WifOR
Wirtschaftsforschung

How digitalisation impact reduces the anticipated labour bottleneck and the extent of the impact on the most important occupational groups in the nine largest sectors in Germany

The influence of digitalisation on the labour situation in Germany

Job and sector-specific analysis up to 2030

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”Digitalisation presents a great opportunity for German firms. The application of new technologies will halve the anticipated workforce bottleneck to “only” 2 million working population up to 2030.“

300,000

additional professionals will be needed in the Healthcare and Pharma sector.

190,000

more professionals will be needed in the Public Sector by 2030.

2 million

additional academics will be lacking due to digitalisation up to 2030.

By 2013, decrease in demand by

940,000 *sales workers*

as a result of digitalisation.

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Abstract – Digitalisation reduces workforce bottleneck

Society's increasingly virtual-digital interconnectivity and new digital technologies characterise economic development and also influences the work environment. Buzzwords such as "Industry 4.0", "Economy 4.0" or "Work 4.0" express the need for action and to shed some light onto the current digitalisation discourse with empirically-based and thus scientifically valid data.

Companies in particular need usable information about how digitalisation will impact their own business model and - closely linked to it – the future demands on their employees. While there are already numerous examples and analyses regarding the partly disruptive influences digitalisation has on companies and sectors, sector-specific forecast for the digital job market are seldom made. These types of research increase in complexity when existing phenomena, like the workforce bottleneck and the effect of demographic shift, have to be taken into account. Researches up to date account for the interplay of the various factors in very different forms, if at all. Thus, this results in conclusions that differ widely from one another, ranging from an irreplaceable loss of hundreds of thousands of jobs, up to a net gain of jobs due to the emergence of new professions.

The objective of the joint WifOR and PwC project is thus - complementary to a later joint study on professionals – to quantitatively identify and analyse the impact of digitalisation on the demand for professionals, as a whole and also on a detailed level, in the nine largest sectors in Germany and the professions belonging to them.
The mostly qualitatively-led discussions so far about the influence of digitalisation will be backed up by empirically credible data and supplemented with new insights that are scientifically grounded for the nine sectors over time, up to 2030.

Digitalisation could reduce the working force shortage in year 2030 by around two million

Digitalisation could be used as an important lever to counter the imminent shortage of professionals as a result of demographics. Depending on the profession and sector, digitalisation could heighten, soften or overcompensate for the expected bottleneck.

In 2030, the shortage would be almost [1] at 4,200,000 professionals without digitalisation – which could drop significantly due to digitalisation effects. Due to advancing digitalisation, the number of professionals lacking in the year 2030 could be reduced to around 2,000,000.

The workforce bottleneck will rise to 4.2 million until ***2030***

[1] Possible differences are rounding up difference

Up to the year 2030, 940,000 fewer sales workers will be in demand compared to today.

Divergent digitalisation impact on the sectors

The impact of digitalisation on each sector takes on many different forms. In the Healthcare and Pharma sector, about 300,000 more professionals are expected to be in demand in 2030. On the other hand, the Retail sector has a workforce that is about 900,000 smaller as a result of digitalisation

The sectors Retail, Industrial Products as well as Healthcare and Pharma are most influenced by digitalisation. While the demand for professionals in Retail drops significantly due to digitalisation, the opposite is true for Healthcare and Pharma, especially for health professionals. Overall, digitalisation has the largest impact on the demand for professionals in these three sectors.

Professions affected in different directions

Independent from sector, digitalisation will have a different impact on current job profiles. Routine tasks would more likely be rationalised in the course of increasing digitalisation, complex tasks requiring higher specificity would see higher demand.

As such, academics in STEM professions will see a rise in demand up to year 2030 of about 510.1, whereas sales worker will see a decline in demand of around 940,000.

In general, digitalisation has a positive impact on academic professions and higher-level professionals. The bottleneck issue could be further reinforced over time due to digitalisation. For supporting roles; the lessening of the bottleneck will be further compounded by the reduction in demand. In specific cases, for example with the general office and secretary professionals, the result could be an even larger oversupply of these professionals.

In the first place, the sector and occupation-specific forecast in terms of the digitalisation of work is possible in this form as the research is based on a combination of approaches, namely: task-based, labour capacity and occupational structure model. On this basis, this research creates an empirically sound database for Germany, built on the foundation of internationally comparable statistical data. Hence, the methodical approach to implementing digitalisation impact on the workforce could be transposed to the DACH regions as well as other European countries.

Objective – Jobs and sectors with varying digitalisation contributions

Advancing digitalisation shapes and influences commercial trade and the work environment through increasing interconnectivity in society and new technologies. Slogans like “Digitalisation of the workplace” and “Work 4.0” are pervasive and often result in fear of the “End of Work” in the public perception

The positive impact of digitalisation in particular is seldom analysed. Physically strenuous activities could be replaced by digitalisation. Many tasks for higher-level personnel and academic professions could become more challenging. This is because new job profiles and qualification requirements also provide new opportunities. For certain employees, opportunities open up for more sophisticated tasks. For companies, there could be more scope for new business models and greater effectiveness. Within the framework of the present research, this should also be demonstrated. In the course of the research, it was examined if the shortage of workers[2] created by demographic shift could be reduced by heavy digitalisation in many cases.

The research landscape is largely divided on whether progressing digitalisation has a positive or negative employment impact on the job market or if certain sectors or professions are affected, also if digitalisation really does relieve the strain on the workforce bottleneck.[3.]

Therefore, in a cooperative study by PwC and WifOR in the near future, additional profession-specific workforce development will be projected and analysed up to year 2030 in nine different sectors in Germany, Austria and Switzerland. Increased labour migration, rise in female employment potential and the participation of the older generation in the workforce are often cited as ways to cover the labour gap in addition to the focus on increasing digitalisation of the work environment.

Hence, within the framework of this short study, the aim is to contribute quantitative findings to primarily qualitative discussions on the digitalisation impact on the labour market in the past. For this purpose, the possible impact of digitalisation on labour demand in nine different sectors are modelled and analysed based on digitalisation scenarios specific to the sector and job. The analysis focuses in this case on nine sectors and the professions in these sectors.

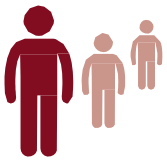
Branchenübersicht

- *Automotive*
- *Gesundheit und Pharma*
- *Technologie, Medien, Telekommunikation*
- *Energie*
- *Retail*
- *Transportation and logistics*
- *Financial Services*
- *Industrielle Produktion*
- *Public sector*

[2] cf. DESTATIS (2015); WifOR and PwC (2016): Labour study for Germany as well as selected comparisons with Austria and Switzerland (unpublished).
[3] cf. BITKOM (2013); Bruegel (2015); IAB (2015); ING DIBA (2015) among others.

Erkenntnisleitende Fragestellungen zum Einfluss der Digitalisation auf die Arbeitskräftesituation

1 *gesamtwirtschaftliche Auswirkung auf Arbeitskräftenachfrage* ?



- Erhöht oder verringert die Digitalisation die Nachfrage nach Arbeitskräften?

2 *absolute und relative Nachfrageeffekte* ?

- Welche Branchen und Berufe haben die größten Nachfrageveränderungen durch die Digitalisation zu erwarten?
- Welche Berufe sind in den Branchen für die größten Veränderungen verantwortlich?

3 *Auswirkung auf die Arbeitskräftesituation* ?

- In welchen Branchen und in welchen Berufen verringert sich der Engpass und wo verschärft sich die Engpasssituation?

The analysis differentiated by occupation and especially by sectors is necessary, because only then can specific features of the German labour market be taken into account. In addition, the underlying approach here combines two current research approaches[4], which considers both the routine and the experiences of certain tasks and their "susceptibility" to digitalisation impact and are supplemented with an occupational structure model. Therefore, the changes over the course of time could also be taken into account.

Those effects on demand associated with digitalisation, namely increase or decline of labour demand for certain professions in the sectors are represented using scenarios of digitalisation development. Hence for the first time, quantifiable results of a possible increase in digitalisation - differentiated by sectors, occupations and the impact on demand development and lastly, also on the labour situation - is possible.

Different players in the job market, including policymakers, companies but also public authorities – are obtaining scientifically founded data and facts pertaining to digitalisation from this analysis. The results show which future qualifications, professions and sectors will see higher labour demand and also where potential could be unleashed. This study follows a three-tier structure.

The positive impact of digitalisation: strenuous physical activities could be replaced by digitalisation.

New job profiles and qualification requirements mean new opportunities – sophisticated tasks for employees and new business models for companies.

[4] cf. Frey and Osborne (2013); Pfeiffer and Suphan (2015).

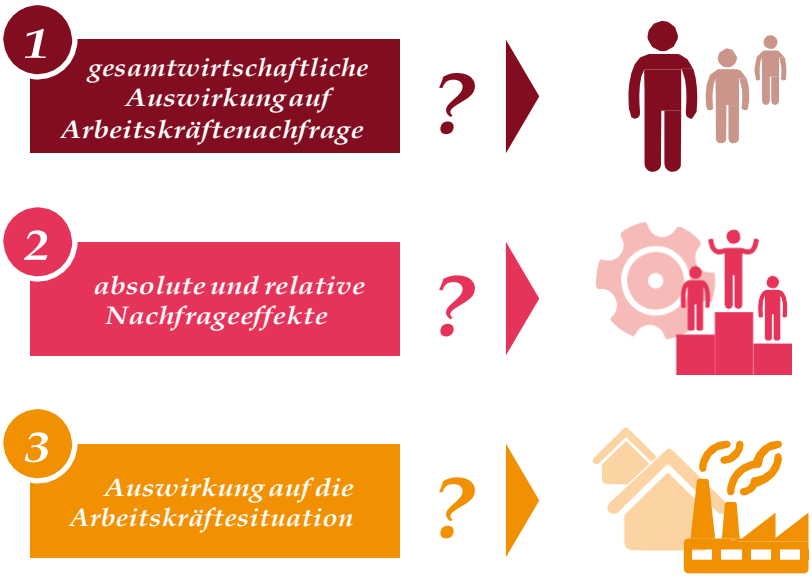
Digitalisation of the work environment – Influence on labour demand

Digitalisation und the accompanying transition of the work environment associated with it would be examined and quantitatively analysed hereafter. The springboard of this analysis is the demographic research from PwC and WifOR, where the potential supply and demand development for nine sectors and up to 43 occupational groups were modelled until year 2030.[5] Building on that, different digitalisation effects were calculated according to occupation and sector[6] with the aid of three different digitalisation scenarios (basic, strong and weak scenarios).

[5] Further information on the demographic research can be requested from the authors.
[6] Further explanations to the methodology used as well as the assumptions for the three scenarios can be found in the methodology appendix.

The analysis focuses on the change in demand for workers as a result of digitalisation. Hereafter, it should be illustrated in which professions and sectors additional demand impulse is anticipated due to more intensive workplace digitalisation and where it can be assumed that productivity increase and rationalisation tendencies reduce demand for workers in the long term. Following a demand-induced depiction of aggregate employment impact over time, an evaluation of the sectors follows - firstly as an overall overview, then supplemented respectively by a short sector profile.

Dreistufiger Analysepfad der Ergebnisse



- Erhöht oder verringert die Digitalisation die Nachfrage nach Arbeitskräften?

- Welche Branchen und Berufe haben die größten Nachfrageveränderungen durch die Digitalisation zu erwarten?
- Welche Berufe sind in den Branchen für die größten Veränderungen verantwortlich?

- In welchen Branchen und in welchen Berufen verringert sich der Engpass und wo verschärft sich die Engpasssituation?

1

Digitalisation changes development of demand and bottleneck

On the one hand, demand for labour is dependent on economic development in each sector and on the other hand, on available supply. As such, increase in digitalisation of the work environment could thus generate additional labour demand – for example, through the development of new technologies, business models etc. However, digitalisation could also lead to certain jobs being obsolete and thus less in demand, e.g. through digital technological productivity gain and the rationalisation impact associated with that, in the form of increased automation.

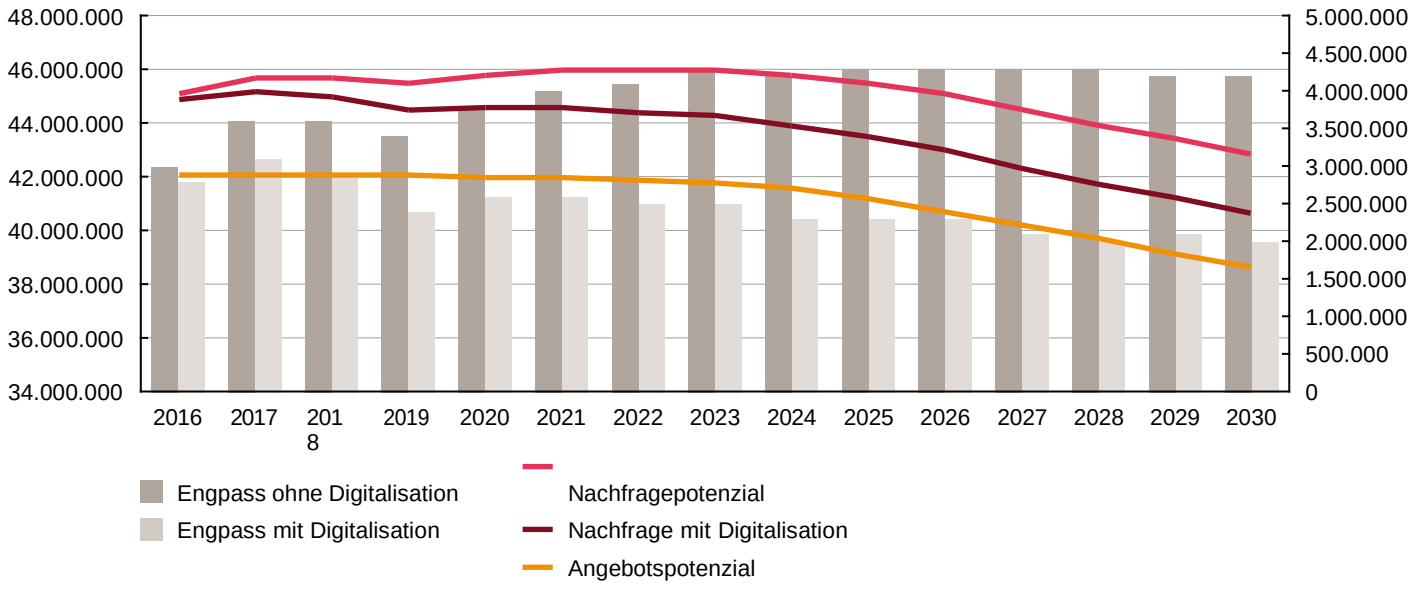
In the diagram below, the effect of demand as well as the impact on the labour situation[7] is shown for all sectors and professions. It becomes apparent that the aggregate effect of digitalisation leads to a reduction in demand and could thus relieve the labour situation in the course of time.

