of all jobs in OECD countries can be highly automated. For all 32 OECD countries analyzed in the study, this means 66 million jobs. Looking at the automation potential from 50 to 70 percent, it is even 32 percent of all jobs. This shows that structural changes are to be expected in large areas of the world of work as a result of digitization.

A study of the McKinsey Global Institute (McKinsey Global Institute, 2017) emphasizes on the job creation aspect of digitization. While NT's do replace jobs, they are creating new work possibilities. Accordingly, one-third of the newly emerged jobs of the past 25 years in the United States are directly linked to NT's, i.e. IT management and app creation. The study further underlines the importance of NT's on economies and their productivity.

The literature review presented has emphasized that the cross relational data and structural elements that has be used to describe the general trends within employment and automation can be applied to the real estate industry. What is unique to real estate, are the sub specialty areas like an emerging online and platform-based services that are already disrupting the real estate business as it has been conventionally run.

3. Methodology and results

Previous research has shown that it is not entire professions that can be automated, but rather tasks within occupations. In the following, the substitutability potential of occupations within the real estate industry in Germany is examined. The substitutability potential of an occupation is defined via the proportion of routine activities, which are likely to be automated by current technological capabilities (Dengler and Matthes, 2015).

When assessing the level of substitutability potential, the categorization suggested by Frey and Osborne (2013) is used: A low substitutability potential exists if a maximum of 30 percent of activities within an occupation can be performed by computers. An average substitutability potential means that between 30 percent and a maximum of 70 percent of activities are automatable. A high substitutability potential means that more than 70 percent of activities could be replaced by digitization.

The methodology applied in this contribution is set out in Figure 1.

In contrast to the previous studies on the impacts of automation on jobs, the substitution probabilities are not determined on the basis of American occupation data, but rather information on occupational research from the expert database BERUFENET (Bundesagentur für Arbeit, 2019), which provides information on all occupations known in Germany online and free of charge. The BERUFENET is used for job placement and information and contains approximately 3,900 occupations. The information provided includes information on the respective professional activities, necessary training or legal regulations.

Dengler and Matthes (2015) originally determined the task composition for each occupation on the basis of this database. For this purpose, the authors created a requirements matrix, in which approximately 8,000 requirements are assigned to the respective occupations. When deciding whether a work requirement should be understood as a routine or non-routine activity, it was explicitly researched whether the respective activity could be carried out by

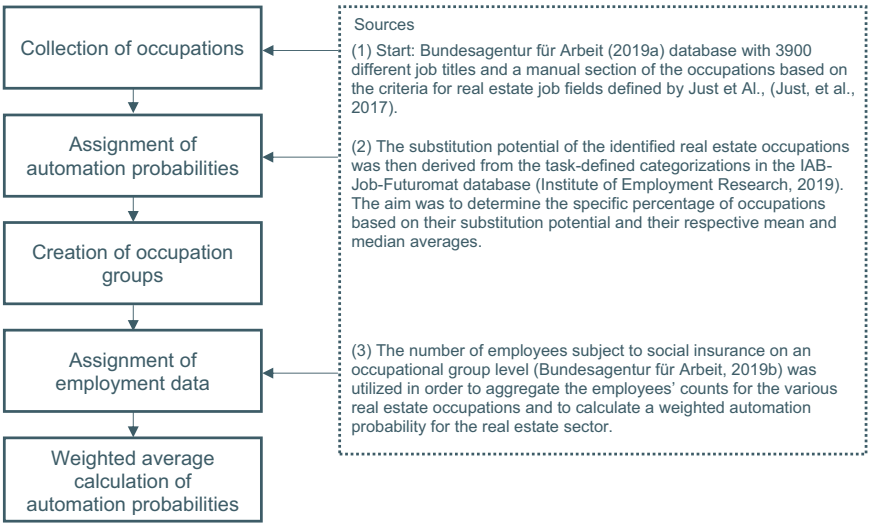

Figure 1.
Methodology for the calculations of the automation probabilities

Source(s): Own representation

computer-controlled machines. Replicability by computers or computer-controlled machines was therefore a central criterion in deciding whether a requirement was categorized as a routine or non-routine activity. Therefore, the proportion of routine activities represent as a measure of the substitutability of these professions. Dengler and Matthes (2015) utilized the requirements matrix and calculated the proportion of routine activities (vs. non-routine activities) by dividing the core requirements in each individual occupation. These shares at individual occupational level are aggregated for the various occupational aggregates with a weight calculated on the basis of the number of employees in 2016.

The requirements matrix is not publicly accessible, however, Dengler and Matthes created the database IAB-Job-Futuromat (Institute of Employment Research, 2019) for the public in order to access the calculated automation probabilities for each occupation. The IAB-Job-Futuromat is a database that contains the occupation-specific substitution potentials along with job specific individual substitution potentials. Furthermore, the IAB-Job-Futuromat provides the substitution potentials for each of the 286 occupations taken from the second data set used in this study. The second data set is the BERUFENET database (Bundesagentur für Arbeit, 2019) which provides occupational titles from which 286 real estate sector occupation titles have been manually collected. These real estate titles have been categorized according to the classification of real estate industry job fields provided by Just *et al.* (2017). It is important to note that real estate can be either defined in a narrow sense or in a broad sense. The real estate sector within a narrow sense consists of the areas 1) real estate trade, 2) renting and leasing and 3) mediation and administration. However, far more activities are frequently also seen as been an essential part of the real estate sector. Consequently, Just *et al.* (2017) add additional areas to the real estate sector in a broad sense: 4) architectural/engineering offices, 5) construction industry (building construction/civil engineering), 6) real estate financers, 7) investment companies, 8) industrial cleaning and 9) other service providers. Some people argue that the planning of building should be seen as an integral aspect of real estate and thus, Architectural/engineering offices should be part of the real estate sector in a narrow sense. Other people might see the construction industry (building construction/civil engineering) as a core aspect of real estate, since the building of

the properties is the most decisive aspect of the changing urban landscape. The decisive aspects of development and equity investment for the real estate sector are covered through the category investment companies. Consequently, we use the broad sense of the real estate sector for the categorization of real estate industry job fields to be able to examine the impacts of digitization on real estate sector jobs.

In the next step the IAB-Job-Futuromat database (Institute of Employment Research, 2019) was used to assign a substitutability probability to each occupation title (KldB 2010 5-digit level). Based on the approach by Dengler and Matthes (2015) each substitutability potential was mapped to the respective occupation title. For example, the job-profile of a facility manager contains the following essential activities. Therefore, the substitution probability of a facility manager is 60 percent (Table I).

These substitution probabilities at individual occupational level are aggregated for the various occupational groups with a weight calculated on the basis of the number of employees in 2018.

This requires a weighted average calculation of the substitutability potential and the respective employee count subject to social insurance. However, the employee count data is only available at occupational group level. In order to map the broadest possible occupational spectrum on the one hand, but on the other remain clear to a certain extent, the employee counts within an occupational group is assumed to be equally distributed following the approach by Dengler and Matthes (2015), which enables to calculate a weight based on the average substitutability of occupation titles within an occupational group and the employee count of the occupational group. Based on this approach the 286 occupation titles within 164 occupational groups have been aggregated covering a total of 5,231,766 employees subject to social insurance within the real estate industry (as set out in Table II). For these 5,231,766 employees within the real estate industry the weighted substitutability potential comes to 47.41 percent. This means that almost a half of all jobs in the real estate sector tasks can be automated by current technical capabilities.

A further insight can be gained by looking at the consolidated automation potential (Table III).

In analogy to Dengler and Matthes (2018), the automation potentials are classified as high (> 70 percent), medium (50 percent to 70 percent) and low (< 30 percent). This categorization that almost 36 percent of all jobs within the real estate sector have a high automation potential. Approximately 15 percent of the occupations have a medium automation potential. Overall, the analysis shows that approximately half of all the jobs within the real estate industry have an automation potential that exceeds 50 percent.

	Activity	Can be performed by computers, robots or artificial intelligence
1	Maintenance management	✗
2	Building system technology, building control technology	✓
3	Building services	✗
4	Invitation to tender, award of contract, description of services	✓
5	Facility management (coordination)	✗
6	Real estate business management	✗
7	Property management	✓
8	Cost and activity accounting	✓
9	Calculation	✓
10	Apply Facility Management Software (CAFM)	✓

Source(s): (Institute of Employment Research, 2019), Dengler and Matthes (2015), own representation

Table I.
Example job profile and substitution potential for the occupation facility manager

	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
1	Skilled workers in commercial and technical business administration (without specialisation)	Aufsichtskräfte im Aus- und Trockenbau, Isolierung, Zimmerei, Glaserei, Rollladen- und Jalousiebau	936,387	44.00%
2	Specialists in building services engineering (without specialisation)	Fachkräfte in der Gebäudetechnik (ohne Spezialisierung)	233,272	66.00%
3	Specialists in construction electrics	Fachkräfte in der Bauelektrik	224,334	75.00%
4	Specialists in metal construction	Fachkräfte im Metallbau	216,635	85.00%
5	Specialists in sanitary, heating and air-conditioning technology	Fachkräfte in der Sanitär-, Heizungs- und Klimatechnik	171,535	70.00%
6	Specialists in woodworking, furniture and interior design	Fachkräfte im Holz-, Möbel- und Innenausbau	142,619	55.75%
7	Specialists in information and telecommunications technology	Fachkräfte in der Informations- und Telekommunikationstechnik	141,812	94.33%
8	Specialists in electrical operating technology	Fachkräfte in der elektrischen Betriebstechnik	116,174	70.00%
9	Specialists for painting and varnishing work	Fachkräfte für Maler- und Lackiererarbeiten	113,616	30.25%
10	Technical draughtsmen and women	Technische Zeichner/innen	111,285	78.25%

Source(s): Appendix Table A1

Table II.
Automation Probability of the ten largest occupation groups

	Number of jobs	Percentage of all jobs
Probability of Automation of over 70%	1,883,724	36.01%
Probability of Automation between 50 and 70%	783,423	14.97%
Sum: Probability of Automation of over 50%	*2,667,147*	*50.98%*

Source(s): Bundesagentur für Arbeit (Bundesagentur für Arbeit, 2019a), Bundesagentur für Arbeit (Bundesagentur für Arbeit, 2019b), Institute of Employment Research (Institute of Employment Research, 2019); own calculations

Table III.
Summarized automation probabilities of jobs in the real estate sector

4. Conclusion

The digital transformation of the real estate sector is lagging behind other sectors. However, the real estate industry is facing seismic change. The adaption of technologies such as data analytics, artificial intelligence, machine learning and robotics are transforming operations. Highly administrative, humanly performed tasks are becoming increasingly redundant. Although the disruption is significant, the industry has a number of limitations that make the complete automation of this sector difficult or impossible to completely make. By contrast, there are notable intersections of negative trends that are also a consideration and that is the deskilling of labor and the greater polarization between highly skilled or professional credentials and employment that can be achieved by anyone. When work can be done by the lowest common denominator, the over abundant supply means that the wages can remain

low. The problem with low wages is two-fold in terms of stagnation, and it means that lower incomes mean that less money is circulating in the economy, and that has a secondary effect of reducing any capacity for reinvestment and then growth. The circular effect on real estate and the economy in general, is punctuated by a smaller pool of consumers for property and a lower overall price as well. The deskilling and polarizing of labor along with the economic stagnation that this causes, is countered by the benefits such as the creation of new industries and work opportunities. Further, there are a number of factors that will contribute to a lag for adopting NT's and the driverless car is a good example where the existing technology is available, but the legislative framework and social acceptance of lags behind. These social and political considerations are significant to the growth of automation and at the same time, they are difficult to predict and therefore create limitations on any model that assesses the risk to employment. Both the obstacles to a quick transformation and job creations thanks to the new possibilities of NT's highlight the necessary aspects that also have to be considered in the interpretation of the 47 percent figure of disappear jobs within the real estate industry. Further, an occupational approach that looks at macroeconomic trends along with standard data collected from current employment data can only represent a snap-shot of a static scenario analysis. This contribution has emphasized that a task-based approach demonstrates how high the percentage is of jobs affected: Almost every second job within the real estate industry. However, also in the real estate industry new jobs will be generated thanks due to NT. For example, in data analytics and photo capturing technologies, there has been a significant amount of benefits and growth for the real estate industry (Conway, 2018).

This contribution has focused on the derivation of an approximation for the magnitude of the job killer aspect of digitization. As set out, digitization has also the job motor aspect and many new jobs will arise thanks to digitization. Structural change can be painful for the affected industries, especially if the size of the change required is considerable. Consequently, the real estate industry should be aware of significant shifts and adjustment pains within the sector due to digitization.

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Appendix

	Occupation title (English name)	Occupation title (German name)	Automation probability per occupation title (in %)	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
1	Technical manager–roof, wall and sealing technology	Fachleiter/in - Dach-, Wand- und Abdichtungstechnik	30.00%	Supervisors in dry and dry construction, insulation, carpentry, glazing, roller shutter and blind construction	Aufsichtskräfte im Aus- und Trockenbau, Isolierung, Zimmerei, Glaserei, Rollladen- und Jalousiebau	8,066	28.43%
2	Master glazier	Glasermeister/in	50.00%	Supervisors in dry and dry construction, insulation, carpentry, glazing, roller shutter and blind construction	Aufsichtskräfte im Aus- und Trockenbau, Isolierung, Zimmerei, Glaserei, Rollladen- und Jalousiebau	8,066	28.43%
3	Industriemeister/in–Acoustic and dry construction	Industriemeister/in - Akustik- und Trockenbau	20.00%	Supervisors in dry and dry construction, insulation, carpentry, glazing, roller shutter and blind construction	Aufsichtskräfte im Aus- und Trockenbau, Isolierung, Zimmerei, Glaserei, Rollladen- und Jalousiebau	8,066	28.43%
4	Industrial foreman–Insulation	Industriemeister/in–Isolierung	20.00%	Supervisors in dry and dry construction, insulation, carpentry, glazing, roller shutter and blind construction	Aufsichtskräfte im Aus- und Trockenbau, Isolierung, Zimmerei, Glaserei, Rollladen- und Jalousiebau	8,066	28.43%
5	Master roller shutter and sun protection technician	Rollladen- und Sonnenschutztechnikermeister/in	45.00%	Supervisors in dry and dry construction, insulation, carpentry, glazing, roller shutter and blind construction	Aufsichtskräfte im Aus- und Trockenbau, Isolierung, Zimmerei, Glaserei, Rollladen- und Jalousiebau	8,066	28.43%
6	Master of heat, cold and sound insulation	Wärme-, Kälte- und Schallschutzisolierermeister/in	17.00%	Supervisors in dry and dry construction, insulation, carpentry, glazing, roller shutter and blind construction	Aufsichtskräfte im Aus- und Trockenbau, Isolierung, Zimmerei, Glaserei, Rollladen- und Jalousiebau	8,066	28.43%

(*continued*)

Table AI. Automation Probability per Occupation Group 164 occupation groups have been collected which consisted of 286 occupation titles. The mean value of the automation probability of an occupation group has been derived from the automation probabilities of the occupation titles it contains

Table AI.

	Occupation title (English name)	Occupation title (German name)	Automation probability per occupation title (in %)	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
7	Work foreman–Finishing	Werkpolier/in–Ausbau	17.00%	Supervisors in dry and dry construction, insulation, carpentry, glazing, roller shutter and blind construction	Aufsichtskräfte im Aus- und Trockenbau, Isolierung, Zimmerei, Glaserei, Rollladen- und Jalousiebau	8,066	28.43%
8	Master roofer	Dachdeckermeister/in	25.00%	Supervisors in building construction	Aufsichtskräfte im Hochbau	23,343	20.83%
9	Scaffolding foreman leader	Gerüstbau-Kolonnenführer/in	17.00%	Supervisors in building construction	Aufsichtskräfte im Hochbau	23,343	20.83%
10	Master scaffolder	Gerüstbauermeister/in	29.00%	Supervisors in building construction	Aufsichtskräfte im Hochbau	23,343	20.83%
11	Master bricklayer and concrete builder	Maurer- und Betonbauermeister/in	14.00%	Supervisors in building construction	Aufsichtskräfte im Hochbau	23,343	20.83%
12	Foreman–Building construction	Polier/in–Hochbau	18.00%	Supervisors in building construction	Aufsichtskräfte im Hochbau	23,343	20.83%
13	Plant foreman–Building construction	Werkpolier/in–Hochbau	22.00%	Supervisors in building construction	Aufsichtskräfte im Hochbau	23,343	20.83%
14	Master model maker	Modellbauermeister/in	69.00%	Supervisors in technical drawing, construction and model making	Aufsichtskräfte im Technischen Zeichnen, Konstruktion und Modellbau	2,849	69.00%
15	Polisher–Civil engineering	Polier/in–Tiefbau	17.00%	Supervisors in civil engineering	Aufsichtskräfte im Tiefbau	8,817	18.00%
16	Master road builder	Straßenbauermeister/in	15.00%	Supervisors in civil engineering	Aufsichtskräfte im Tiefbau	8,817	18.00%
17	Master hydraulic engineer	Wasserbaumeister/in	18.00%	Supervisors in civil engineering	Aufsichtskräfte im Tiefbau	8,817	18.00%
18	Plant foreman–civil engineering	Werkpolier/in–Tiefbau	22.00%	Supervisors in civil engineering	Aufsichtskräfte im Tiefbau	8,817	18.00%
19	Construction machinery foreman	Baumaschinenmeister/in	44.00%	Supervisors in construction and transport equipment management	Aufsichtskräfte in der Bau- und Transportgeräteführung	2,374	44.00%

(*continued*)

Table AI.

	Occupation title (English name)	Occupation title (German name)	Automation probability per occupation title (in %)	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
20	Master screed layer	Estrichlegermeister/in	29.00%	Supervisors in floor laying	Aufsichtskräfte in der Bodenverlegung	875	33.00%
21	Master tiler, tiler and mosaic layer	Fliesen-, Platten- und Mosaiklegermeister/in	30.00%	Supervisors in floor laying	Aufsichtskräfte in der Bodenverlegung	875	33.00%
22	Master parquet layer	Parkettlegermeister/in	40.00%	Supervisors in floor laying	Aufsichtskräfte in der Bodenverlegung	875	33.00%
23	Master electrical engineer	Elektrotechnikermeister/in	64.00%	Supervisors in electrical engineering	Aufsichtskräfte in der Elektrotechnik	15,733	73.67%
24	Industrial foreman–Electrical engineering	Industriemeister/in–Elektrotechnik	80.00%	Supervisors in electrical engineering	Aufsichtskräfte in der Elektrotechnik	15,733	73.67%
25	Master Information Technician	Informationstechnikermeister/in	77.00%	Supervisors in electrical engineering	Aufsichtskräfte in der Elektrotechnik	15,733	73.67%
26	Industrial foreman–Lacquer	Industriemeister/in–Lack	82.00%	Supervisors in paint and varnish technology	Aufsichtskräfte in der Farb- und Lacktechnik	1,288	82.00%
27	Industrial foreman–Glass	Industriemeister/in–Glas	78.00%	Supervisors in industrial glass production and processing	Aufsichtskräfte in der Industriellen Glasherstellung und -verarbeitung	310	78.00%
28	Industrial foreman–Ceramics	Industriemeister/in–Keramik	85.00%	Supervisors in industrial ceramics production and processing	Aufsichtskräfte in der Industriellen Keramikherstellung und -verarbeitung	251	85.00%
29	Master ceramist	Keramikermeister/in	64.00%	Supervisors in the arts and crafts of ceramics and glass design	Aufsichtskräfte in der kunsthandwerklichen Keramik- und Glasgestaltung	127	64.00%
30	Industrial foreman–Plastics and rubber	Industriemeister/in–Kunststoff und Kautschuk	77.00%	Supervisors in plastics and rubber production and processing	Aufsichtskräfte in der Kunststoff-, Kautschukherstellung und -verarbeitung	1,972	77.00%
31	Welding foreman	Schweißwerkmeister/in	75.00%	Supervisors in metal construction and welding technology	Aufsichtskräfte in der Metallbau- und Schweißtechnik	9,441	75.00%

(*continued*)

Table AI.