The future situation on the job market will be shaped by rising shortages, especially for professionals workers and academic professions (see bottleneck without digitalisation). Over time, the supply potential drops faster and more sharply than demand (keyword "demographic shift"), so that on average, almost 4,000,000 workers could be lacking annually until 2030.

With the digitalisation scenario presented here, there could be a reduction in demand. Therefore, the bottleneck could be reduced on average to 2,400,000 professionals lacking per year.

Nonetheless, due to the ascribed digitalisation effect, drop in demand – and as such also a possible relieve of the bottleneck - is not anticipated for every sector. Thus, in the next step, the impact on the demand for labour and also the labour situation will be shown according to sector and occupation

Nachfrageeffekte der Digitalisation und Auswirkung auf die Arbeitskräftesituation



[7] "labour situation" refers to the interplay between labour supply and labour demand. The following relationship applies: labour shortage = labour demand > labour supply; labour surplus = labour demand < labour supply.

2

Digitalisation effects according to sector

Further workplace digitalisation could lead to an increase or decrease in demand in the nine sectors. A positive impact on demand is expected when the positive employment impulse due to digitalisation outweighs the negative. Decline in demand always occurs when digitalisation leads to higher productivity and rationalisation effects.

In the diagram below, the absolute demand effects are shown in the year 2030, differentiated according to sectors.

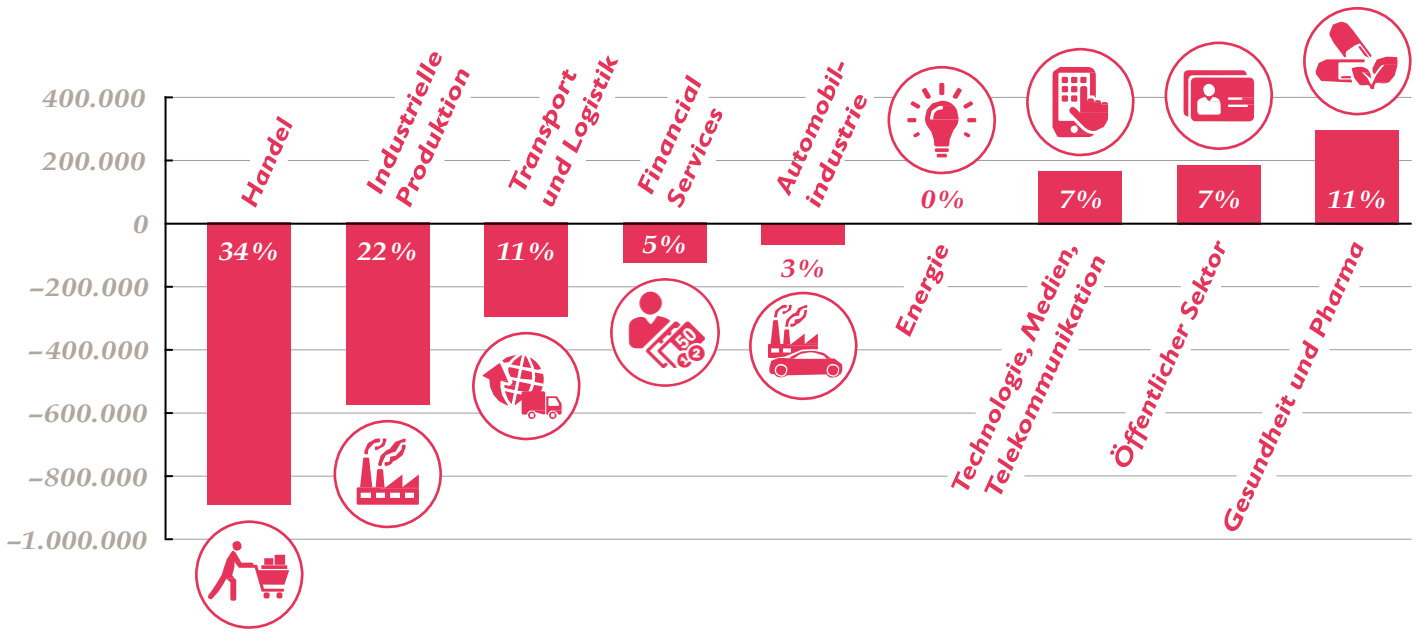
In addition, the respective share of each sector on the aggregate digitalisation effect is provided (in terms of amount).

Two third of the digitalisation effects affect three sectors

In 2030, digitalisation effects range from a decline in demand in the Retail sector of 900,000 workers to an increase in demand of about 300,000 in Healthcare and Pharma. Across all the sectors, it can be recognised at first glance that demand could decline in most of the sectors analysed.

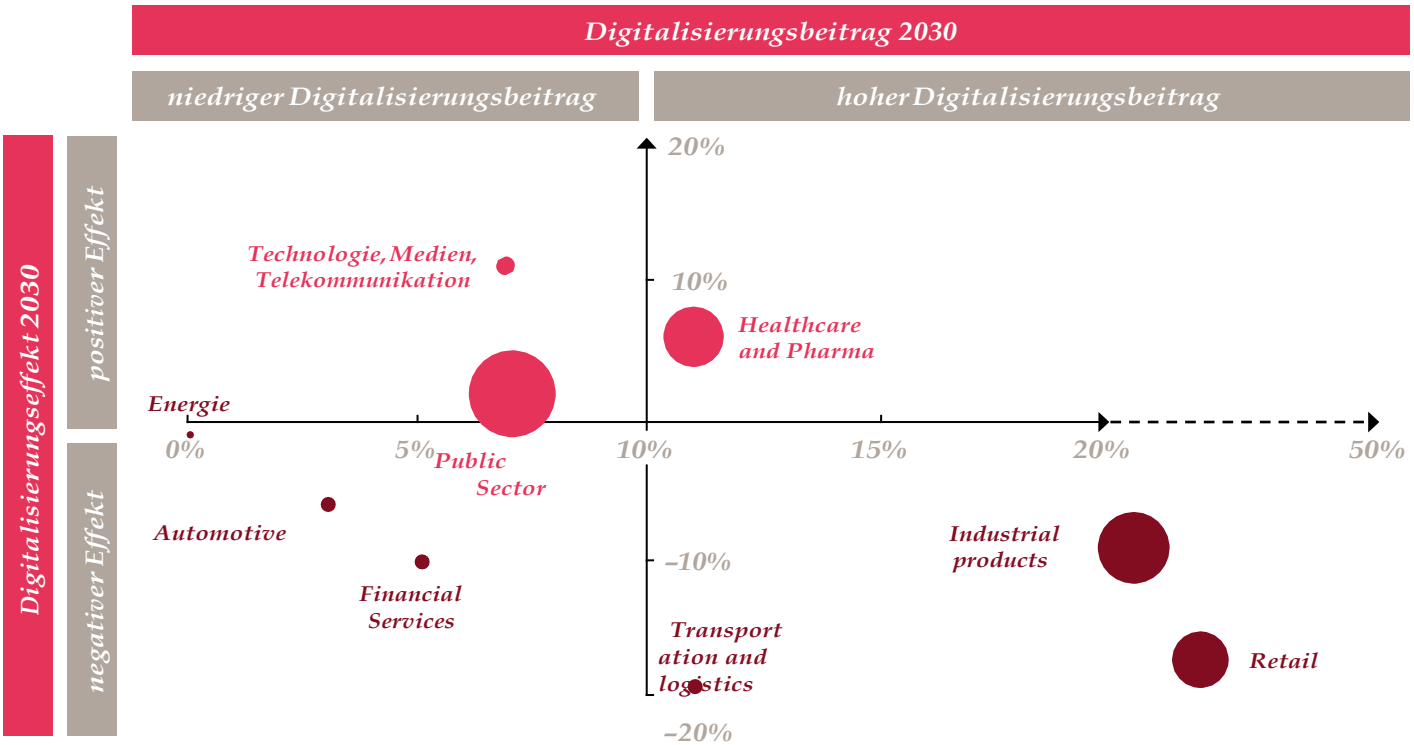
Furthermore, the decline in total is higher than the expected gain attributed to digitalisation. Hence, it could either result in a possible exoneration of the labour situation or a possible escalation of the workforce bottleneck in the individual sector. The largest absolute change in demand is in the Retail sector, followed by Industrial Products and then Healthcare and Pharma. Around two thirds of the anticipated digitalisation effect (positive and negative) on demand could be attributed to three sectors.

Absolute und relative Verteilung der Digitalisationseffekte auf die Nachfrage in den Branchen im Jahr 2030



Due to growing digitalisation, demand for professionals in the Technology and Media sector increases by 11 %.

fourfold table nach Branchen



Besides the absolute effect, the relative impact for each sector is also in focus – that is, to what extent each sector would be affected by the digitalisation-induced impact on demand. The induced impact on demand could mean again an increase or decrease in demand for labour. The decisive factor hereby is the expected labour demand in each sector in the year 2030. In the summarising fourfold table, the sector-specific digitalisation effect as well as the respective digitalisation contribution is illustrated.

Digitalisation effect corresponds to the induced change in demand due to expected digitalisation in the individual sectors – that is, how strongly the original demand would rise or drop due to digitalisation (values along the y-axis). The contribution to digitalisation shows the share of each sector on the absolute digitalisation effect on the overall economy (values along the x-axis). The strongest relative increase in demand is expected for the Technology, Media and Telecommunications sector – however, its share on the entire digitalisation contribution is minor.

In the fourfold table, the size of the circle represents the absolute demand for professionals in the respective sectors or the respective profession.

It becomes clear that the Technology sector has the highest relative digitalisation effect – an 11% increase in demand for workers is expected here in 2030. Due to progressing digitalisation, it can be assumed that higher investment for the development of new business models and a resulting rise in demand for workers may occur.

Transport and Logistics sector most affected

As a result of digitalisation, certain sectors would see a lesser demand for workers. The decline is at 1% in the Energy sector and up to 19% in the Transport and Logistics sector. Hence in relative terms, the Transport and Logistics sector is most affected by induced demand effects. The reason behind this is that certain jobs can be cut down due to advancing digitalisation and in addition, digitalisation in certain segments causes higher productivity improvement, which could result in a drop in labour demand.

Retail and Industrial Products with highest digitalisation contribution

The sizes of the circles in the diagram represent the absolute labour demand in the respective sector. In concrete terms, this means that the demand in the Public Sector in 2030, Healthcare and Pharma as well as Industrial Products will be the highest in absolute terms. In contrast, the Energy and Transportation and Logistics sectors are the least affected in 2030. This could be attributed to the absolute size of each sector. Combined with the digitalisation effect, the respective share of overall digitalisation contribution is obtained. It becomes apparent that Retail and Industrial Products are the two sectors most affected by digitalisation. Falling demand in Retail could only be compensated to a certain extent by an increase in demand in the sectors with positive digitalisation effects, thus the overall effect is declining demand.

In addition, it is striking that although there is a relative higher drop in demand expected, the contribution to digitalisation of the sector is nonetheless still somewhere in the mid range. With regards to the Energy sector, it can be deduced that the digitalisation scenario hardly has an impact on demand development.

The public sector alone will lack 820,000 professionals in

2030

Digitalisation exacerbates workforce bottleneck

The demand changes described so far cause a change in the workforce bottleneck in the sectors. In the diagram below, a comparison of the requirements[8] for 2030 with and without digitalisation scenario is shown.

In 2030, bottlenecks are to be anticipated in almost all sectors. This means, the expected labour demand exceeds the supply. The most serious shortage in absolute terms is predicted to be in Healthcare and Pharma (lacking about 720,000 workers), Public Sector (lacking about 820,000 workers) as well as Industrial Products (lacking about 550,000 workers).

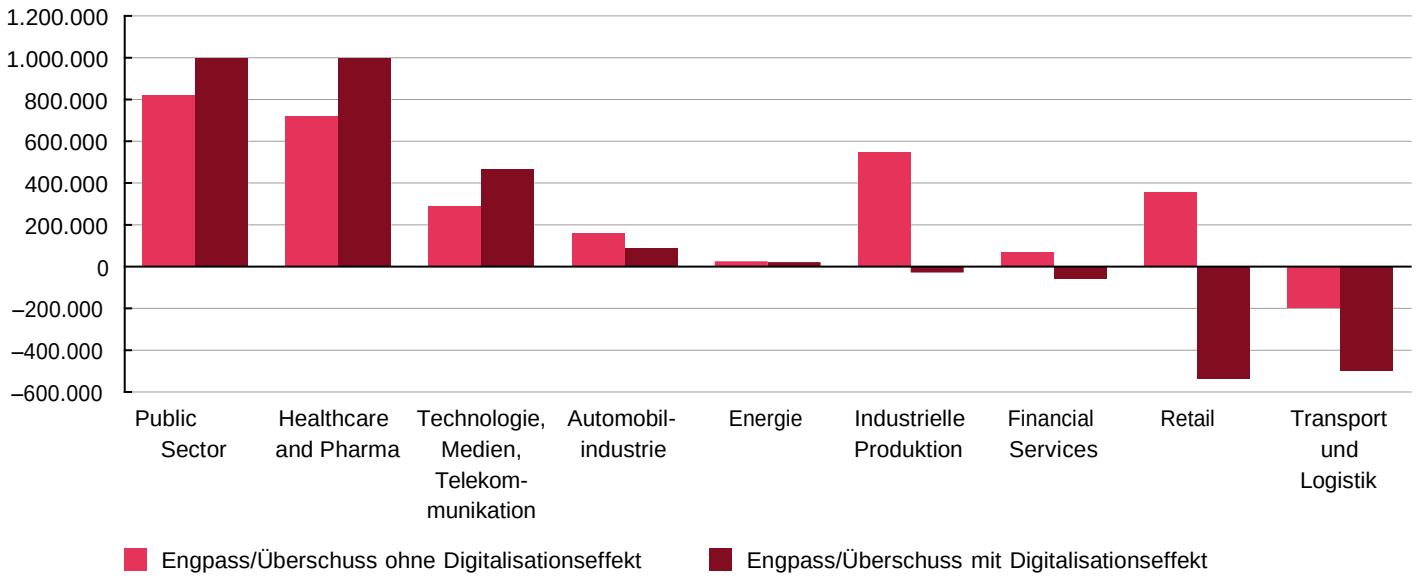
The digitalisation scenario assumed results in an exacerbation of the shortages in the first two sectors as well as in the Telecommunication sector, due to additional demand for professionals. Compared to the initial point without digitalisation, the bottleneck could be further heightened as follows: in Healthcare and Pharma by about 280,000 or 39%, in the Public Sector by around 190,000 or 23% and in the Technology sector by ca. 180,000 or almost 62%.

Retail and Financial Services: from shortage to surplus

In the other sectors, digitalisation could mean a relief on the labour situation.
In Financial Services and Retail, the projected bottleneck could even shift to a possible surplus in workers.

For the other sectors, this means that an additional potential of workers could be unleashed onto the market, which could cover the forecasted shortages. In the Transport and Logistic sector, the surplus of workers due to digitalisation could more than double. This could also mean a possible potential for other sectors. In addition, it should be pointed out that it is necessary to offer corresponding retraining or further qualification so that the potential workforce can be optimally employed in other sectors and fields of work.

Engpass nach Branchen im Jahr 2030 – Vergleich mit und ohne Digitalisationseffekt



[8] Bottleneck: demand > supply; Surplus: demand < supply.

Automotive

The results thus far have demonstrated that with about 3%, Automotive will have the second lowest relative and also absolute share of the overall digitalisation effect in 2030.

On the basis of the digitalisation scenario assumed, a drop in demand of about 71,000 workers in 2030 could be anticipated, corresponding to ca. 5.5% of the predicted labour demand in the Automotive sector in the same year.[9]

However, not all jobs will be less in demand. In contrast, there would also be occupations which are more in demand in the Automotive sector as a result of digitalisation.

In the facing fourfold table, the respective digitalisation influence for ten selected occupations in the sector can be seen.
The diameter of the circle reflects the prevalence of the respective job within the sector. The larger the circle is, the higher the demand for this job in the Automotive sector.

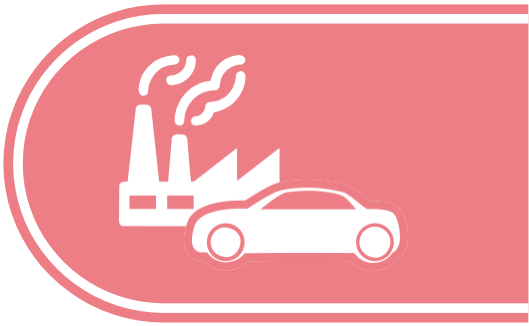
Drop in demand for metal workers

About one fifth of the demand decline for labour anticipated in 2030 due to digitalisation of the workplace can be attributed to the group of metal workers. This can be largely traced back to the automation processes and the rationalisation potential resulting from it. Furthermore, this occupational group is responsible for about 20% of the digitalisation contribution in the sector.

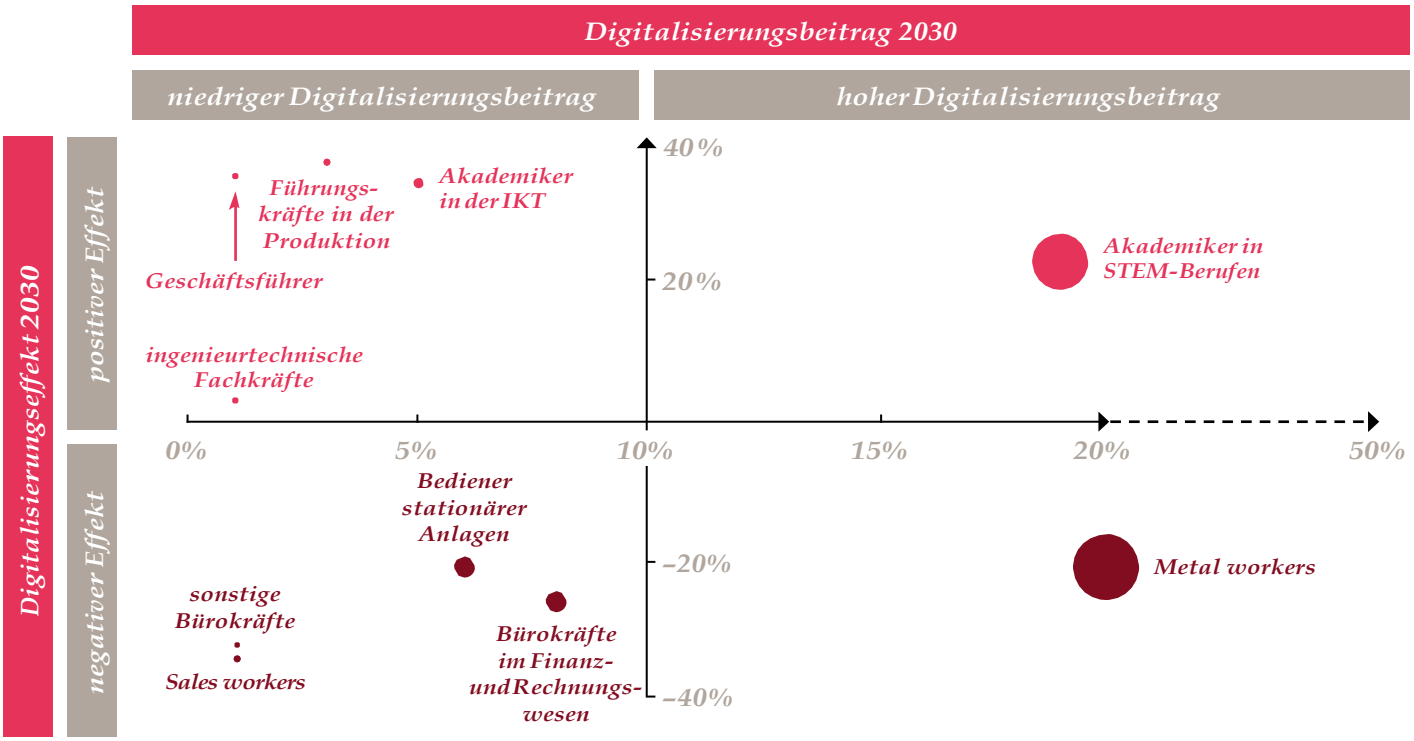
A lower demand is also predicted in the sector for stationary plant operators (-21% of the anticipated job-specific demand) and finance and accounting clerks (–26% of the anticipated job-specific demand). With 6% and 8% respectively, their share in terms of the sector-specific aggregate effect is rather low.

Demand for STEM academics rises by **23%**

[9] The values for demand mentioned in this chapter for the nine sectors refer to the results of the international demographic research from PwC and WifOR (Publication Spring 2016).



fourfold table Automotive für ausgewählte Berufsgruppen



However, digitalisation does not only lead to demand decline, it can also have a positive impact on hiring for certain occupations (cf. all jobs above the x-axis). It can be observed that academics in STEM professions in particular, exhibit not only a high positive digitalisation effect (23 % increase in demand in 2030 due to digitalisation possible), but also a high digitalisation contribution of about 19%.

In addition, other academic professions and managers have high digitalisation effects. Due to their lower demand in absolute numbers in comparison to the academics in STEM occupations, they only have a low digitalisation contribution.

As a result, the increase in demand in these occupational groups cannot make up for the demand decline in other groups. Hence, a slight drop in labour demand can be seen on the whole for the Automotive sector.

Energy sector

In the Energy sector, there are also professions shaped by digitalisation showing increasing and decreasing labour demand. A selection of occupational groups can be seen in the fourfold table on the opposite page.

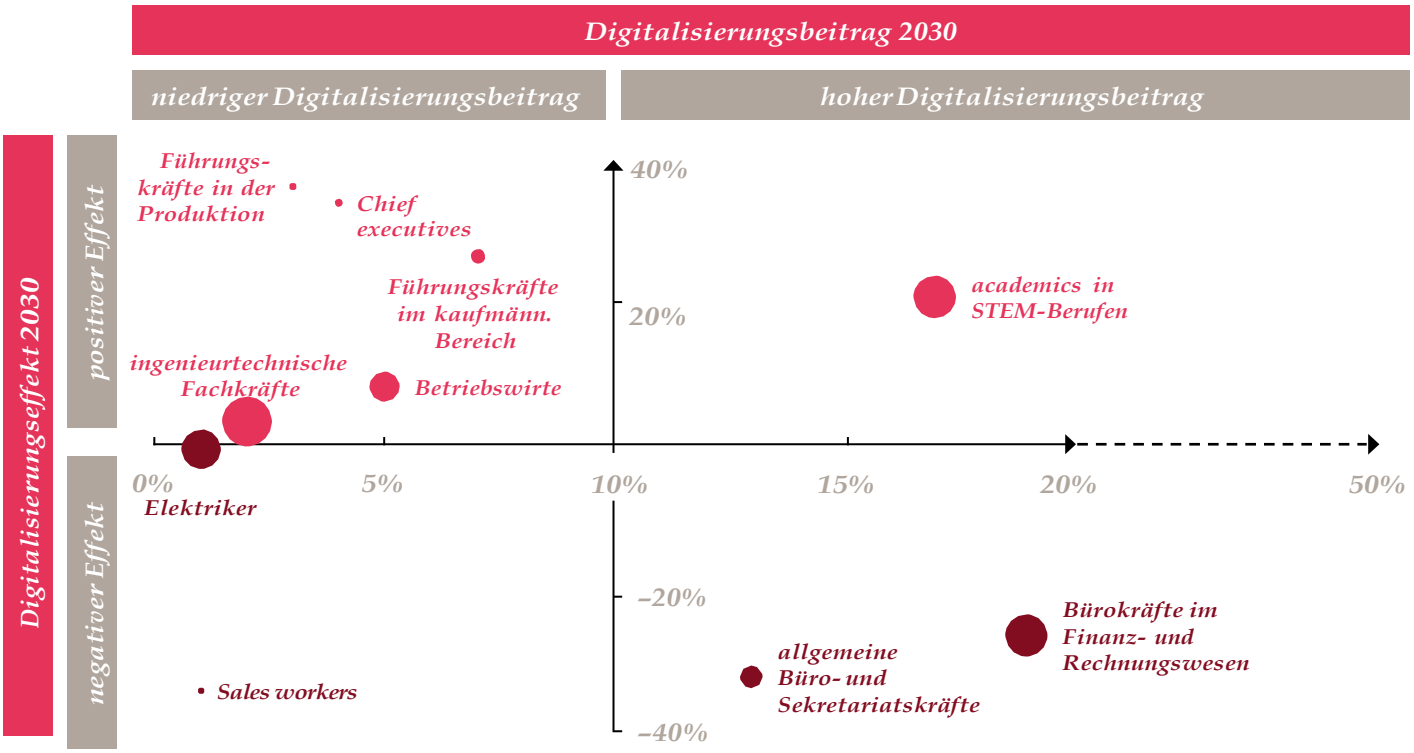
On the y-axis, the relative digitalisation effect of a profession can be seen and on the x-axis, the digitalisation contribution. The size of the circle reflects the absolute demand of the respective occupation.

Finance and accounting as well as general and keyboard clerks have the highest negative relative digitalisation impact in the Energy sector with –26% and –32% respectively, representing a high digitalisation contribution at the same time. With a digitalisation contribution of about 19%, clerks in finance and accounting form the occupational group with the highest digitalisation contribution in the sector. In contrast, electricians are high in demand (40,000). However, they only have a very small relative digitalisation effect of –1% and thus a low impact for the aggregate employment impact of the Energy sector (digitalisation contribution of 1%).

In the Energy sector, digitalisation effect is low: the drop relates to 3,700 professionals.

Increase and decrease in demand will almost even out

fourfold table Energy sector für ausgewählte Berufsgruppen



Academics in STEM professions especially are more highly in demand. In this field, there is a combination of higher absolute demand (44,000) and high positive digitalisation effect (+23%). This results in academics in STEM professions having a large digitalisation contribution of 17%.

In the year 2030, science and engineering professionals on the other hand have a digitalisation contribution of 2% although they are the largest occupational group with the highest demand (51,000). This can be attributed to the positive but weak relative change in demand (+3%) of the professional field due to digitalisation.

In general, the fourfold table of the Energy sector present an evenly distributed picture. Positive and negative employment impacts mostly even themselves out so that the aggregate employment impact of digitalisation is only 3,700 professionals fewer.

Financial Services

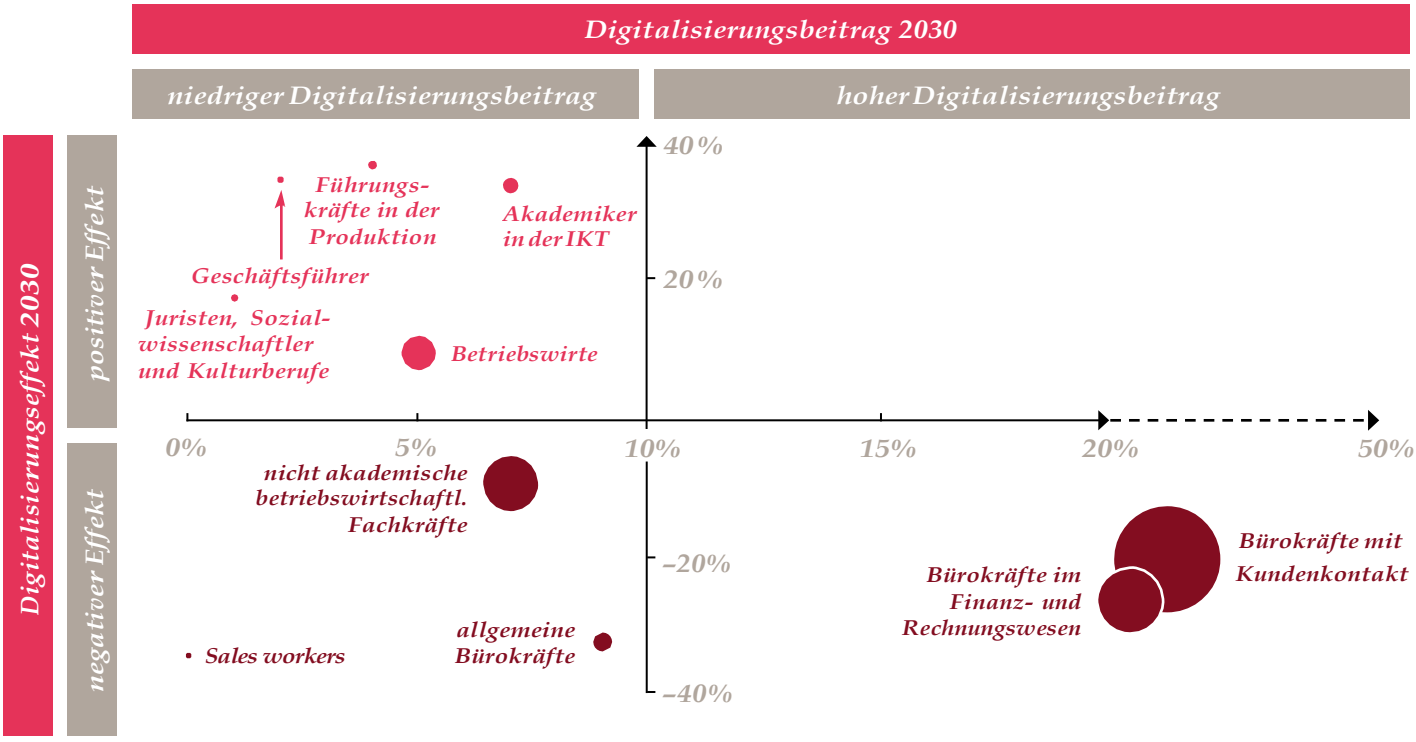
The Financial Services sector make up about 5% of the digitalisation effect of the entire economy. Up to 2030, there would be a decline in demand of about 130,000 professionals. Financial Services have relatively few occupational groups but they are substantial in size. The fourfold table also illustrates this clearly. The respective size of the circles symbolises the absolute demand for professionals in each occupation. Furthermore, along the y-axis, the relative digitalisation effect can be seen and on the x-axis, the digitalisation contribution (share of the individual occupation on the overall digitalisation impact of the sector).