	Occupation title (English name)	Occupation title (German name)	Automation probability per occupation title (in %)	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
32	Master of concrete block and terrazzo manufacturer	Betonstein- und Terrazzoherstellermeister/in	44.00%	Supervisors in natural stone and mineral processing and processing as well as building material production	Aufsichtskräfte in der Naturstein-, Mineralaufbereitung und -verarbeitung sowie Baustoffherstellung	1,344	59.50%
33	Master of concrete block and terrazzo manufacturer	Betonstein- und Terrazzoherstellermeister/in	44.00%	Supervisors in natural stone and mineral processing and processing as well as building material production	Aufsichtskräfte in der Naturstein-, Mineralaufbereitung und -verarbeitung sowie Baustoffherstellung	1,344	59.50%
34	Industrial foreman–concrete block industry	Industriemeister/in–Betonsteinindustrie	50.00%	Supervisors in natural stone and mineral processing and processing as well as building material production	Aufsichtskräfte in der Naturstein-, Mineralaufbereitung und -verarbeitung sowie Baustoffherstellung	1,344	59.50%
35	Industrial foreman–lime/cement	Industriemeister/in–Kalk/Zement	100.00%	Supervisors in natural stone and mineral processing and processing as well as building material production	Aufsichtskräfte in der Naturstein-, Mineralaufbereitung und -verarbeitung sowie Baustoffherstellung	1,344	59.50%
36	Waste water master	Abwassermeister/in	50.00%	Supervisors in supply and disposal	Aufsichtskräfte in der Ver- und Entsorgung	5,832	52.40%
37	Master tank and apparatus builder	Behälter- und Apparatebauermeister/in	63.00%	Supervisors in supply and disposal	Aufsichtskräfte in der Ver- und Entsorgung	5,832	52.40%
38	Master craftsman–recycling and waste management and urban cleaning	Meister/in - Kreislauf- u.Abfallwirtschaft u.Städtereinigung	22.00%	Supervisors in supply and disposal	Aufsichtskräfte in der Ver- und Entsorgung	5,832	52.40%

(*continued*)

Table AI.

	Occupation title (English name)	Occupation title (German name)	Automation probability per occupation title (in %)	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
39	Master craftsman–Pipe, sewer and industrial service	Meister/in - Rohr-, Kanal- und Industrieservice	63.00%	Supervisors in supply and disposal	Aufsichtskräfte in der Ver- und Entsorgung	5,832	52.40%
40	Water master	Wassermeister/in	64.00%	Supervisors in supply and disposal	Aufsichtskräfte in der Ver- und Entsorgung	5,832	52.40%
41	Domestic operations manager	Hauswirtschaftliche/r Betriebsleiter/in	50.00%	Supervisors in home economics and consumer consulting	Aufsichtskräfte in Hauswirtschaft und Verbraucherberatung	11,433	58.50%
42	Master craftsman–housekeeping	Meister/in–Hauswirtschaft	67.00%	Supervisors in home economics and consumer consulting	Aufsichtskräfte in Hauswirtschaft und Verbraucherberatung	11,433	58.50%
43	Master interior decorator	Raumausstattermeister/in	31.00%	Supervisors in interior design, visual marketing, interior design	Aufsichtskräfte in Innenarchitektur, visuelles Marketing, Raumausstattung	703	31.00%
44	Master installer and heating engineer	Installateur- und Heizungsbauermeister/in	62.00%	Supervisors in plumbing, sanitary, heating and air-conditioning technology	Aufsichtskräfte in Klempnerei, Sanitär-, Heizungs- und Klimatechnik	10,843	48.50%
45	Master refrigeration system builder	Kälteanlagenbauermeister/in	54.00%	Supervisors in plumbing, sanitary, heating and air-conditioning technology	Aufsichtskräfte in Klempnerei, Sanitär-, Heizungs- und Klimatechnik	10,843	48.50%
46	Master plumber	Klempnermeister/in	56.00%	Supervisors in plumbing, sanitary, heating and air-conditioning technology	Aufsichtskräfte in Klempnerei, Sanitär-, Heizungs- und Klimatechnik	10,843	48.50%
47	Master builder of kilns and air heaters	Ofen- und Luftheizungsbauermeister/in	22.00%	Supervisors in plumbing, sanitary, heating and air-conditioning technology	Aufsichtskräfte in Klempnerei, Sanitär-, Heizungs- und Klimatechnik	10,843	48.50%
48	Master painter and varnisher	Maler- und Lackierermeister/in	36.00%	Supervisors in painting, varnishing, stucco work, building waterproofing, wood and building protection	Aufsichtskräfte in Malerei, Lackiererei, Stuckateurarbeiten, Bauwerksabdichtung, Holz- und Bautenschutz	6,487	32.50%

(*continued*)

Table AI.

	Occupation title (English name)	Occupation title (German name)	Automation probability per occupation title (in %)	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
49	Master craftsman–Timber and building protection trade	Meister/in - Holz- und Bautenschutzgewerbe	29.00%	Supervisors in painting, varnishing, stucco work, building waterproofing, wood and building protection	Aufsichtskräfte in Malerei, Lackiererei, Stuckateurarbeiten, Bauwerksabdichtung, Holz- und Bautenschutz	6,487	32.50%
50	Master craftsman–Protection and safety	Meister/in–Schutz und Sicherheit	0.00%	Supervisors in object, personal and fire protection, work safety	Aufsichtskräfte in Objekt-, Personen-, Brandschutz, Arbeitssicherheit	6,487	0.00%
51	Engineer–Horticulture	Ingenieur/in–Gartenbau	35.00%	Experts in horticulture (without specialization)	Experten im Gartenbau (ohne Spezialisierung)	1,692	35.00%
52	Business economist (university) - Bank und Finanzdienstl	Betriebswirt/in (Hochschule) - Bank und Finanzdienstl	39.00%	Experts in investment consulting and other financial services	Experten in Anlageberatung und sonstigen Finanzdienstleistungen	15,595	39.00%
53	Engineer–safety engineering	Ingenieur/in–Sicherheitstechnik	11.00%	Experts in occupational safety and safety technology	Experten in Arbeitssicherheit und Sicherheitstechnik	20,172	11.00%
54	Engineer–Waste Management	Ingenieur/in–Abfallwirtschaft	20.00%	Experts in waste management	Experten in der Abfallwirtschaft	896	20.00%
55	Architect	Architekt/in	21.00%	Experts in architecture	Experten in der Architektur	69,594	21.00%
56	Business economist (university) - Construction industry	Betriebswirt/in (Hochschule) - Bauwirtschaft	29.00%	Experts in construction accounting and costing	Experten in der Bauabrechnung und -kalkulation	333	29.00%
57	Civil servant–Higher civil engineering service	Beamt(er/in) - Höherer bautechnischer Dienst	17.00%	Experts in construction planning and supervision (without specialisation)	Experten in der Bauplanung und -überwachung (ohne Spezialisierung)	54,432	15.50%
58	Engineer–Construction	Ingenieur/in–Bau	14.00%	Experts in construction planning and supervision (without specialisation)	Experten in der Bauplanung und -überwachung (ohne Spezialisierung)	54,432	15.50%
59	Engineer–Building Physics	Ingenieur/in–Bauphysik	40.00%	Experts in construction expertise and construction control	Experten in der Bausachverständigung und Baukontrolle	1,194	40.00%

(*continued*)

Table AI.

	Occupation title (English name)	Occupation title (German name)	Automation probability per occupation title (in %)	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
60	Engineer–building materials	Ingenieur/in–Baustoffe	50.00%	Experts in building material testing	Experten in der Baustoffprüfung	154	50.00%
61	Engineer–Building Technology/Facility Management	Ingenieur/in–Gebäudetechnik/ Facility-Management	55.00%	Experts in building services engineering (without specialisation)	Experten in der Gebäudetechnik (ohne Spezialisierung)	2,999	55.00%
62	Engineer–Geotechnics	Ingenieur/in–Geotechnik	40.00%	Experts in geotechnics	Experten in der Geotechnik	942	40.00%
63	Engineer–Wood Technology	Ingenieur/in–Holztechnik	50.00%	Experts in woodworking and wood processing (without specialisation)	Experten in der Holzbe- und -verarbeitung (ohne Spezialisierung)	762	50.00%
64	Business economist (university) - Real estate	Betriebswirt/in (Hochschule) - Immobilien	32.00%	Experts in real estate marketing and management	Experten in der Immobilienvermarktung und -verwaltung	1,478	32.00%
65	Engineer–Information and communication technology	Ingenieur/in - Informations-, Kommunikationstechnik	50.00%	Experts in information and telecommunications technology	Experten in der Informations- und Telekommunikationstechnik	13,674	50.00%
66	Interior designer	Innenarchitekt/in	40.00%	Experts in interior design	Experten in der Innenarchitektur	5,022	40.00%
67	Design engineer (m/f)	Konstruktionsingenieur/in	38.00%	Experts in design and equipment construction	Experten in der Konstruktion und im Gerätebau	14,052	38.00%
68	Urban and regional planner	Stadt- und Regionalplaner/in	0.00%	Experts in urban and spatial planning	Experten in der Stadt- und Raumplanung	5,714	0.00%
69	IT engineer	Ingenieurinformatiker/in	17.00%	Experts in technical computer science	Experten in der technischen Informatik	3,622	17.00%
70	Civil servant–Surveying (high technical service)	Beamt(er/in) - Vermessungswesen (höh. techn. Dienst)	88.00%	Experts in surveying technology	Experten in der Vermessungstechnik	7,314	77.00%
71	Civil servant–Surveying (high technical service)	Beamt(er/in) - Vermessungswesen (höh. techn. Dienst)	88.00%	Experts in surveying technology	Experten in der Vermessungstechnik	7,314	77.00%
72	Surveying engineer	Vermessungsingenieur/in	55.00%	Experts in surveying technology	Experten in der Vermessungstechnik	7,314	77.00%
73	Engineer–Water Management	Ingenieur/in–Wasserwirtschaft	0.00%	Experts in water management	Experten in der Wasserwirtschaft	1,730	0.00%

(*continued*)

Table A1.