Demand decline concentrated on two occupational groups

Customer services and finance and accounting clerks both stand out as the groups that could cause a negative employment impact. They show not only the highest absolute labour demand (400,000 and 250,000 respectively) but also high relative digitalisation effect (–20 and –26% respectively). This combination results in the high digitalisation contributions of 30 and 25% respectively, which means that these two occupational groups alone make up more than half of the entire digitalisation effect of the sector

130.000 *fewer professionals will be required in the Finance sector.*

fourfold table Financial Services für ausgewählte Berufsgruppen



In contrast, there are some occupations with a positive employment impact but all of them with only a low digitalisation contribution, thus of lesser importance in terms of overall impact for the sector. Even though chief executives and managers in particular display very high positive relative digitalisation effects (35 and 37% respectively), the low absolute demand (15,000 and 29,000 respectively) mean digitalisation contributions of only 2 and 4%.

This combination - professions with demand decline and high digitalisation contributions as well as professions with demand increase and low digitalisation contributions - result in an overall decline in labour demand as mentioned above.

Rising need in occupational groups with low digitalisation share

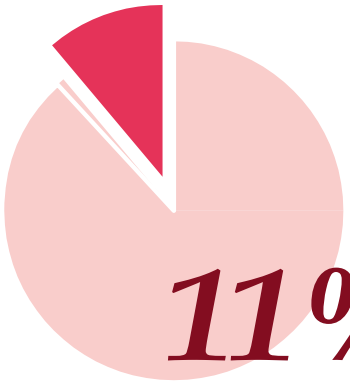
Healthcare and Pharma

Approximately a tenth of the overall digitalisation impact of all sectors can be attributed to the Healthcare and Pharma sector. The sector would experience a total increase in demand of 300,000 jobs whereby these openings are distributed very differently across the various occupational groups. The distribution can be seen in the fourfold table for ten professions.

In the Healthcare and Pharma sector, the demand of the respective occupational group develops very differently.
While two occupations on the right side of the y-axis with large circles can be found, the jobs left of the y-axis are seen with smaller circles.

Health associate professionals as well as health professionals have high relative digitalisation changes (11% and 29% respectively) and at the same time, a large share (52% combined) of the aggregate digitalisation impact of the sector.

The jobs left of the y-axis also have in part high relative digitalisation impact; but their influence on overall digitalisation is low because of their low total numbers. In these quadrants of the table, the largest positive influence can be observed for the legal, social and cultural professions, which make up 3% of the digitalisation effect across the sector with about 34,000 additional jobs.

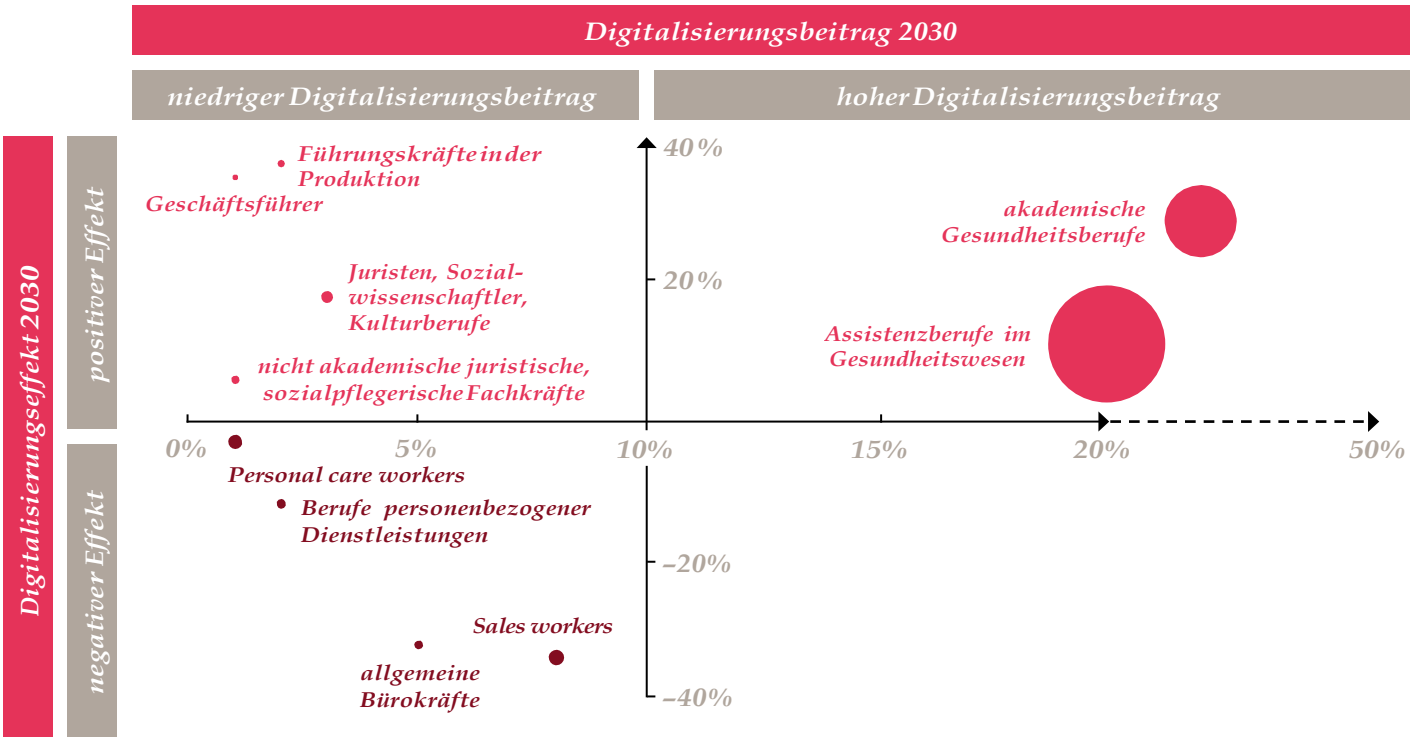


***11%** of the overall*

digitalisation effect applies to

the Healthcare
and Pharma sector.

fourfold table Healthcare and Pharmafür ausgewählte Berufsgruppen



In this sector, the largest negative influence is on sales workers. By 2030, demand for this occupational group would drop by an estimated 81,000. This reflects 34% of the overall demand for this group.

It is striking that the negative effects can be observed in occupational groups where a lower digitalisation contribution is anticipated. The table highlights that positive effects outweigh the negative.

Overall, digitalisation has a positive impact for the sector, driven by the two largest occupational groups. In addition to the excessive demand that is already palpable nowadays, digitalisation will further fuel the demand for academic and health associate professions.

Demand in the largest occupational groups will grow further

Retail

Up to the year 2030, Retail with about 900,000 workers is predicted to encounter the largest decline in demand compared to other sectors. This corresponds to approximately 34% of the overall induced change in demand due to digitalisation. The fourfold table shows that despite the anticipated drop in demand, there are still jobs in this sector that will increase in demand due to digitalisation impact.

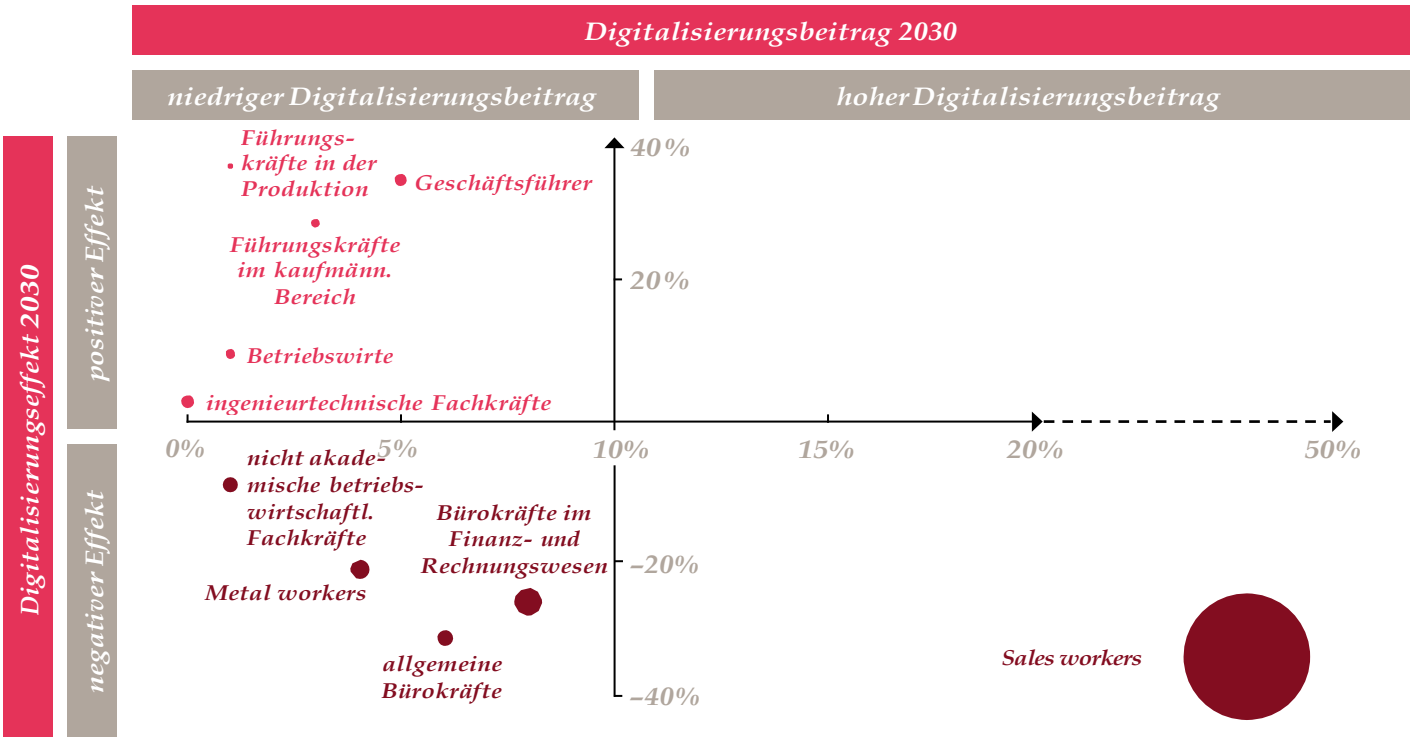
Professions that are predicted to be more in demand can be found above the x-axis – however, only on the left side of the y-axis in this sector. This signifies that although there would be more demand for these jobs, they do not have a large share on the overall digitalisation effect of the sector.

It also becomes obvious that this relates particularly to academic or highly qualified professionals. For chief executives especially, demand could increase by around 35%. Digitalisation contribution at about 5% for this occupational group in the sector is nonetheless quite minimal. The respective sizes of the circles reflect also the level of demand for the occupation in the entire sector. It becomes apparent that the jobs with the highest demand are located below the x-axis.

900,000

fewer professionals will be required by Retail due to digitalisation up to the year 2030.

fourfold table Retail für ausgewählte Berufsgruppen



Located below the x-axis are the professions where lower demand is expected. It is noticeable that about half of the entire digitalisation effect in the sector can be attributed to sales workers. In 2030, a demand decline of roughly 34% is anticipated here - due largely to automation effect and further electronic developments. In addition, it becomes clear that the reduction in demand for sales workers is responsible for nearly half (48%) of the entire digitalisation effect in the Retail sector. Also showing a regressive development in demand are the general as well as finance and accounting clerks.

The drop in demand for sales workers represents almost half of the entire digitalisation effect in the Retailsector.

Industrial Products

The sectors belonging to Industrial Products (Chemistry and Metal sectors, Machines and Plant Engineering as well as Construction) employ a range of different occupational groups. This broad spectrum means that the absolute total labour demand is spread across many different jobs. This can be observed in the fourfold table of the sector with the smallest circles, whose diameter represent the share of each profession on the total demand of the sector.

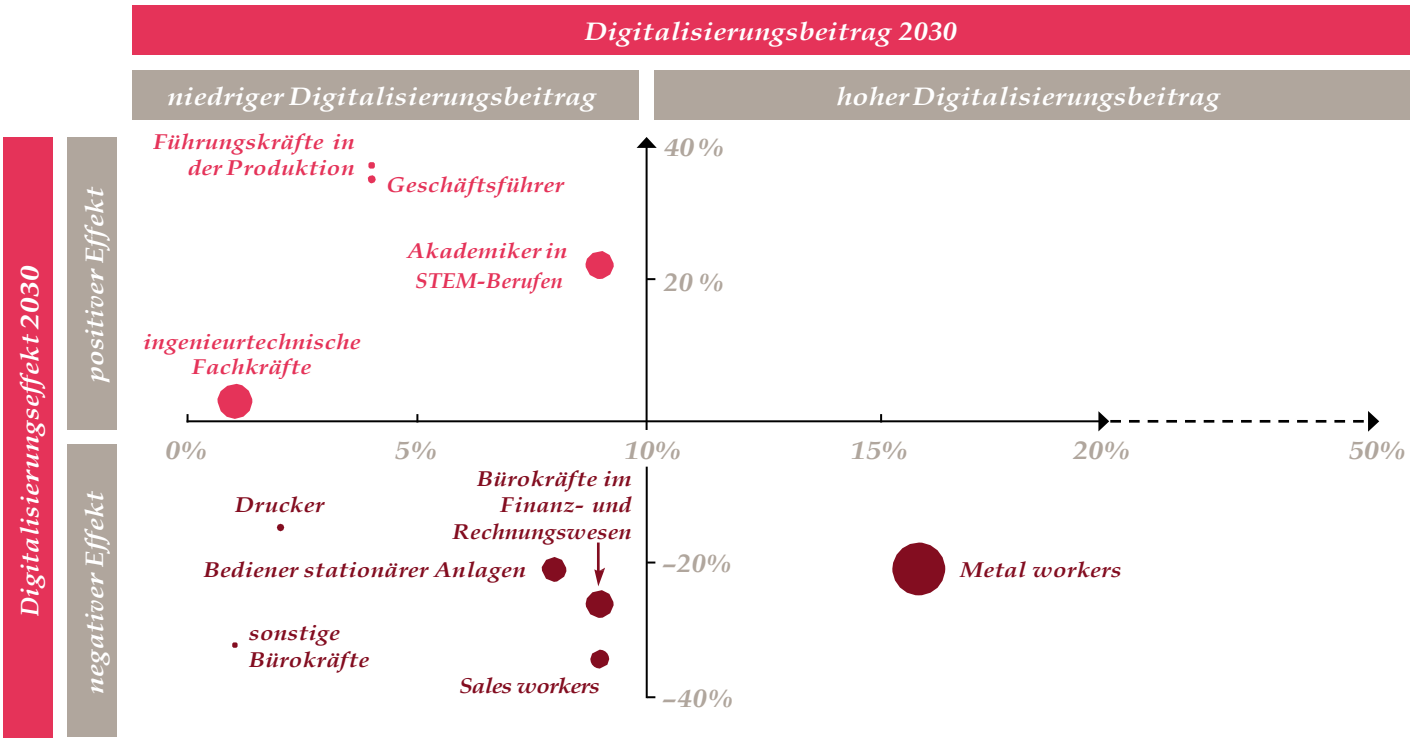
Furthermore along the x-axis, the relation between the job-specific change in demand due to digitalisation and the absolute demand for the job - the relative digitalisation effect - becomes obvious. Along the y-axis, the share of the respective profession on the overall effect for the sector, the digitalisation contribution, is also apparent.

Due to the variety of job profiles in Industrial Production, only a single occupational group can be found with high digitalisation contribution: the metal workers - where there are approximately a million employed in the sector. Combined with a negative digitalisation effect of 21%, this leads to a high digitalisation contribution of this group at 16%.

Only sales workers in the sector are more strongly affected by digitalisation. At -34%, this group has the largest negative relative digitalisation effect of all the jobs represented here. However, its share on the overall digitalisation effect of the sector is only 9%, as only around 360,000 sales workers will be required in IndustrialProduction

Digitalisation will lead to a decline in demand for traditional occupational groups

fourfold table Industrial products für ausgewählte Berufsgruppen



Academics in STEM professions have the highest digitalisation contribution (9%) in connection with a positive relative digitalisation effect (+23%). The only other occupational group that shows a proportionally high absolute demand (670,000) and a positive digital employment effect (+3%) is the occupational group of engineering professionals.

The deciding factor will be which tasks can be further automated and transformed into routine procedures. At the moment, we have to assume that the positive employment impact due to digitalisation will have a lower impact than the negative. What new jobs and what new challenges employees will face in the context of digitalisation and to what extent this need can be covered, remains to be seen.

It can well be the case that companies would not require fewer workers, but workers with other qualifications.

Their relative digitalisation effect is nevertheless too low to have a larger influence on the whole sector, the digitalisation contribution of the job is thus only 1%.The forecast makes it clear that in year 2030, the Industrial Production sector would anticipate a total demand decline of 580,000 jobs due to digitalisation.

Digitalisation in Industrial Products increases demand for academics in STEM professions by **23%**.

Technology, Media and Telecommunications

In addition to the Public Sector as well as Healthcare and Pharma, the Technology, Media and Telecommunications sector belong to the few segments that will see more labour demand. In the year 2030, it could be the case that the predicted labour demand will increase by around 11%. This would be the highest relative increase in demand (in comparison to the situation without digitalisation) of all the nine sectors analysed in this research.

This sector is characterised by academic professions that will be more in demand in the wake of digitalisation with ICT and associate professionals leading the way here. On top of this, other professions will be influenced in different ways by digitalisation. The distribution of the professions in the fourfold table corresponds to the relative digitalisation effect (demand increase or decline) of the respective profession and the digitalisation contribution, namely share of the job in the sector-specific demand change. The respective diameters of the circles show the extent of demand in the corresponding professions.

Pivotal for the rise in demand are academics in ICT, with a relative digitalisation effect of 34% and 45% of the digitalisation contribution in the whole sector.

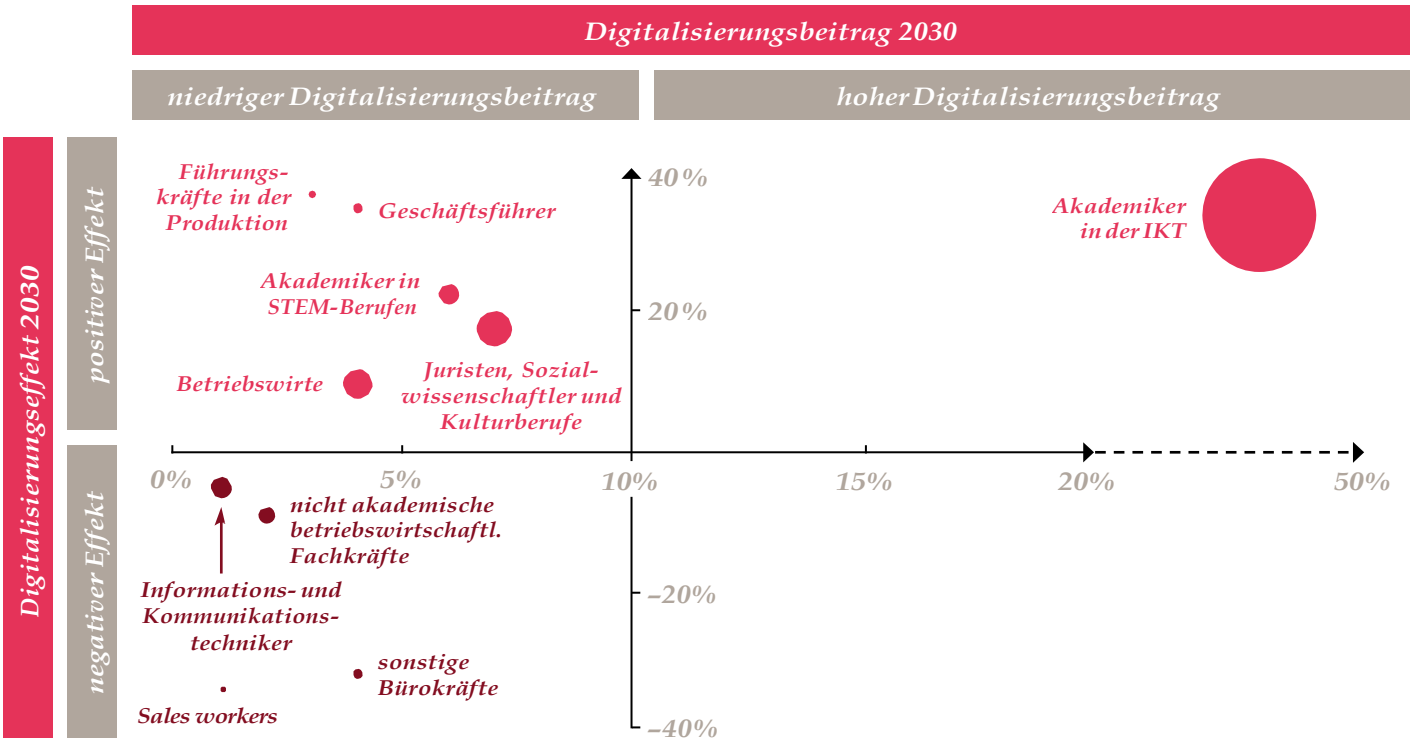
The highest relative increase in demand (37%) is caused by managers in production, but the digitalisation contribution (3%) is rather low due to the lower demand with about 12,000 jobs.

The influence of the absolute demand becomes clear when legal, social and cultural professionals, where in the sector 140,000 are employed, are taken into account in the comparison.

Despite the lower relative employment impact of this occupational group (18%), its contribution to the digitalisation effect of the Technology sector at 7% is more than twice as large. Significant is also the impact of the academics in STEM professions with a 6% digitalisation contribution.

*At **11%**, demand for professionals in the Media and Telecommunication sector would experience the highest impact due to digitalisation.*

fourfold table Technology, media and telecommunications für ausgewählte Berufsgruppen



However, the relative demand effect is not positive for every occupational group; there are also jobs where there will be demand decline in the Technology, Media and Telecommunications sector. For these jobs, in contrast to the jobs above the x-axis in the fourfold table, we are dealing with (higher-level) professionals.

The largest relative demand decline of –34%will affect the group of sales workers, which has a high rationalisation potential through digitalisation. However, this group has only around 12,000 workers; its contribution to the overall digitalisation impact on the sector is only 1%. With around 41,000 other clerical support workers, this group has a larger influence on the digitalisation effect of the sector: with a high relative digitalisation impact of -32%, they contribute 4% to the overall digitalisation effect in the sector.

Nevertheless, demand increase for jobs with positive digitalisation effect predominates overall. Thus, in the Technology sector, the employment growth as mentioned is possible.

The high share of academic professions results in high increase in demand due to digitalisation

Transportation and Logistics

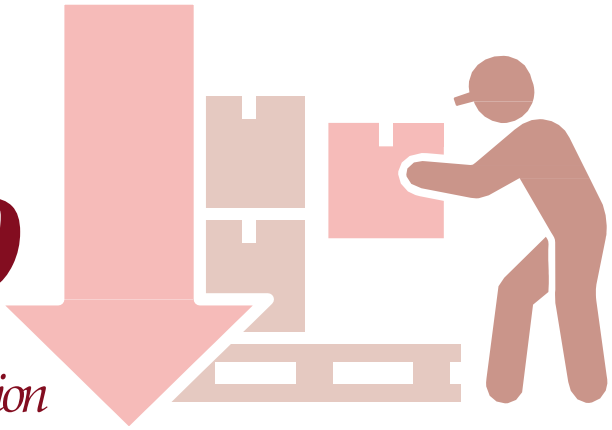
In the Transportation and Logistics sector, labour demand could reduce by 300,000 due to digitalisation in the year 2030.

Clerks in finance and accounting as well as drivers and mobile plant operators, which are the two largest occupational groups in the Transportation and Logistics sector, are significantly negatively affected by digitalisation.

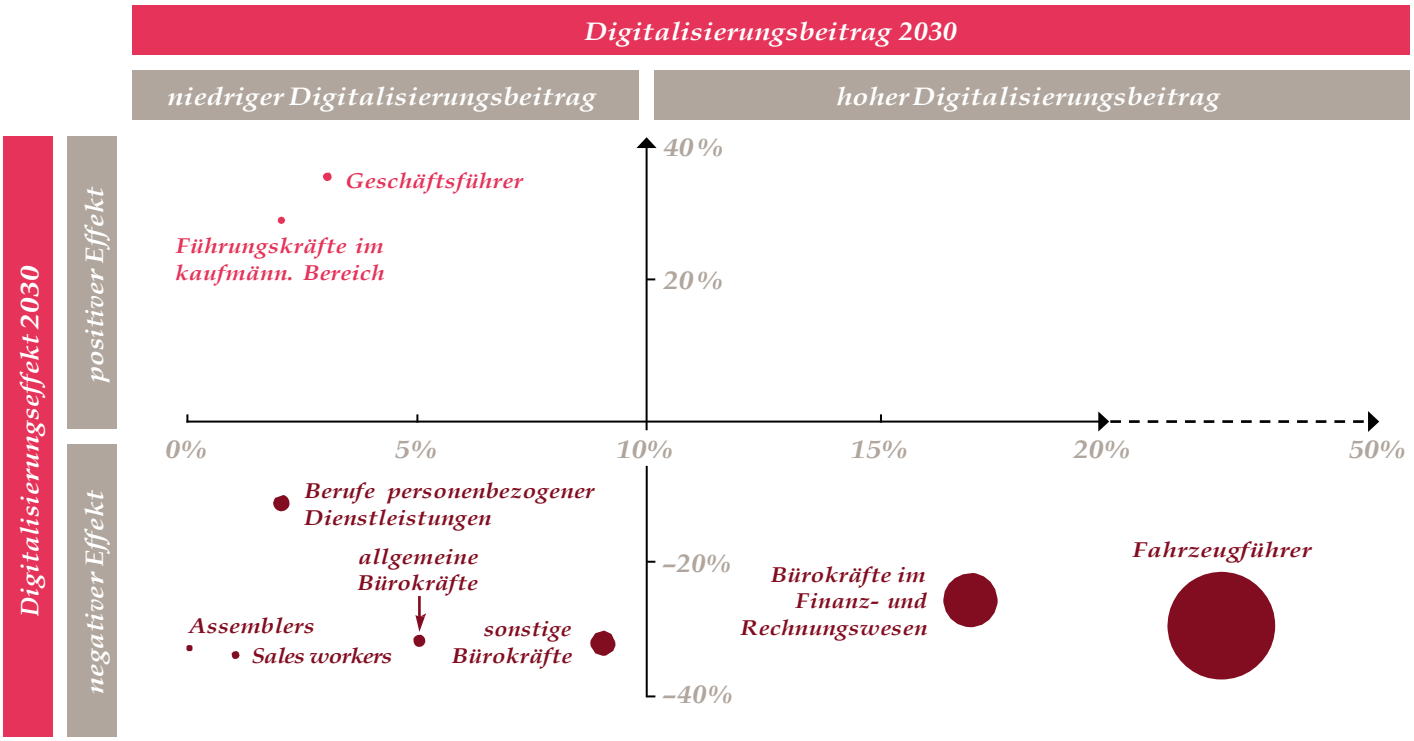
With 17% and 38% respectively, they contribute substantially to the overall digitalisation effect of the sector. Sales workers and assemblers also show sharply declining demand. However, the influence of each occupational group in this sector is low. Hence, their digitalisation contribution is below 10% of the overall sector impact.

300,000

lesser workers will be required by transportation and logistics companies through digitalisation.



fourfold table Transportation and logistics für ausgewählte Berufsgruppen



Rising demand effects can be true for the highly qualified. For chief executives, an additional demand for over 10,000 professionals and so could result in a positive digitalisation effect of around 35%.

However, the digitalisation contribution of around 3% is almost negligible on the sector effect. As such, the potential drop in demand masks the higher demand due to digitalisation in the Transportation and Logistics sector.

50% *of the decline in demand is apportioned to drivers and mobile plant operators.*

Public Sector

For the Public sector, digitalisation effect on the employment situation in 2030 is shown clearly by the ten most important occupational groups of this sector.
As a reminder: the y-axis of the fourfold table shows the digitalisation effect on the labour demand, on the x-axis the digitalisation contribution of each job to the overall change in labour demand in the sector.
The diameter of each circle reflects the scope of the demand for each job – the larger the circle, the higher the absolute demand for this job in the Public Sector.

In the year 2030, the Public Sector with around 190,000 professionals would thus see the second highest increase in demand of all the nine sectors analysed.