	Occupation title (English name)	Occupation title (German name)	Automation probability per occupation title (in %)	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
74	Engineer–Glass, Ceramics, Binders	Ingenieur/in–Glas, Keramik, Bindemittel	70.00%	Experts in materials technology	Experten in der Werkstofftechnik	3,000	70.00%
75	Security manager	Sicherheitsmanager/in	10.00%	Experts in object, personal, fire protection, occupational safety (other specific activity information)	Experten in Objekt-, Personen-, Brandschutz, Arbeitssicherheit (sonstige spezifische Tätigkeitsangabe)	o.A	10.00%
76	Building and object coater	Bauten- und Objektbeschichter/in	38.00%	Specialists for painting and varnishing work	Fachkräfte für Maler- und Lackiererarbeiten	113,616	30.25%
77	painter and varnisher–building and corrosion protection	Maler/in und Lackierer/in - Bauten- und Korrosionsschutz	29.00%	Specialists for painting and varnishing work	Fachkräfte für Maler- und Lackiererarbeiten	113,616	30.25%
78	Painter and varnisher–design and maintenance	Maler/in und Lackierer/in–Gestaltung und Instandhaltung	29.00%	Specialists for painting and varnishing work	Fachkräfte für Maler- und Lackiererarbeiten	113,616	30.25%
79	Painter and varnisher–Church painting and monument preservation	Maler/in und Lackierer/in–Kirchenmalerei und Denkmalpflege	25.00%	Specialists for painting and varnishing work	Fachkräfte für Maler- und Lackiererarbeiten	113,616	30.25%
80	Expansion manager	Ausbaumanager/in	30.00%	Specialists for stucco work	Fachkräfte für Stuckateurarbeiten	16,921	30.00%
81	Finishing skilled worker	Ausbaufacharbeiter/in	0.00%	Skilled workers in dry and dry construction (without specialisation)	Fachkräfte im Aus- und Trockenbau (ohne Spezialisierung)	20,588	6.50%
82	Drywall fitter	Trockenbaumonteur/in	13.00%	Skilled workers in dry and dry construction (without specialisation)	Fachkräfte im Aus- und Trockenbau (ohne Spezialisierung)	20,588	6.50%
83	Building mechanic for demolition and concrete separation technology	Bauwerksmechaniker/in für Abbruch und Betontrenntechnik	0.00%	Specialists in the demolition of buildings	Fachkräfte im Bauwerksabbruch	727	0.00%

(*continued*)

Table AI.

	Occupation title (English name)	Occupation title (German name)	Automation probability per occupation title (in %)	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
84	Mining and mechanical engineer–Transport and maintenance	Berg- und Maschinenmann/-frau - Transport und Instandhaltung	80.00%	Specialists in mining and surface mining	Fachkräfte im Berg- und Tagebau	13,577	79.83%
85	Mining and machine operator–tunnelling and extraction	Berg- und Maschinenmann/-frau - Vortrieb und Gewinnung	83.00%	Specialists in mining and surface mining	Fachkräfte im Berg- und Tagebau	13,577	79.83%
86	Mining Technologist–Civil Engineering	Bergbautechnologe/-technologin - Tiefbautechnik	75.00%	Specialists in mining and surface mining	Fachkräfte im Berg- und Tagebau	13,577	79.83%
87	Mining technologist–Deep drilling technology	Bergbautechnologe/-technologin - Tiefbohrtechnik	83.00%	Specialists in mining and surface mining	Fachkräfte im Berg- und Tagebau	13,577	79.83%
88	Mining Technologist–Civil Engineering	Bergbautechnologe/-technologin - Tiefbautechnik	75.00%	Specialists in mining and surface mining	Fachkräfte im Berg- und Tagebau	13,577	79.83%
89	Mining technologist–Deep drilling technology	Bergbautechnologe/-technologin - Tiefbohrtechnik	83.00%	Specialists in mining and surface mining	Fachkräfte im Berg- und Tagebau	13,577	79.83%
90	Concrete and reinforced concrete constructor	Beton- und Stahlbetonbauer/in	17.00%	Specialists in concrete and reinforced concrete construction	Fachkräfte im Beton- und Stahlbetonbau	33,184	17.00%
91	Concrete and reinforced concrete constructor	Beton- und Stahlbetonbauer/in	17.00%	Specialists in concrete and reinforced concrete construction	Fachkräfte im Beton- und Stahlbetonbau	33,184	17.00%
92	Scaffolder	Gerüstbauer/in	0.00%	Specialists in scaffolding construction	Fachkräfte im Gerüstbau	11,873	0.00%
93	Skilled construction worker	Hochbaufacharbeiter/in	0.00%	Specialists in building construction (without specialisation)	Fachkräfte im Hochbau (ohne Spezialisierung)	57,669	0.00%
94	Skilled worker–wood and building protection work	Fachkraft - Holz- und Bautenschutzarbeiten	25.00%	Specialists in wood and building protection	Fachkräfte im Holz- und Bautenschutz	1,407	37.00%
95	Wood and building protector–Building protection	Holz- und Bautenschützer/in–Bautenschutz	43.00%	Specialists in wood and building protection	Fachkräfte im Holz- und Bautenschutz	1,407	37.00%

(*continued*)

Table AI.

	Occupation title (English name)	Occupation title (German name)	Automation probability per occupation title (in %)	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
96	Wood and building protector–Wood protection	Holz- und Bautenschützer/in–Holzschutz	43.00%	Specialists in wood and building protection	Fachkräfte im Holz- und Bautenschutz	1,407	37.00%
97	Specialist–Furniture, kitchen and moving service	Fachkraft - Möbel-, Küchen- und Umzugsservice	38.00%	Specialists in woodworking, furniture and interior design	Fachkräfte im Holz-, Möbel- und Innenausbau	142,619	55.75%
98	Wood mechanic (m/f) - manufacturer Building element, wooden pack and frame	Holzmechaniker/in-Herst. v. Bauelement.,Holzpackm. u. Rahmen	80.00%	Specialists in woodworking, furniture and interior design	Fachkräfte im Holz-, Möbel- und Innenausbau	142,619	55.75%
99	Wood mechanics/ manufacturers of furniture and interior components	Holzmechaniker/in-Herstellen v. Möbeln u. Innenausbauteilen	67.00%	Specialists in woodworking, furniture and interior design	Fachkräfte im Holz-, Möbel- und Innenausbau	142,619	55.75%
100	Wood mechanic/ assembler. of interior fittings and construction elements	Holzmechaniker/in-Montier. v. Innenausbaut. u. Bauelementen	38.00%	Specialists in woodworking, furniture and interior design	Fachkräfte im Holz-, Möbel- und Innenausbau	142,619	55.75%
101	Canal builder	Kanalbauer/in	0.00%	Specialists in canal and tunnel construction	Fachkräfte im Kanal- und Tunnelbau	3,777	0.00%
102	Hydraulic engineer	Wasserbauer/in	0.00%	Specialists in cultural and hydraulic engineering	Fachkräfte im Kultur- und Wasserbau	5,636	0.00%
103	Bricklayer	Maurer/in	0.00%	Specialists in the bricklaying trade	Fachkräfte im Maurerhandwerk	92,388	0.00%
104	Specialist for metal technology–construction technology	Fachkraft für Metalltechnik–Konstruktionstechnik	86.00%	Specialists in metal construction	Fachkräfte im Metallbau	216,635	85.00%
105	Construction mechanic	Konstruktionsmechaniker/in	86.00%	Specialists in metal construction	Fachkräfte im Metallbau	216,635	85.00%

(*continued*)

Table AI.

	Occupation title (English name)	Occupation title (German name)	Automation probability per occupation title (in %)	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
106	Metalworker–Construction technology	Metallbauer/in–Konstruktionstechnik	83.00%	Specialists in metal construction	Fachkräfte im Metallbau	216,635	85.00%
107	Technical model maker–view	Technische/r Modellbauer/in–Anschauung	90.00%	Specialists in model making	Fachkräfte im Modellbau	9,917	96.67%
108	Technical model maker–foundry	Technische/r Modellbauer/in–Gießerei	100.00%	Specialists in model making	Fachkräfte im Modellbau	9,917	96.67%
109	Technical model maker–bodywork and production	Technische/r Modellbauer/in–Karosserie und Produktion	100.00%	Specialists in model making	Fachkräfte im Modellbau	9,917	96.67%
110	protective and security force	Schutz- und Sicherheitskraft	0.00%	Specialists in object, value and personal protection	Fachkräfte im Objekt-, Werte- und Personenschutz	189,637	0.00%
111	Furnace and air heating engineer	Ofen- und Luftheizungsbauer/in	17.00%	Specialists in furnace and air heating construction	Fachkräfte im Ofen- und Luftheizungsbau	2,371	17.00%
112	Assistant–Product Design	Assistent/in–Produktdesign	0.00%	Specialists in product and industrial design	Fachkräfte im Produkt- und Industriedesign	2,680	0.00%
113	Pipeline builder	Rohrleitungsbauer/in	20.00%	Specialists in pipeline construction	Fachkräfte im Rohrleitungsbau	22,973	20.00%
114	Roller shutter and sun protection mechatronics technician	Rollladen- und Sonnenschutzmechatroniker/in	43.00%	Specialists in the construction of roller shutters and venetian blinds	Fachkräfte im Rollladen- und Jalousiebau	4,963	43.00%
115	Firing and chimney builder	Feuerungs- und Schornsteinbauer/in	0.00%	Specialists in chimney construction	Fachkräfte im Schornsteinbau	1,476	0.00%
116	Asphalt farmer	Asphaltbauer/in	20.00%	Specialists in road and asphalt construction	Fachkräfte im Straßen- und Asphaltbau	33,686	10.00%
117	Road builder	Straßenbauer/in	0.00%	Specialists in road and asphalt construction	Fachkräfte im Straßen- und Asphaltbau	33,686	10.00%
118	Special civil engineer	Spezialtiefbauer/in	10.00%	Specialists in civil engineering (without specialisation)	Fachkräfte im Tiefbau (ohne Spezialisierung)	32,020	5.00%

(*continued*)

Table AI.