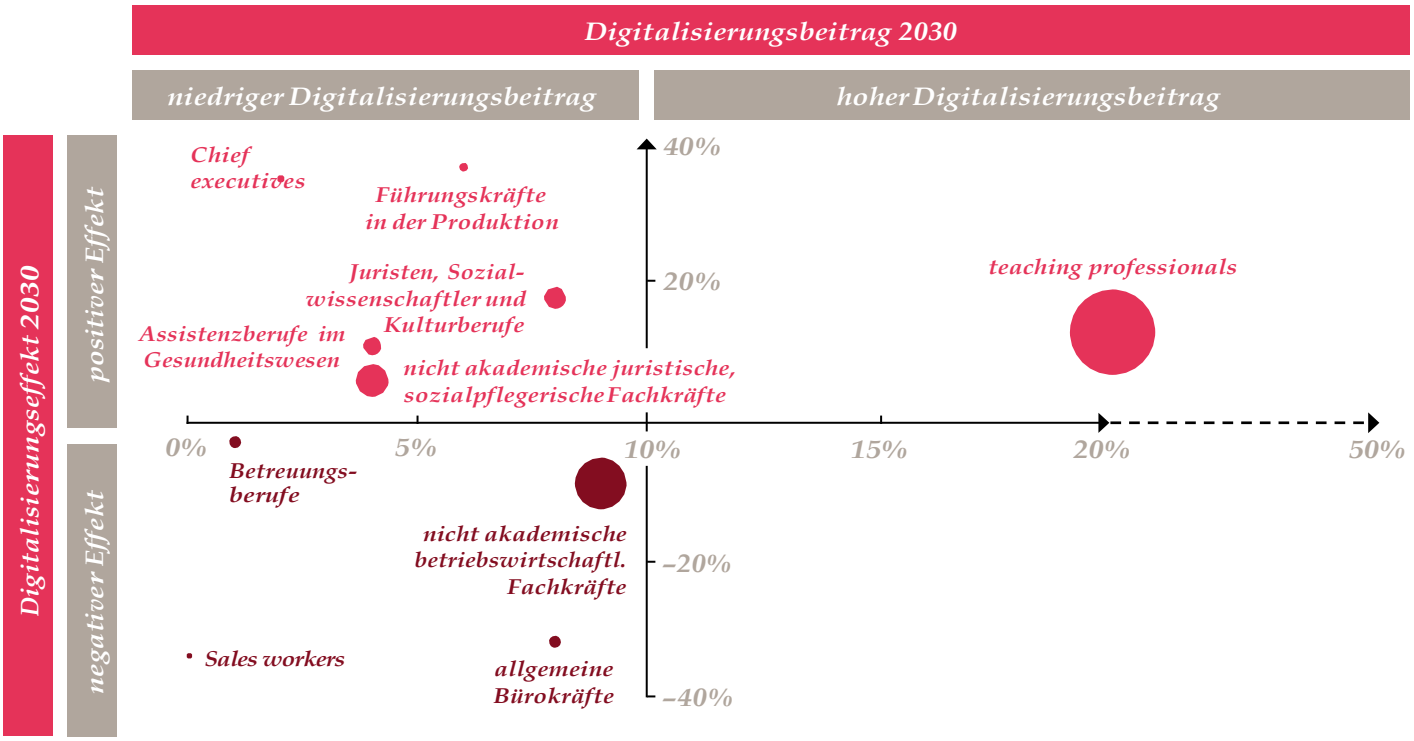
Despite a significant growth in labour demand in the Public sector, there will also be professions which will decrease in demand. They can be seen below the x-axis in the fourfold table.

It is conspicuous that the digitalisation contribution of each of these jobs is below 10% and thus actually only have a low impact on the overall sector impact.

Nonetheless, impact on demand for each of the professions could sometimes be relatively high. General clerks will see a drop of almost one third versus the demand expected without digitalisation. For business associate professionals, a lower decline of 9% in demand is anticipated. However, in absolute terms, this is higher in comparison to general clerks (see size of circles).

***190,000** additional workers will be required by the Public Sector due to digitalisation.*

fourfold table Public Sector für ausgewählte Berufsgruppen



The Public Sector is increasingly characterised by professions that would be more in demand due to increasing digitalisation. (see professions above the x-axis). Also for this sector, academic and highly qualified professionals in particular, would be further more in demand.

The largest share of demand growth is attributed mostly to the group of teaching professionals[10]. An increase in demand of up to 13% of the initial demand without digitalisation effect is possible. This corresponds to a demand for 240,000 professionals.

The main contributor to this growth is that in the future, more professionals will be needed to educate others in order to meet the new demands and to impart skills for the digitalised workplace.

Demand for the group of teaching professions rises by

13%.

[10] Included are for instance teachers, university professors but also trainers in the Information Technology segment.

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Digitalisation effects in selected professions

The analysis up to now has shown that not only among the sectors in general but also professions in different sectors can have diverging digitalisation effects. Hence thereafter, the impact of digitalisation on each profession will be analysed with focus on the sector.

Firstly, professions with the highest absolute digitalisation effects in 2030 will be listed; this can be either an increase or decrease in demand. This examination will then be supplemented by the fourfold matrix in order to display the relative aspects of digitalisation effects. Lastly, the development of the bottleneck situation will be elaborated for selected professions.

Given that demand change (due to digitalisation) according to professions can depend on the qualifications required respectively, the relationship between the trend in demand and the level of qualification for the jobs will also be differentiated.

Higher demand for higher qualified and academic occupational groups

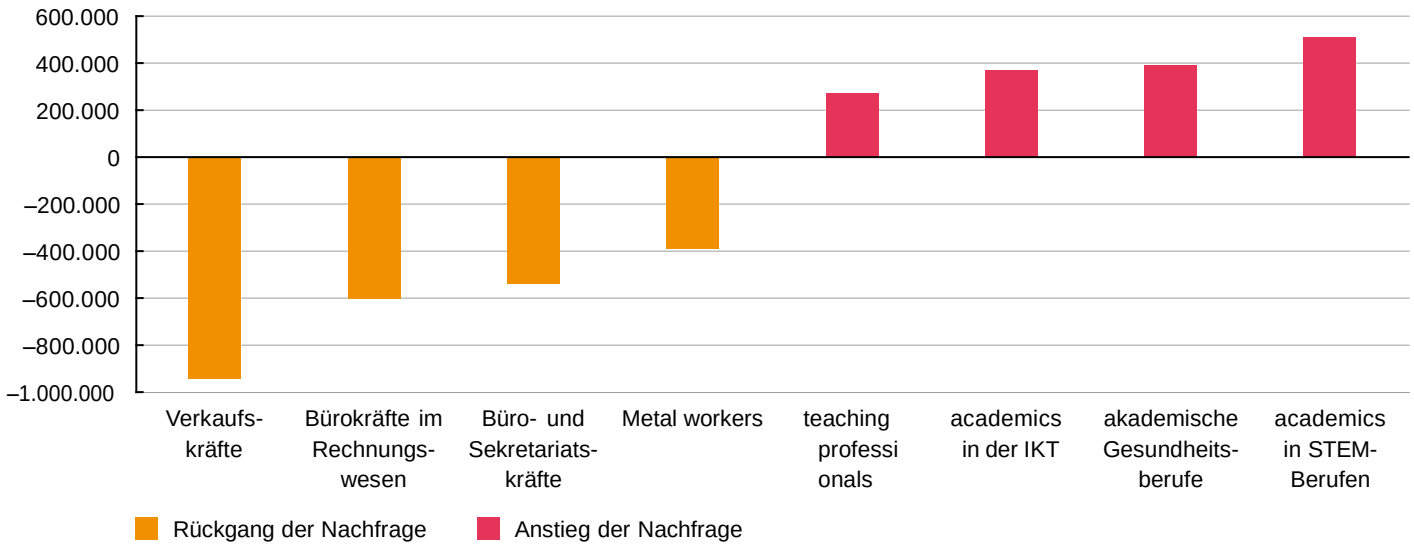
In the facing diagram, the professions with the highest absolute increase and decrease in demand in 2030, based on the assumed digitalisation scenario, can be seen. The ochre bars represent the jobs with the highest decline in absolute terms; the red bars represent those with the highest rise in year 2030.

According to this, sales workers are the "digitalisation losers" - demand for this occupational group will drop by 940,000 in 2030.

"Digitalisation winners "are the academic STEM professions especially, where about half a million more workers are required until 2030.

Around ***500,000*** *additional jobs for academics in STEM professions will be created by digitalisation.*

Berufe mit dem jeweils höchsten Nachfrageanstieg und -rückgang im Jahr 2030



Jobs with the highest increase in demand in absolute terms – academics in ICT, graduate health professionals, academics in STEM professions and teaching professionals – belong to the general group of academic professions. Jobs in the group have comparable job profiles and require a high level of qualification.

Highest absolute demand decline: sales workers

There is no comparable job profile for the jobs that will face the largest drop in demand by 2030: sales workers, clerks in accounting, general and keyboard clerks and metal workers.

However, the characteristics for these four occupational groups are namely, low level of qualification compared to the academic professions and the tasks involved are usually simple routine work[11].

The influence of qualification level on job demand and bottleneck situation will be elaborated in detail next. In addition, further occupational groups will be added to the fourfold table. Comparable job profiles will be analysed in connection with an increase or decrease in demand.

[11] cf. ILO (2012), S. 12 f.

Lowest digitalisation contribution and demand decline: assemblers

By 2030, employment demand in the overall economy would have an impact particularly on sales workers, which with 11%, has the largest digitalisation contribution. Moreover, the high absolute demand for 2,800,000 workers (without digitalisation) will be reduced by 34% as a result of the significant relative digitalisation effect.

Digitalisation could also have a negative impact on assemblers. They display a large negative relative digitalisation effect of -33%. Due to their low absolute demand of 200,000, the absolute digitalisation contribution to the overall economy is to a lesser extent.

In contrast, digitalisation increases demand for academics in STEM professions. Their digitalisation contribution is 6%. This high digitalisation contribution is on one hand, a result from the high positive relative digitalisation effect of +23% (relative demand increase compared to situation without digitalisation effect) and on the other hand, from the high absolute demand of 2,200,000.

Although health associate professionals have a larger role in terms of absolute demand (2,500,000), the lower relative digitalisation effect of +11% means a lower digitalisation contribution of only 3%.

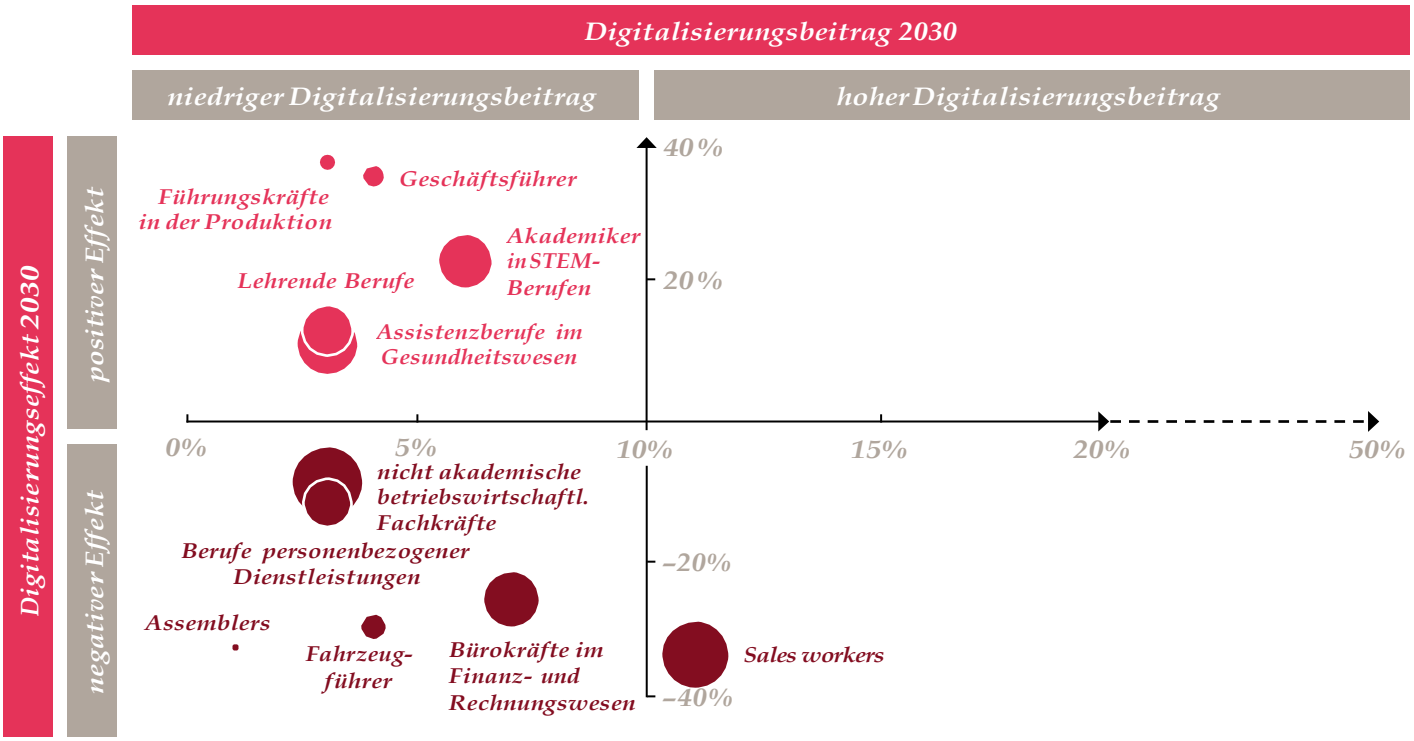
It can be observed that there are occupational groups with positive (above the x-axis) and with negative employment effect (below the x-axis). The two largest digitalisation contributions comes from professions with reduction in demand

That is a clear sign that the positive change in demand cannot compensate for the negative. After all, this can also be seen in the aggregate employment impact of digitalisation up to 2030, where there is a decrease of about 2,200,000 workers.

11% and thus the highest digitalisation contribution goes to sales workers.

Up to 2030, the aggregate employment impact of digitalisation comes to 2.2 million workers.

fourfold table Gesamtwirtschaft



Managers and academic professions sought

A positive digitalisation contribution comes primarily from professions belonging to the general groups of managers: (chief executives and production managers) and academic professions (academics in STEM professions, health professionals, business professionals, teaching professionals).

Jobs in the main group of managers also have a similar job profile. Main components of responsibilities are planning, leading, coordinating and assessing comprehensive activities of the company, the public authorities and other organisations or their organisation entities, partly supplemented by the tasks of creating and checking guidelines, rules and regulations. The job profiles of the academic professions have comparable tasks and responsibilities.

Decline in demand could arise for professionals and support staff

Sales workers, business associate professionals and assemblers are affected by a high negative digitalisation impact. These jobs have similar job profiles, primarily routine tasks. In the digitalisation scenario - these tasks will be replaced by machines with advancing automation in production.
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The higher the qualification, the higher the demand

Professions requiring high qualifications will constantly see an increase in absolute and relative demand due to digitalisation.

These jobs require resolving complex issues, making decisions and taking responsibility for them as well as the conceptualisation of theoretical and methodical relationships. Lastly, they contribute significantly to knowledge creation and transfer.

Technical and digital innovations will not be able to replace these tasks initially. On the contrary, demand for these qualifications will increase up to 2030 because the setting up of new business segments, educating and training employees and implementing new tasks in the wake of workplace digitalisation increase the need for these qualifications.

Digitalisation would exacerbate the shortage of academics, resulting in 3.3 million professionals lacking by 2030

Jobs that require mid-level qualifications - for example, upper level professionals - is insignificant to digitalisation contribution, neither in absolute nor in relative terms does the demand for these professionals change much in these jobs.

Underlying the performance assessment for mid-level qualifications is a broad task spectrum with different complexities. These are tasks and responsibilities that require simple, technical and numeric-intellectual capabilities, such as with assemblers, as well as jobs that require completing complex tasks, but without taking on responsibility and generating knowledge. This includes health associate professionals for example.

The lower the qualification, the higher the negative effect

Jobs requiring a low qualification level to perform the tasks would be increasingly replaced due to virtual digital and information-technical development. Until 2030, demand for these jobs would thus drop correspondingly.

Engpass- und Überschusssituation nach Qualifikationsstufen mit und ohne Digitalisationseffekt für die Jahre 2020, 2025 und 2030

2020		mit Digitalisationseffekt
akademische Berufe	820.000	1.400.000
gehobene Fachkräfte	1.100.000	1.100.000
Fachkräfte	1.600.000	13.000
Hilfsarbeitskräfte	170.000	–350.000
2025		**mit Digitalisationseffekt**
akademische Berufe	1.100.000	2.400.000
gehobene Fachkräfte	1.200.000	1.300.000
Fachkräfte	1.600.000	–1.300.000
Hilfsarbeitskräfte	48.000	–880.000
2030		**mit Digitalisationseffekt**
akademische Berufe	1.300.000	3.300.000
gehobene Fachkräfte	1.300.000	1.400.000
Fachkräfte	1.400.000	–2.600.000
Hilfsarbeitskräfte	–81.000	–1.300.000

For academic professions requiring a high level of qualification, digitalisation will exacerbate the already existing shortage today. This bottleneck will be more acute from year to year. Hence by 2020, the shortage could already increase to 1,400,000 from the 820,000 lacking today.

Due to digitalisation, the bottleneck without digitalisation could become more than 2.5 times higher in the year 2030. In contrast, digitalisation results in a surplus situation for professionals and unskilled labour on the job market.

Jobs in the group of managers, which include chief executives, production managers, hospitality managers as well as administrative and commercial managers, belong to the group with the highest relative and absolute increase in demand– thus seeing an intensification of the bottleneck in the year 2030.

For all the professions shown in the diagram, advancing digitalisation will cause a large increase in shortage in the year 2030. The highest absolute digitalisation effect in the form of an increase in demand applies for academics in STEM professions. It would see the highest absolute increase in bottleneck due to digitalisation, where there could be a 2.5 times increase in the scenario without digitalisation.

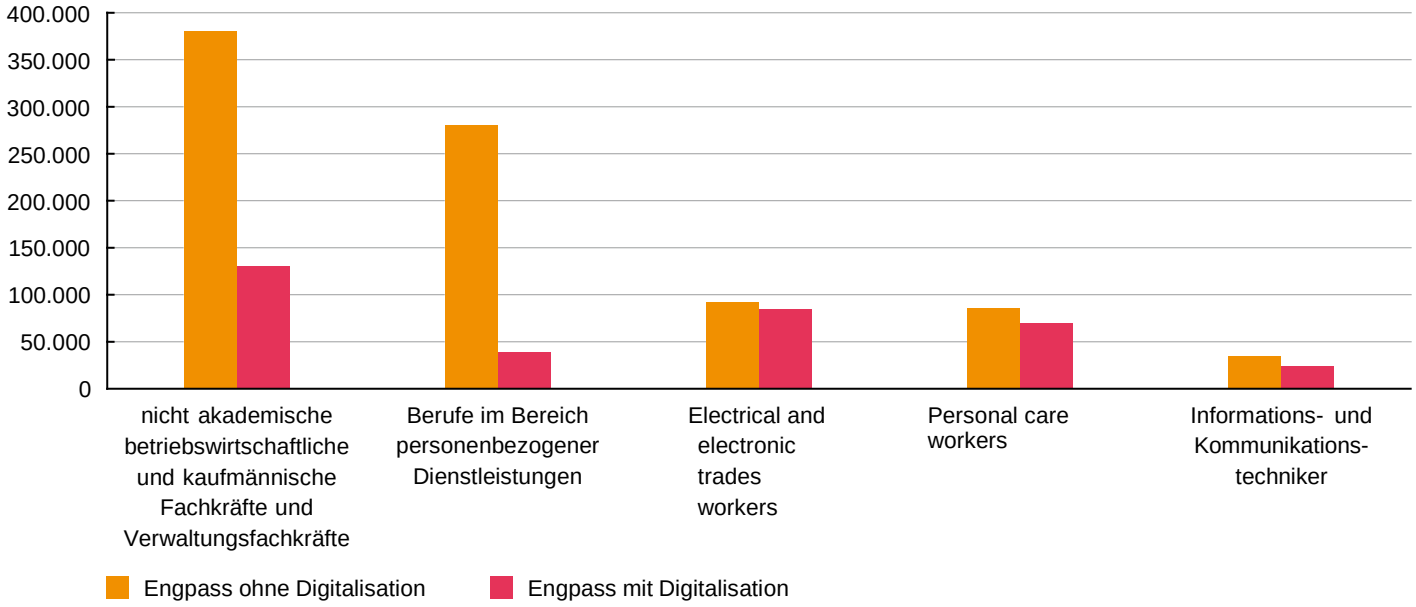
For production and specialised services managers, the shortage situation could even almost quadruple.

Up to 2030, the bottleneck for individual jobs could however be eased or reduced as a result of digitalisation. In the diagram below, there are five selected professions where the shortage with and without digitalisation impact could lessen.

Due to digitalisation, the bottleneck situation could ameliorate significantly

Business associate professionals for instance will see a shortage of 380,000 workers in 2030 without digitalisation impact. Under the premises of advancing digitalisation, this shortage is reduced by 66% to about 130,000 missing workers. For the information and communications technicians, there is hardly a digitalisation effect, even though the shortage will also lessen due to digitalisation.

Engpasssituation mit und ohne Digitalisationseffekt im Jahr 2030 – abschwächende Wirkung



Due to digitalisation, 2.5 is the factor by which the shortage for academics in STEM professions will grow by 2030.

From bottleneck to surplus - without digitalisation effect, up to 190,000 general clerks would be lacking. As a result of digitalisation, there would be a surplus of 350,000.

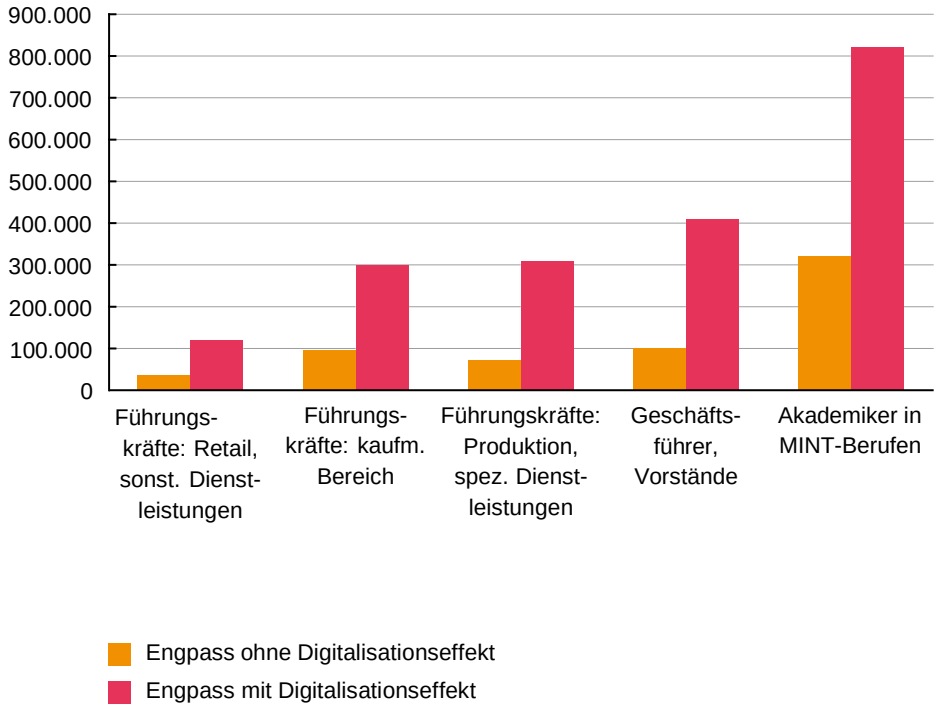
Digitalisation could lead to an oversupply of general and keyboard clerks

Digitalisation could also lead to a flip in the bottleneck situation. This becomes clear in the accompanying graphic for jobs in various main job groups and thus varying profiles for jobs and requirements

The drop in demand due to digitalisation results in the change from bottleneck to surplus for the professions shown.

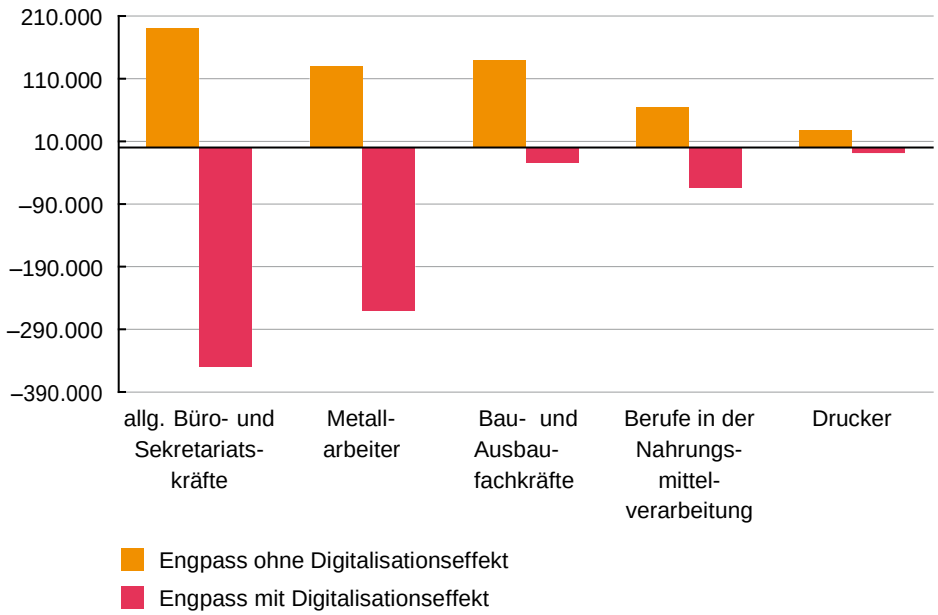
While digitalisation could convert a bottleneck to a high oversupply in absolute terms for general and keyboard clerks as well as metal workers,a levelling out of demand and supply could be the result for building and related trade workers and printing workers.

Engpasssituation mit und ohne Digitalisationseffekt im Jahr 2030 – verstärkende Wirkung



In the occupational group of general keyboard clerks for example, a shortage of 190,000 workers is to be expected without digitalisation in 2030. However, digitalisation effect results in a reversion of this situation for this profession -: a surplus of 350,000 workers.

Engpasssituation mit und ohne Digitalisationseffekt im Jahr 2030 – überkompensierende Wirkung



Digitalisation excursion: Impact of different scenarios

Results presented in this research are based on a so-called **basic scenario**, which assumes a constant moderate growth in digitalisation over the course of time and across the entire economy. This has the same impact across all professions and sectors; hence it is a basic standard digitalisation occurring in the economy and society. As the benchmark model, the basic scenario assumes the current most plausible annual growth rate. Digitalisation is thus realised gradually, based on a constant digitalisation growth rate. In order to cater to other possible development in digitalisation, we modelled two other scenarios with other growths.

The **weak scenario** assumes an initial digitalisation rate that is below average, which then gradually reaches a higher growth rate. This path is based on the assumption that digitalisation develops in a self-enforcing process. A faster initial digitalisation growth, but also a quicker onset of the saturation phase is depicted in the **strong scenario**. This is based on the assumption that a large part of investment in digitalisation would already take place in the near future and as such, available potential for digitalisation would be tapped earlier.

Based on the basic scenario,
2028 *is the year where the highest digitalisation effect is perceptible*

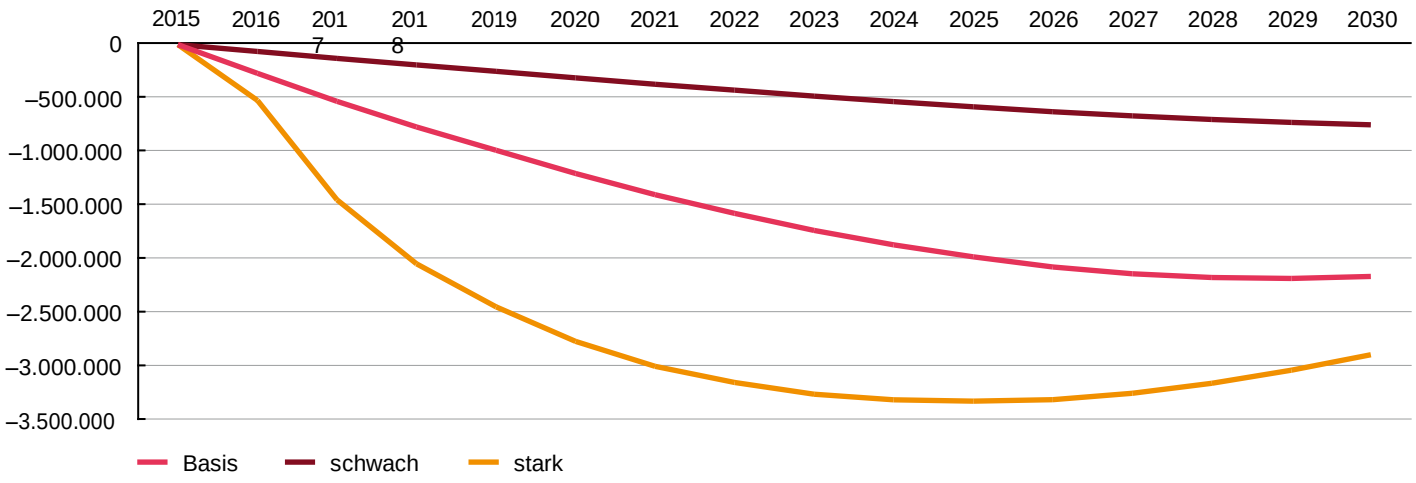
The results from the weak and the strong scenario can differ from that of the reference model, the basic scenario. In order to get an idea of how a different future digitalisation development could affect the results compared to the basic scenario, the aggregate digitalisation effect across all scenarios will be compared with each other. Viewing the overall digitalisation effect of the three scenarios shows more clearly the different trajectories digitalisation can take.

In the weak scenario, there is an increase in digitalisation effect every year, over the entire period (2016 to 2030) - even though this is only moderate in absolute terms.