	Occupation title (English name)	Occupation title (German name)	Automation probability per occupation title (in %)	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
119	Civil engineering skilled worker	Tiefbaufacharbeiter/in	0.00%	Specialists in civil engineering (without specialisation)	Fachkräfte im Tiefbau (ohne Spezialisierung)	32,020	5.00%
120	Furnishing consultant	Einrichtungsfachberater/in	50.00%	Specialists in the sale of furniture and furnishings	Fachkräfte im Verkauf von Möbeln und Einrichtungsgegenständen	41,616	50.00%
121	Financial assistant	Finanzassistent/in	73.00%	Investment advisory and other financial services professionals	Fachkräfte in Anlageberatung und sonstigen Finanzdienstleistungen	6,305	73.00%
122	Specialist–recycling and waste management	Fachkraft - Kreislauf- und Abfallwirtschaft	33.00%	Specialists in waste management	Fachkräfte in der Abfallwirtschaft	10,184	33.00%
123	Electronics technician–automation technology (handicraft)	Elektroniker/in–Automatisierungstechnik (Handwerk)	75.00%	Specialists in automation technology	Fachkräfte in der Automatisierungstechnik	21,777	75.00%
124	Electronics Technician–Automation Technology (Industry)	Elektroniker/in–Automatisierungstechnik (Industr, i.e.)	75.00%	Specialists in automation technology	Fachkräfte in der Automatisierungstechnik	21,777	75.00%
125	Electronics Technician–Energy and Building Technology	Elektroniker/in - Energie- und Gebäudetechnik	75.00%	Specialists in construction electrics	Fachkräfte in der Bauelektrik	224,334	75.00%
126	Electronics Technician–Building and Infrastructure Systems	Elektroniker/in - Gebäude- und Infrastruktursysteme	75.00%	Specialists in construction electrics	Fachkräfte in der Bauelektrik	224,334	75.00%
127	Technical Assistant–Structural Engineering	Techn. Assistent/in–Bautechnik	50.00%	Specialists in construction planning and supervision (without specialisation)	Fachkräfte in der Bauplanung und -überwachung (ohne Spezialisierung)	9,894	50.00%

(*continued*)

Table AI.

	Occupation title (English name)	Occupation title (German name)	Automation probability per occupation title (in %)	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
128	Specialist–road and traffic engineering	Fachkraft - Straßen- und Verkehrstechnik	50.00%	Specialists in the construction planning of traffic routes and facilities	Fachkräfte in der Bauplanung von Verkehrswegen und -anlagen	347	50.00%
129	Precast concrete constructor	Betonfertigteilbauer/in	50.00%	Specialists in the production of building materials	Fachkräfte in der Baustoffherstellung	21,292	79.57%
131	Process mechanic - stone-/earth-based building materials	Verfahrensmechaniker/in - Steine-/Erdenind.- Baustoffe	100.00%	Specialists in the production of building materials	Fachkräfte in der Baustoffherstellung	21,292	79.57%
132	Process mechanic - Stone-/Earth-Industrial - Plasterplast/fibre ore	Verfahrensmechaniker/in - Steine-/Erdenind.- Gipspl./Faserz	100.00%	Specialists in the production of building materials	Fachkräfte in der Baustoffherstellung	21,292	79.57%
133	Process mechanic - stone-/soilind.- lime./ pores	Verfahrensmechaniker/in - Steine-/Erdenind.- Kalks./Porenb	100.00%	Specialists in the production of building materials	Fachkräfte in der Baustoffherstellung	21,292	79.57%
134	Process mechanic–Rock/soil aggregate ready-mixed concrete	Verfahrensmechaniker/in - Steine-/Erdenind.- Transportbeton	100.00%	Specialists in the production of building materials	Fachkräfte in der Baustoffherstellung	21,292	79.57%
135	Process mechanic - stone-/soil-presp. concrete ore	Verfahrensmechaniker/in - Steine-/Erdenind.- vorg. Betonerz	57.00%	Specialists in the production of building materials	Fachkräfte in der Baustoffherstellung	21,292	79.57%
136	Building material tester	Baustoffprüfer/in	86.00%	Specialists in building material testing	Fachkräfte in der Baustoffprüfung	4,002	86.00%
137	Building sealer	Bauwerksabdichter/in	50.00%	Specialists in waterproofing buildings	Fachkräfte in der Bauwerksabdichtung	2,889	50.00%
138	Technical Assistant for the Monument	Denkmaltechnische/r Assistent/ in	60.00%	Specialists in building maintenance and renewal	Fachkräfte in der Bauwerkserhaltung und -erneuerung	719	60.00%
139	Roofer	Dachdecker/in	0.00%	Specialists in the roofing trade	Fachkräfte in der Dachdeckerei	49,809	0.00%
140	Electronics technician–industrial engineering	Elektroniker/in–Betriebstechnik	70.00%	Specialists in electrical operating technology	Fachkräfte in der elektrischen Betriebstechnik	116,174	70.00%

(*continued*)

Table AI.

	Occupation title (English name)	Occupation title (German name)	Automation probability per occupation title (in %)	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
141	Electrical engineering assistant	Elektrotechnische/r Assistent/in	100.00%	Specialists in electrical engineering (without specialization)	Fachkräfte in der Elektrotechnik (ohne Spezialisierung)	31,722	100.00%
142	Screed layer	Estrichleger/in	33.00%	Specialists in screed and terrazzo laying	Fachkräfte in der Estrich- und Terrazzoverlegung	4,265	33.00%
143	Tile, slab and mosaic layers	Fliesen-, Platten- und Mosaikleger/in	20.00%	Specialists in the laying of tiles, slabs and mosaics	Fachkräfte in der Fliesen-, Platten- und Mosaikverlegung	26,317	20.00%
144	Building cleaner	Gebäudereiniger/in	13.00%	Specialists in building cleaning	Fachkräfte in der Gebäudereinigung	101,587	13.00%
145	Housekeeper/House technician	Hauswart/in/Haustechniker/in	40.00%	Specialists in building services engineering (without specialisation)	Fachkräfte in der Gebäudetechnik (ohne Spezialisierung)	233,272	66.00%
146	Technical Assistant–Building Services Engineering	Techn. Assistent/in–Gebäudetechnik	92.00%	Specialists in building services engineering (without specialisation)	Fachkräfte in der Gebäudetechnik (ohne Spezialisierung)	233,272	66.00%
147	Glazier–Window and glass facade construction	Glaser/in - Fenster- und Glasfassadenbau	29.00%	Specialists in the glazier's shop	Fachkräfte in der Glaserei	9,770	44.50%
148	Glazier–Glazing and glass construction	Glaser/in–Verglasung und Glasbau	60.00%	Specialists in the glazier's shop	Fachkräfte in der Glaserei	9,770	44.50%
149	Glassmaker	Glasmacher/in	100.00%	Specialists in glass production	Fachkräfte in der Glasherstellung	9,556	100.00%
150	Housekeeper	Hauswirtschafter/in	38.00%	Specialists in home economics	Fachkräfte in der Hauswirtschaft	85,530	35.50%
151	Domestic helper/assistant	Hauswirtschaftshelfer/in/-assistent/in	33.00%	Specialists in home economics	Fachkräfte in der Hauswirtschaft	85,530	35.50%
152	Woodworking mechanic	Holzbearbeitungsmechaniker/in	86.00%	Skilled workers in woodworking and wood processing (without specialisation)	Fachkräfte in der Holzbe- und -verarbeitung (ohne Spezialisierung)	14,498	86.00%

(*continued*)

Table AI.

	Occupation title (English name)	Occupation title (German name)	Automation probability per occupation title (in %)	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
153	Real estate assistant	Immobilienassistent/in	25.00%	Experts in real estate marketing and management	Fachkräfte in der Immobilienvermarktung und -verwaltung	33,796	25.00%
154	Real estate agent	Immobilienkaufmann/-frau	25.00%	Experts in real estate marketing and management	Fachkräfte in der Immobilienvermarktung und -verwaltung	33,796	25.00%
155	Technical-commercial assistant–building services	Technisch-kaufmännische/r Assistent/in–Gebäudeservice	25.00%	Experts in real estate marketing and management	Fachkräfte in der Immobilienvermarktung und -verwaltung	33,796	25.00%
156	Industrial ceramist (m/f) in model technology	Industriekeramiker/in Modelltechnik	100.00%	Specialists in industrial ceramics (model technology)	Fachkräfte in der Industriekeramik (Modelltechnik)	981	100.00%
157	Industrial ceramist (m/f) in plant engineering	Industriekeramiker/in Anlagentechnik	92.00%	Specialists in industrial ceramics (process and plant engineering)	Fachkräfte in der Industriekeramik (Verfahrens- und Anlagentechnik)	4,104	96.00%
158	Industrial ceramist in process engineering	Industriekeramiker/in Verfahrenstechnik	100.00%	Specialists in industrial ceramics (process and plant engineering)	Fachkräfte in der Industriekeramik (Verfahrens- und Anlagentechnik)	4,104	96.00%
159	Electronics technician–Information and telecommunications technology	Elektroniker/in - Informations- u. Telekommunikationstechnik	100.00%	Specialists in information and telecommunications technology	Fachkräfte in der Informations- und Telekommunikationstechnik	141,812	94.33%
160	Electronics Technician–Information and Systems Technology	Elektroniker/in - Informations- und Systemtechnik	83.00%	Specialists in information and telecommunications technology	Fachkräfte in der Informations- und Telekommunikationstechnik	141,812	94.33%
161	Information electronics technician	Informationselektroniker/in	100.00%	Specialists in information and telecommunications technology	Fachkräfte in der Informations- und Telekommunikationstechnik	141,812	94.33%
162	Assistant–Interior Architecture	Assistent/in–Innenarchitektur	20.00%	Specialists in interior design	Fachkräfte in der Innenarchitektur	384	20.00%
163	Insulation technician	Isolierfacharbeiter/in	20.00%	Specialists in insulation	Fachkräfte in der Isolierung	11,464	10.00%

(*continued*)

Table AI.

	Occupation title (English name)	Occupation title (German name)	Automation probability per occupation title (in %)	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
164	Heat, cold and sound insulation specialist	Wärme-, Kälte- und Schallschutzisolierer/in	0.00%	Specialists in insulation	Fachkräfte in der Isolierung	11,464	10.00%
165	Plant assistant–Craft trades	Betriebsassistent/in–Handwerk	40.00%	Skilled workers in commercial and technical business administration (without specialisation)	Fachkräfte in der kaufmännischen und technischen Betriebswirtschaft (ohne Spezialisierung)	936,387	44.00%
166	Plant assistant–Craft trades	Betriebsassistent/in–Handwerk	40.00%	Skilled workers in commercial and technical business administration (without specialisation)	Fachkräfte in der kaufmännischen und technischen Betriebswirtschaft (ohne Spezialisierung)	936,387	44.00%
167	Industrial clerk (m/f)	Industriekaufmann/-frau	56.00%	Skilled workers in commercial and technical business administration (without specialisation)	Fachkräfte in der kaufmännischen und technischen Betriebswirtschaft (ohne Spezialisierung)	936,387	44.00%
168	Technical business economist–Craftsmanship	Technische/r Betriebswirt/in–Handwerk	40.00%	Skilled workers in commercial and technical business administration (without specialisation)	Fachkräfte in der kaufmännischen und technischen Betriebswirtschaft (ohne Spezialisierung)	936,387	44.00%
169	Plumber	Klempner/in	71.00%	Specialists in plumbing (without specialization)	Fachkräfte in der Klempnerei (ohne Spezialisierung)	17,516	71.00%
170	Industrial Ceramist Decoration Technology	Industriekeramiker/in Dekorationstechnik	100.00%	Specialists in handicraft glass, ceramic and porcelain painting	Fachkräfte in der kunsthandwerklichen Glas-, Keram- und Porzellanmalerei	1,030	100.00%
171	Ceramist	Keramiker/in	80.00%	Professionals in the craft of ceramics design	Fachkräfte in der kunsthandwerklichen Keramikgestaltung	2,583	80.00%
172	Parquet layer	Parkettleger/in	50.00%	Specialists in parquet laying	Fachkräfte in der Parkettverlegung	4,440	50.00%
173	Interior decorator	Raumausstatter/in	13.00%	Specialists in room furnishing	Fachkräfte in der Raumausstattung	18,210	13.00%

(*continued*)

Table AI.

	Occupation title (English name)	Occupation title (German name)	Automation probability per occupation title (in %)	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
174	Plant mechanic–Sanitary, heating and air-conditioning technology	Anlagenmechaniker/in - Sanitär-, Heizungs- und Klimatechnik	70.00%	Specialists in sanitary, heating and air-conditioning technology	Fachkräfte in der Sanitär-, Heizungs- und Klimatechnik	171,535	70.00%
175	Specialist for metal technology–Forming and wire technology	Fachkraft für Metalltechnik - Umform- und Drahttechnik	83.00%	Specialists in non-cutting metalworking	Fachkräfte in der spanlosen Metallbearbeitung	25,275	83.00%
176	Civil servant (m/f) - Surveying (middle technical service)	Beamt(er/in) - Vermessungswesen (mittl. techn. Dienst)	88.00%	Specialists in surveying technology	Fachkräfte in der Vermessungstechnik	18,230	69.00%
177	Civil servant (m/f) - Surveying (middle technical service)	Beamt(er/in) - Vermessungswesen (mittl. techn. Dienst)	88.00%	Specialists in surveying technology	Fachkräfte in der Vermessungstechnik	18,230	69.00%
178	Surveying technician–mountain surveying	Vermessungstechniker/in–Bergvermessung	50.00%	Specialists in surveying technology	Fachkräfte in der Vermessungstechnik	18,230	69.00%
179	Surveying technician–Surveying	Vermessungstechniker/in–Vermessung	50.00%	Specialists in surveying technology	Fachkräfte in der Vermessungstechnik	18,230	69.00%
180	Specialist–Sewage technology	Fachkraft–Abwassertechnik	60.00%	Specialists in water supply and waste water technology	Fachkräfte in der Wasserversorgungs- und Abwassertechnik	26,160	77.00%
181	Specialist–Pipe, sewer and industrial services	Fachkraft - Rohr-, Kanal- und Industrieservice	100.00%	Specialists in water supply and waste water technology	Fachkräfte in der Wasserversorgungs- und Abwassertechnik	26,160	77.00%
182	Specialist–Water supply engineering	Fachkraft–Wasserversorgungstechnik	71.00%	Specialists in water supply and waste water technology	Fachkräfte in der Wasserversorgungs- und Abwassertechnik	26,160	77.00%
183	Specialist–Water Management	Fachkraft–Wasserwirtschaft	56.00%	Specialists in water management	Fachkräfte in der Wasserwirtschaft	1,218	56.00%
184	Carpenter/room owner	Zimmerer/Zimmerin	13.00%	Specialists in carpentry	Fachkräfte in der Zimmerei	50,621	13.00%
185	Construction equipment operator	Baugeräteführer/in	0.00%	Drivers of earthmoving and related machinery	Führer/innen von Erdbewegungs- und verwandten Maschinen	49,472	0.00%

(*continued*)

Table AI.

	Occupation title (English name)	Occupation title (German name)	Automation probability per occupation title (in %)	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
186	Wood farmer	Holzwirt/in	55.00%	Executives in woodworking and wood processing	Führungskräfte in der Holzbe- und -verarbeitung	189	55.00%
187	Banker (m/f)	Bankkaufmann/-frau	88.00%	Commercial banking specialists	Kaufmännische Bankfachkräfte	431,547	88.00%
188	Business administrator–Bank	Fachwirt/in–Bank	50.00%	Commercial banking specialists	Kaufmännische Bankspezialisten	33,220	50.00%
189	Business economist (university) - Commerce	Betriebswirt/in (Hochschule) - Handel	41.00%	Commercial experts in trade (without specialization)	Kaufmännische Experten im Handel (ohne Spezialisierung)	558	41.00%
190	Business administrator–Trade	Fachwirt/in–Handel	42.00%	Commercial specialists in trade (without specialization)	Kaufmännische Spezialisten im Handel (ohne Spezialisierung)	17,302	42.00%
191	Technical specialist (m/f) - hardware technology	Technische/r Fachkaufmann/-frau - Beschlagtechnik	44.00%	Commercial specialists in trade (other specific activity information)	Kaufmännische Spezialisten im Handel (sonstige spezifische Tätigkeitsangabe)	3,608	46.67%
192	Technical specialist–sanitary/heating/air conditioning	Technische/r Fachkaufmann/-frau - Sanitär/Heizung/Klima	58.00%	Commercial specialists in trade (other specific activity information)	Kaufmännische Spezialisten im Handel (sonstige spezifische Tätigkeitsangabe)	3,608	46.67%
193	Technical specialist (m/f) - tools/machines	Technische/r Fachkaufmann/-frau - Werkzeuge/Maschinen	38.00%	Commercial specialists in trade (other specific activity information)	Kaufmännische Spezialisten im Handel (sonstige spezifische Tätigkeitsangabe)	3,608	46.67%
194	Insurance specialist	Versicherungsfachmann/-frau	63.00%	Commercial insurance specialists	Kaufmännische Versicherungsfachkräfte	135,493	63.00%
195	Business Administrator–Insurance and Finance	Fachwirt/in–Versicherungen und Finanzen	58.00%	Commercial insurance specialists	Kaufmännische Versicherungsspezialisten	42,753	58.00%
196	Notary	Notar/in	33.00%	Notaries (m/f)	Notare/Notarinnen	2,906	33.00%
197	Specialist attorney at law	Fachanwalt/-anwältin	20.00%	Attorneys at law	Rechtsanwälte/-anwältinnen	33,887	20.00%
198	Chimney sweep	Schornsteinfeger/in	20.00%	Chimney sweeps	Schornsteinfeger/innen	8,892	20.00%
199	painter and varnisher–restoration work	Maler/in und Lackierer/in–Restaurierungsarbeiten	33.00%	Specialists for painting and varnishing work	Spezialisten für Maler- und Lackiererarbeiten	396	32.00%

(*continued*)

Table AI.

	Occupation title (English name)	Occupation title (German name)	Automation probability per occupation title (in %)	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
200	Restorer–painter and varnisher craft	Restaurator/in - Maler- und Lackiererhandwerk	31.00%	Specialists for painting and varnishing work	Spezialisten für Maler- und Lackiererarbeiten	396	32.00%
201	Technician–Civil engineering (extension)	Techniker/in–Bautechnik (Ausbau)	40.00%	Specialists in dry and drywall construction (without specialisation)	Spezialisten im Aus- und Trockenbau (ohne Spezialisierung)	539	40.00%
202	Technician–Civil engineering (concrete construction)	Techniker/in–Bautechnik (Betonbau)	40.00%	Specialists in concrete and reinforced concrete construction	Spezialisten im Beton- und Stahlbetonbau	834	40.00%
203	fire protection specialist	Brandschutzfachkraft	25.00%	Fire protection specialists	Spezialisten im Brandschutz	3,865	25.00%
204	Specialist–building management	Fachmann/-frau - Gebäudebewirtschaftung	25.00%	Specialists in Facility Management	Spezialisten im Facility-Management	9,201	46.67%
205	Business administrator–Facility Management	Fachwirt/in - Facility-Management	55.00%	Specialists in Facility Management	Spezialisten im Facility-Management	9,201	46.67%
206	Facility Manager	Facility-Manager/in	60.00%	Specialists in Facility Management	Spezialisten im Facility-Management	9,201	46.67%
207	Technician–Civil engineering (structural engineering)	Techniker/in–Bautechnik (Hochbau)	50.00%	Specialists in building construction (without specialisation)	Spezialisten im Hochbau (ohne Spezialisierung)	4,633	50.00%
208	Restorer–Furniture and wooden objects	Restaurator/in–Möbel und Holzobjekte	54.00%	Specialists in wood, furniture and interior construction	Spezialisten im Holz-, Möbel- und Innenausbau	2,678	52.00%
209	Technician–wood technology (furniture construction and interior design)	Techniker/in–Holztechnik (Möbelbau und Raumgestaltung)	50.00%	Specialists in wood, furniture and interior construction	Spezialisten im Holz-, Möbel- und Innenausbau	2,678	52.00%
210	Bricklayer–Restoration work	Maurer/in–Restaurierungsarbeiten	0.00%	Specialists in the bricklaying trade	Spezialisten im Maurerhandwerk	313	6.50%
211	Restorer–Masonry trade	Restaurator/in–Maurerhandwerk	13.00%	Specialists in the bricklaying trade	Spezialisten im Maurerhandwerk	313	6.50%

(*continued*)

Table AI.

	Occupation title (English name)	Occupation title (German name)	Automation probability per occupation title (in %)	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
212	Technician–metal construction technology (steel construction)	Techniker/in–Metallbautechnik (Stahlbau)	63.00%	Specialists in metal construction	Spezialisten im Metallbau	3,952	63.00%
213	Technician–Civil engineering (civil engineering)	Techniker/in–Bautechnik (Tiefbau)	50.00%	Specialists in civil engineering (without specialisation)	Spezialisten im Tiefbau (ohne Spezialisierung)	2,011	50.00%
214	Consultant–Financial Services	Fachberater/in–Finanzdienstleistungen	43.00%	Specialists in investment advice and other financial services	Spezialisten in Anlageberatung und sonstigen Finanzdienstleistungen	14,741	47.33%
215	Business administrator–financial consultancy	Fachwirt/in–Finanzberatung	44.00%	Specialists in investment advice and other financial services	Spezialisten in Anlageberatung und sonstigen Finanzdienstleistungen	14,741	47.33%
216	Business administrator–Investment	Fachwirt/in–Investment	55.00%	Specialists in investment advice and other financial services	Spezialisten in Anlageberatung und sonstigen Finanzdienstleistungen	14,741	47.33%
217	Business administrator–Construction	Fachwirt/in–Bau	60.00%	Specialists in construction accounting and costing	Spezialisten in der Bauabrechnung und -kalkulation	4,055	60.00%
218	Civil servant–Senior civil engineering service	Beamt(er/in) - Gehobener bautechnischer Dienst	25.00%	Specialists in construction planning and supervision (without specialisation)	Spezialisten in der Bauplanung und -überwachung (ohne Spezialisierung)	25,456	41.67%
219	Technician–Civil engineering (construction operation)	Techniker/in–Bautechnik (Baubetrieb)	50.00%	Specialists in construction planning and supervision (without specialisation)	Spezialisten in der Bauplanung und -überwachung (ohne Spezialisierung)	25,456	41.67%
220	Technician–Civil engineering (without focus)	Techniker/in–Bautechnik (ohne Schwerpunkt)	50.00%	Specialists in construction planning and supervision (without specialisation)	Spezialisten in der Bauplanung und -überwachung (ohne Spezialisierung)	25,456	41.67%

(*continued*)

Table AI.

	Occupation title (English name)	Occupation title (German name)	Automation probability per occupation title (in %)	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
221	Technician–Civil engineering (renovation of a building)	Techniker/in–Bautechnik (Bauerneuerung/Bausanierung)	40.00%	Specialists in building maintenance and renovation	Spezialisten in der Bauwerkserhaltung und -erneuerung	1,764	40.00%
222	Technician–Electrical engineering (without focus)	Techniker/in–Elektrotechnik (ohne Schwerpunkt)	88.00%	Specialists in electrical engineering (without specialization)	Spezialisten in der Elektrotechnik (ohne Spezialisierung)	50,568	88.00%
223	Technician–Cleaning and hygiene technology	Techniker/in - Reinigungs- und Hygienetechnik	40.00%	Specialists in building cleaning	Spezialisten in der Gebäudereinigung	1,437	40.00%
224	Specialist–Building services engineering	Fachkraft–Gebäudetechnik	90.00%	Specialists in building services engineering (without specialisation)	Spezialisten in der Gebäudetechnik (ohne Spezialisierung)	13,313	83.33%
225	Specialist planner–energy and building technology	Fachplaner/in - Energie- und Gebäudetechnik	78.00%	Specialists in building services engineering (without specialisation)	Spezialisten in der Gebäudetechnik (ohne Spezialisierung)	13,313	83.33%
226	Technician–building system technology	Techniker/in–Gebäudesystemtechnik	82.00%	Specialists in building services engineering (without specialisation)	Spezialisten in der Gebäudetechnik (ohne Spezialisierung)	13,313	83.33%
227	Technician–Geological Engineering	Techniker/in–Geologietechnik	14.00%	Specialists in geotechnics	Spezialisten in der Geotechnik	739	14.00%
228	Technician–glass technology (glass and window construction technology)	Techniker/in–Glastechnik (Glas- und Fensterbautechnik)	58.00%	Specialists in glass production	Spezialisten in der Glasherstellung	715	70.00%
229	Technician–glass technology (glassworks technology)	Techniker/in–Glastechnik (Glashüttentechnik)	82.00%	Specialists in glass production	Spezialisten in der Glasherstellung	715	70.00%
230	Specialist housekeeper	Fachhauswirtschafter/in	38.00%	Specialists in home economics	Spezialisten in der Hauswirtschaft	3,293	40.00%

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Table AI.

	Occupation title (English name)	Occupation title (German name)	Automation probability per occupation title (in %)	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
231	Technician–Nutrition and Supply Management	Techniker/in - Ernährungs- und Versorgungsmanagement	44.00%	Specialists in home economics	Spezialisten in der Hauswirtschaft	3,293	40.00%
232	Economist–Home economics	Wirtschafter/in–Hauswirtschaft	38.00%	Specialists in home economics	Spezialisten in der Hauswirtschaft	3,293	40.00%
233	Technician–Wood technology (model and mould making)	Techniker/in–Holztechnik (Modell- und Formenbau)	79.00%	Specialists in woodworking and wood processing (without specialisation)	Spezialisten in der Holzbe- und -verarbeitung (ohne Spezialisierung)	2,303	71.00%
234	Technician–Wood technology (without focus)	Techniker/in–Holztechnik (ohne Schwerpunkt)	63.00%	Specialists in woodworking and wood processing (without specialisation)	Spezialisten in der Holzbe- und -verarbeitung (ohne Spezialisierung)	2,303	71.00%
235	Business economist (technical college) - Real estate	Betriebswirt/in (Fachschule) - Immobilien	27.00%	Specialists in real estate marketing and management	Spezialisten in der Immobilienvermarktung und -verwaltung	28,837	17.33%
236	Business administrator–Real estate	Fachwirt/in–Immobilien	25.00%	Specialists in real estate marketing and management	Spezialisten in der Immobilienvermarktung und -verwaltung	28,837	17.33%
237	Real estate expert	Immobiliensachverständige/r	0.00%	Specialists in real estate marketing and management	Spezialisten in der Immobilienvermarktung und -verwaltung	28,837	17.33%
238	Technician–Ceramic Technology	Techniker/in–Keramiktechnik	73.00%	Specialists in industrial ceramics (process and plant engineering)	Spezialisten in der Industriekeramik (Verfahrens- und Anlagentechnik)	215	73.00%
239	Technician–Electrical Engineering (Information/ Communication)	Techniker/in–Elektrotechnik (Information/Kommunikation)	78.00%	Specialists in information and telecommunications technology	Spezialisten in der Informations- und Telekommunikationstechnik	38,216	78.00%
240	Designer–Colour technique/room design	Gestalter/in–Farbtechnik/ Raumgestaltung	0.00%	Specialists in interior design	Spezialisten in der Innenarchitektur	1,238	0.00%
241	Designer–Wood/ Furniture/Room design	Gestalter/in–Holz/Möbel/ Raumgestaltung	0.00%	Specialists in interior design	Spezialisten in der Innenarchitektur	1,238	0.00%

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Table AI.

	Occupation title (English name)	Occupation title (German name)	Automation probability per occupation title (in %)	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
242	Technician–Computer Science (Network Technology)	Techniker/in–Informatik (Netzwerktechnologie)	42.00%	Specialists in IT network technology	Spezialisten in der IT-Netzwerktechnik	8,863	42.00%
243	Security Technician (IT)	Sicherheitstechniker/in (IT)	80.00%	Specialists in IT network technology, IT coordination, IT administration and IT organization (other specific activities)	Spezialisten in der IT-Netzwerktechnik, IT-Koordination, IT-Administration und IT-Organisation (sonstige spezifische Tätigkeitsangabe)	6,307	80.00%
244	Business economist–Craftsmanship	Betriebswirt/in–Handwerk	54.00%	Specialists in commercial and technical business management (without specialization)	Spezialisten in der kaufmännischen und technischen Betriebswirtschaft (ohne Spezialisierung)	53,256	39.13%
245	Business economist–Industry	Betriebswirt/in–Industr, i.e.	29.00%	Specialists in commercial and technical business management (without specialization)	Spezialisten in der kaufmännischen und technischen Betriebswirtschaft (ohne Spezialisierung)	53,256	39.13%
246	Specialist for commercial business management (HwO)	Fachmann/-frau für kaufmännische Betriebsführung (HwO)	27.00%	Specialists in commercial and technical business management (without specialization)	Spezialisten in der kaufmännischen und technischen Betriebswirtschaft (ohne Spezialisierung)	53,256	39.13%
247	Business administrator–Craftsmanship	Fachwirt/in–Handwerk	36.00%	Specialists in commercial and technical business management (without specialization)	Spezialisten in der kaufmännischen und technischen Betriebswirtschaft (ohne Spezialisierung)	53,256	39.13%
248	Business economist	Fachwirt/in–Wirtschaft	40.00%	Specialists in commercial and technical business management (without specialization)	Spezialisten in der kaufmännischen und technischen Betriebswirtschaft (ohne Spezialisierung)	53,256	39.13%
249	Technical-commercial skilled worker–craftsmanship	Technisch-kaufmännische Fachkraft–Handwerk	33.00%	Specialists in commercial and technical business management (without specialization)	Spezialisten in der kaufmännischen und technischen Betriebswirtschaft (ohne Spezialisierung)	53,256	39.13%

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Table AI.

	Occupation title (English name)	Occupation title (German name)	Automation probability per occupation title (in %)	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
250	Technical business economist (further education)	Technische/r Betriebswirt/in (Weiterbildung)	44.00%	Specialists in commercial and technical business management (without specialization)	Spezialisten in der kaufmännischen und technischen Betriebswirtschaft (ohne Spezialisierung)	53,256	39.13%
251	Technical specialist (m/f)	Technische/r Fachwirt/in	50.00%	Specialists in commercial and technical business management (without specialization)	Spezialisten in der kaufmännischen und technischen Betriebswirtschaft (ohne Spezialisierung)	53,256	39.13%
252	CAD specialist (without centre of gravity)	CAD-Fachkraft (ohne Schwerpunkt)	75.00%	Specialists in design and equipment construction	Spezialisten in der Konstruktion und im Gerätebau	95,402	77.75%
253	CAD-Specialist - Construction	CAD-Fachkraft - Bau	70.00%	Specialists in design and equipment construction	Spezialisten in der Konstruktion und im Gerätebau	95,402	77.75%
254	CAD Specialist–Metal	CAD-Fachkraft - Metall	86.00%	Specialists in design and equipment construction	Spezialisten in der Konstruktion und im Gerätebau	95,402	77.75%
255	Design engineer	Konstrukteur/in	80.00%	Specialists in design and equipment construction	Spezialisten in der Konstruktion und im Gerätebau	95,402	77.75%
256	Technician–glass technology (glass design)	Techniker/in–Glastechnik (Glasgestaltung)	36.00%	Specialists in handicraft glassblowing	Spezialisten in der kunsthandwerklichen Glasbläserei	57	36.00%
257	Parquet layer–Restoration work	Parkettleger/in–Restaurierungsarbeiten	43.00%	Specialists in parquet laying	Spezialisten in der Parkettverlegung	21	36.50%
258	Restorer–parquet laying trade	Restaurator/in–Parkettlegerhandwerk	30.00%	Specialists in parquet laying	Spezialisten in der Parkettverlegung	21	36.50%
259	Design consultant–interior decorator	Gestaltungsberater/in–Raumausstatterhandwerk	18.00%	Specialists in interior design	Spezialisten in der Raumausstattung	294	20.50%
260	restorer–interior decorator	Restaurator/in–Raumausstatterhandwerk	23.00%	Specialists in interior design	Spezialisten in der Raumausstattung	294	20.50%
261	Business administrator–solar technology	Fachwirt/in–Solartechnik	36.00%	Specialists in regenerative energy technology	Spezialisten in der regenerativen Energietechnik	3,403	56.33%

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	Occupation title (English name)	Occupation title (German name)	Automation probability per occupation title (in %)	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
262	Service technician–wind turbine technology	Servicemonteur/in–Windenergieanlagentechnik	73.00%	Specialists in regenerative energy technology	Spezialisten in der regenerativen Energietechnik	3,403	56.33%
263	Solar technician	Solartechniker/in	60.00%	Specialists in regenerative energy technology	Spezialisten in der regenerativen Energietechnik	3,403	56.33%
264	Technician–Heating, ventilation and air-conditioning technology	Techniker/in - Heizungs-, Lüftungs-, Klimatechnik	80.00%	Specialists in sanitary, heating and air-conditioning technology	Spezialisten in der Sanitär-, Heizungs- und Klimatechnik	7,361	73.50%
265	Technician–Sanitary engineering	Techniker/in–Sanitärtechnik	67.00%	Specialists in sanitary, heating and air-conditioning technology	Spezialisten in der Sanitär-, Heizungs- und Klimatechnik	7,361	73.50%
266	Welding specialist	Schweißfachmann/-frau	63.00%	Specialists in welding and joining technology	Spezialisten in der Schweiß- und Verbindungstechnik	1,941	59.50%
267	Welding technician	Schweißtechniker/in	56.00%	Specialists in welding and joining technology	Spezialisten in der Schweiß- und Verbindungstechnik	1,941	59.50%
268	Blaster	Sprengmeister/in	57.00%	Specialists in blasting technology	Spezialisten in der Sprengtechnik	1,430	57.00%
269	Financial manager	Finanzwirt/in	39.00%	Specialists in tax administration	Spezialisten in der Steuerverwaltung	1,108	39.00%
270	Technician–computer science (technical computer science)	Techniker/in–Informatik (techn. Informatik)	45.00%	Specialists in technical informatics	Spezialisten in der technischen Informatik	5,079	45.00%
271	Specialist–Quality Assurance/ Management	Fachkraft–Qualitätssicherung/-management	57.00%	Specialists in technical quality assurance	Spezialisten in der technischen Qualitätssicherung	53,055	57.00%
272	Technician–Environmental protection. (Water supply and disposal)	Techniker/in–Umweltschutzt. (Wasserver- u. -entsorgung)	55.00%	Specialists in environmental protection technology (other specific activities)	Spezialisten in der Umweltschutztechnik (sonstige spezifische Tätigkeitsangabe)	192	55.00%

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Table AI.

	Occupation title (English name)	Occupation title (German name)	Automation probability per occupation title (in %)	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
273	Energy consultant	Energieberater/in	25.00%	Specialists in environmental management and consulting	Spezialisten in der Umweltschutzverwaltung und -beratung	5,580	41.00%
274	Business administrator–Energy industry	Fachwirt/in–Energiewirtschaft	57.00%	Specialists in environmental management and consulting	Spezialisten in der Umweltschutzverwaltung und -beratung	5,580	41.00%
275	Civil servant (m/f) - Surveying (technical service)	Beamt(er/in) - Vermessungswesen (geh. techn. Dienst)	88.00%	Specialists in surveying technology	Spezialisten in der Vermessungstechnik	6,398	75.33%
276	Civil servant (m/f) - Surveying (technical service)	Beamt(er/in) - Vermessungswesen (geh. techn. Dienst)	88.00%	Specialists in surveying technology	Spezialisten in der Vermessungstechnik	6,398	75.33%
277	Technician–Surveying technology	Techniker/in–Vermessungstechnik	50.00%	Specialists in surveying technology	Spezialisten in der Vermessungstechnik	6,398	75.33%
278	Restorer–Carpentry	Restaurator/in–Zimmererhandwerk	14.00%	Specialists in carpentry	Spezialisten in der Zimmerei	245	7.00%
279	Carpenter (m/f) - Restoration work	Zimmerer/Zimmerin–Restaurierungsarbeiten	0.00%	Specialists in carpentry	Spezialisten in der Zimmerei	245	7.00%
280	Business administrator–Notary's office	Fachwirt/in–Notariat	29.00%	Specialists in law firm and notary's office	Spezialisten in Rechtsanwaltskanzlei und Notariat	o.A	29.00%
281	Business administrator–financing and leasing	Fachwirt/in–Finanzierung und Leasing	43.00%	Specialists in insurance and financial services (other specific activities)	Spezialisten in Versicherungs- und Finanzdienstleistungen (sonstige spezifische Tätigkeitsangabe)	3,013	43.00%
282	Roadkeeper	Straßenwärter/in	0.00%	Road and tunnel attendants	Straßen- und Tunnelwärter/innen	27,446	0.00%
283	Construction draughtsman	Bauzeichner/in	67.00%	Technical draughtsmen and women	Technische Zeichner/innen	111,285	78.25%

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Table AI.

	Occupation title (English name)	Occupation title (German name)	Automation probability per occupation title (in %)	Occupation group (English name)	Occupation group (German name)	Employee count	Averaged automation probability per occupation group (in %)
284	Technical system planner–Electrotechnical systems	Technische/r Systemplaner/in–Elektrotechnische Systeme	83.00%	Technical draughtsmen and women	Technische Zeichner/innen	111,285	78.25%
285	Technical system planner–steel and metal construction technology	Technische/r Systemplaner/in–Stahl- und Metallbautechnik	80.00%	Technical draughtsmen and women	Technische Zeichner/innen	111,285	78.25%
286	Technical system planner–supply and equipment techn	Technische/r Systemplaner/in–Versorgungs- u. Ausrüstungst	83.00%	Technical draughtsmen and women	Technische Zeichner/innen	111,285	78.25%

Source(s): Bundesagentur für Arbeit (2019a), Bundesagentur für Arbeit (2019b), Institute of Employment Research (2019); own calculations