The increase is in the form of a demand decline across all sectors and professions. In contrast, the maximum demand effect is already reached in 2025 in the strong scenario, by 2028 in the basic scenario. Thereafter, the annual digitalisation effect will be less significant. It is interesting to note that independent from which digitalisation pathway is assumed, the aggregate demand impact always draws closer over the course of time. The largest absolute difference is between the weak and strong scenario - which already reaches its peak in 2024, corresponding to a difference of about 2,800,1 professionals. In 2030, the difference between the weak and strong scenario will only be about 2,100,000.

This demonstrates clearly that from a certain digitalisation rate onwards, a marginal digitalisation increase only has a low digitalisation effect. At this point, a very high level of digitalisation in the economy and society has been reached – up to this point in time, information-technological innovation that were carried out by workers have been replaced – only moderate employment impact is to be gained by further digitalisation. Depending on the scenario chosen, this digitalisation level is reached at a faster or slower rate.

Digitalisationseffekt (gesamt) nach Szenarien im Zeitverlauf



Conclusion and outlook – Opportunities for politics and the economy

Forecasts show that an increasing digitalisation from the macroeconomic perspective could reduce the anticipated shortage of professionals from over four million in 2030 to about two million. In the Public Sector as well as in Healthcare and Pharma and Telecommunication, digitalisation could trigger further demand for labour. This could potentially intensify the labour shortage in these sectors. On the other hand, digitalisation would cause a strong decline in labour demand in the Retail sector.

Conclusion

With regards to professions, digitalisation causes in a mixed picture: highly qualified professions with complex requirements will be more in demand in the future, this include academics in STEM professions for instance. In the area of routine tasks, digitalisation causes progressive rationalisation - where the demand for professionals would significantly drop as a whole, for the occupational group of sales workers in particular.

On the basis of empirical modelling of digitalisation impact according to sectors, professions and qualifications at various points in time, we can claim the following essential results.

2 million

professionals will still be lacking in Germany up to year 2030 despite digitalisation.

Easing of the labour situation is possible through digitalisation

- Bottleneck in the year 2030 without digitalisation scenario almost at 4,200,000 workers
- Bottleneck in the year 2030 with digitalisation scenario (basic) at about 2,000,000 missing professionals

Diverging effects of digitalisation for the sectors

- In Healthcare and Pharma, an additional demand of ca. 300,000 professionals would be anticipated in 2030, while Retail would see a demand decline of around 900,000.
- In Retail, Industrial Products and the Public Sector, two thirds of the (absolute) digital effect is realised; the Technology sector has the highest relative digitalisation effect.
- The main driver of digitalisation effect is different for the sectors. While in the Public Sector about a fifth of the absolute digitalisation effect is caused by teaching professionals, it is the sales workers in Retail that is responsible for half of the digitalisation contribution.

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20 % *of the digitalisation contribution in the Public Sector pertains to teaching professionals alone.*

Professions affected by digitalisation in different scope and directions

- Routine tasks could more likely be rationalised in the course of progressing digitalisation, complex tasks with specific requirements will experience an increase in demand.
- Academics in STEM professions could anticipate an increase in demand of about 510,000; sales workers a demand decline of approximately 940,000 in the year 2030.
- Digitalisation could worsen, relieve or overcompensate for the bottleneck situation anticipated.

Digitalisation requires more better-trained professionals

- In academic jobs and for higher level professionals, the digitalisation impact is highly positive.
- The shortage situation could worsen over time for academically-qualified professionals due to digitalisation; for support workers, the lower shortage due to demand decline could be reinforced and could result in a large surplus.

The results of the short study highlights that there is no uniform direction of impact and no homogeneous digitalisation effect. Therefore, in certain sectors and jobs, more professionals will be required; those who can drive digitalisation and meet the new demands. On the other hand, potential could be unleashed onto other sectors and professions, which in theory could be available to cover the prevalent shortages in other sectors and professions. Nonetheless, this cannot take place without appropriate education and further training. Over the course of time, digitalisation effects could be further intensified independent of the scenario chosen. In perspective, it would thus result in adjustments to the labour supply (in the form of altered education and training). Digitalisation can thus be seen as an opportunity to meet the challenges on the job market and as a possible relief, specific to both sector and job.

This research is designed in such a way that it can be transposed onto the international job markets. Hence, making an analysis of the Austrian and Swiss labour market possible (based on the research on professionals).

Recommended actions

The forecasts leave no doubt - digitalisation of the economy and society is not a fashion trend. The Internet of Things, Industry 4.0, robotics or big data generalised under the collective term „Digitalisation", will fundamentally change the manner that companies operate and people live.
In some areas like in the Media sector, the change is almost concluded. In other branches of industry, the revolution has already begun or is at the starting point.

Critics of digitalisation focus especially on the possible negative effects of digitalisation. Issues such as data security, legal framework and international norms certainly have to be discussed intensely and worked upon. However, labelling digitalisation sweepingly as "job killer", in order to evoke fear and resistance, is not going to bring about any sustainable solutions.

Therefore, we would like to inspire an objective debate with this research, where the arguments are based on historical data and statistic projections using different scenarios. In view of the fact that up to 2030, Germany will have around four million fewer workers available than needed due to demographic shift, ultimately the impact of digitalisation on the labour market is less a curse than a relief.

However, in order to utilise this development as an opportunity, politics and the economy have to set the course on time. The creation of important framework conditions as well as targeted investment are important steps to securing Germany's future as a business location and to ensure its people are ready for challenges ahead.

Digitlisation could bring back earlier labour intensive processes to Germany

Digitalisation is not a "job killer" - it reduces the labour bottleneck until 2030.

Politics

From a socio-political point of view, digitalisation offers a huge opportunity to reduce dramatically the anticipated labour bottleneck due to demographic development. In Germany, this bottleneck will be more serious than in most other countries. As a reminder, Germany is facing the same demographic challenge as the oldest country of the world, Japan. As a result, around 3.5 million fewer workers will be available in 2030 than today. Digitalisation could thus be a leverage that has a significantly higher change potential than a change of the pensionable age for example, or a shift in women's employment rate.

For this, the following has to happen - developing intelligent labour market concepts, enabling the economy to become a force in innovation and informing society actively and transparently about advantages in international competition, when digitalisation is grabbed as an opportunity: investing in digitalisation ensures the competitiveness with competing locations worldwide, successful companies contribute to an additional growth of the gross domestic product and digitalisation can lead to the emergence as well as foster new jobs. For example, by shifting earlier work-intensive but automated processes today in production and administration back to Germany, which requires highly qualified professionals.

Professionals have to be educated and further trained quickly and well

Research forecasts show that digitalisation leads to a lower labour demand for certain occupational groups. In future, people affected would still find it difficult to find a suitable job despite good specialised training, – should they not obtain any chances to further develop their knowledge or to use them in new spheres of activity.

Should these workers already be able to make use of good education and training in the near future, they would be able to provide the qualifications required by digitalisation and in a large part even perform superior tasks. A crucial prerequisite for this would be that the state promotes especially the qualification of the trainers through targeted programmes for teachers in schools, universities and in job education and further training.

Thoughts should also be put into the guidelines for a future-oriented training. The silo or expert training would prove to be no longer appropriate in the disruptive setting of digitalisation. Traditional thought patterns would not be suitable to meet new developments; instead, broadly designed training, creativity and independent problem solving should be promoted.

The signal effect that could come about from a quick and consequent digitalisation of the government and countries should also not be underestimated. The digitalisation of communication between establishments and citizens on one hand as well as digitalisation of administration on the other has already had a positive effect in terms of acceptance and pervasiveness of new technologies in the economy and society in numerous countries. Such an effect can speed up when cities with digitalised administration and own in-house operations form the hotbed for a "Smart City".

Digital adult education centre for digital new training in each decade

For this, the state has to spread education spending on several shoulders, especially in cooperation with business enterprises. In return, companies should be incentivised in order to take over the necessary spending in educating and further training of their employees.
An important stimulus could hereby be a tax-financed further education scheme.

The state and the economy could approach this as an important mission for Germany's sustainable prosperity as a location under the roof of a "digital adult education centre", which promotes targeted education and further training in every decade of one's life.

"Digital adult education centre" makes Germany fit for digitalisation.

Digitalisation has a higher change potential than the pensionable age.

Economy

Many companies in Germany have been rumoured not to be too concerned in concrete terms with the issues of digitalisation and the demographic shift; also because the forecasted changes are too far in the future and appears not tangible enough.

Today, many managers already confirm this, that the anticipated labour shortage due to demographic development will lead to two main developments in the middle term, the remuneration for the highly qualified and digitalisation specialists will grow and employees in occupation groups, whose qualifications lose meaning significantly due to digitalisation, will be much less in demand.

Here the gap keeps widening further, the further digitalisation progresses. Shortage and surplus are two sides of the same medal and will present significant problems to the companies in future. This makes digitalisation – in combination with the effects of the demographic shift – interesting and meaningful as a business case.

The demographic shift is the business case for digitalisation.

Demographic shift is the business case for digitalisation

The return on invest for the business case "digitalisation" is not only a short-term monetary one but it helps to sustainably lessen the drawbacks for Germany as a business location that arise due to the demographic shift, thus ensuring the own future of the company.

Digitalisation helps in safeguarding the future of companies

In their own interest, companies are always already investing in the education and further training of its employees especially – in order to leverage on untapped potential. In view of the foreseeable developments, companies and the state should become more engaged more to develop and finance corresponding programmes.

This is necessary because digitalisation will give considerably more meaning to the concept of lifelong learning.

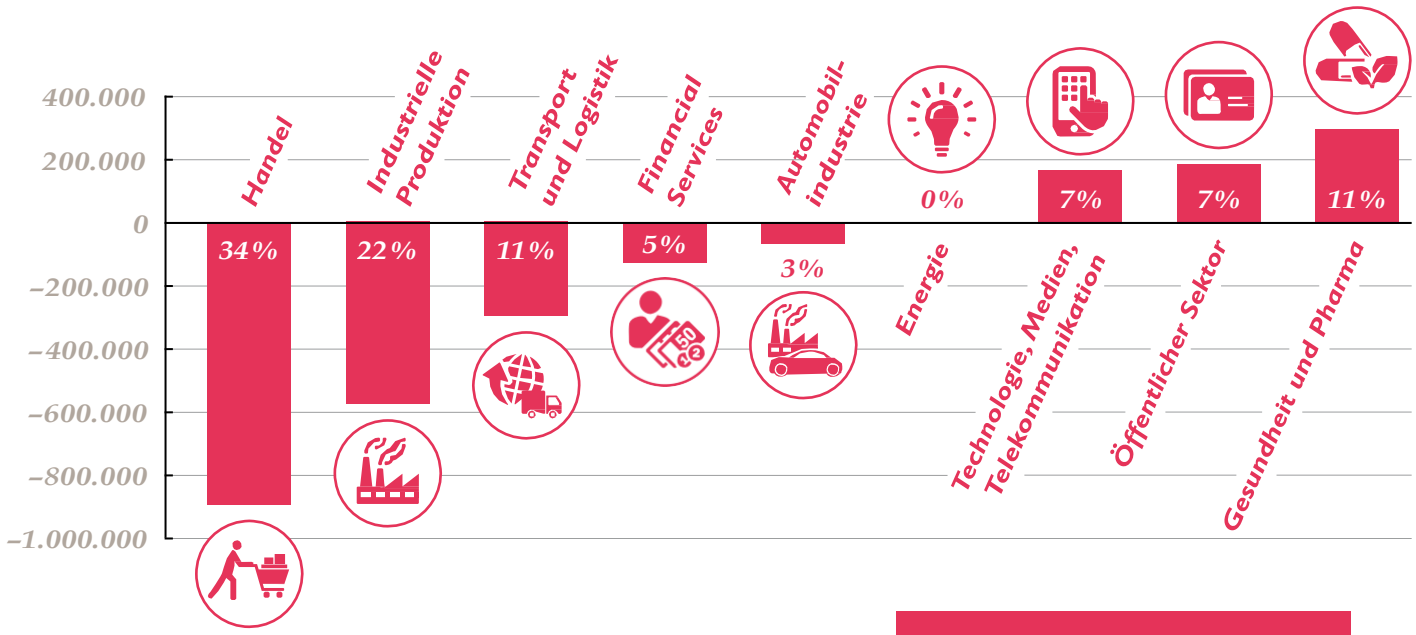
Digitalisation leads to a return of jobs

Digitalisation will also lead to further automation of work-intensive processes in production and administration. As a result, parts of the company previously outsourced into cost-effective countries abroad could return to the German headquarters, as outsourcing will no longer offer any, or too little, cost benefits.

However, highly qualified professionals would be required in Germany for the managing of these processes brought back. This means that for many segments, production could develop from high work intensity to high qualification intensity due to digitalisation

In the employer's point of view, the number of attractive job offers thus grows, which can lead to a further strengthening of its own market position. The company also benefits from a higher efficiency domestically.

Absolute und relative Verteilung der Digitalisationseffekte auf die Nachfrage in den Branchen im Jahr 2030



"Lifelong learning" gains significantly in meaning.

Methodical Annex

In the next chapter, the methodical basis of the research will be briefly presented. In addition to limiting research objective, the methodical basis to calculate the employment impact of digitalisation will be shown. Central influencing factors here are the digitalisation coefficient, digitalisation rate as well as job-specific demand.

Methodology

The results are derived based on an innovative and newly conceived quantitative model to project digitalisation effect, which is the impact of digitalisation on the labour demand. For this, scientifically established methodology is employed – including the task-based approach[12] and the labour capacity approach[13]. In addition, these are supplemented by an occupational structure model and combined to form a new closed aggregate model. The model is based on a bottom-up approach.

This means that the digitalisation effects are first calculated on the micro aggregation level (job-specific digitalisation effect) and then brought together to superordinate aggregates (including sector-specific digitalisation effect).

Job-specific digitalisation effects are influenced by three factors: job-specific digitalisation coefficents (1), the digitalisation rate (2) and the job-specific demand (3).

[12] cf. Frey and Osborne (2013).
[13] cf. Pfeiffer and Suphan (2015).

Job-specific digitalisation coefficient

The job-specific coefficient reflects on one hand the sensitivity of a job to digitalisation influences and on the other hand, decides the direction of impact (positive or negative) of the digitalisation effect of an occupation. The digitalisation coefficient is calculated by a combination of task-based as well as labour capacity approach, which is supplemented by an occupational structure model.

The task-based approach assumes that routine tasks (simple, repetitive tasks), in contrast to non-routine tasks (difficult, complex tasks), are much easier to be replaced by machines. Based on expert evaluations on the likelihood of automation of individual tasks, it makes it possible to state the likelihood of automating a job given the respective profile of the tasks for the job.

However, the task-based approach is not free from criticism. It has been accused of overestimating technical developments and underestimating the hurdles of implementing new technologies. Moreover, only the possibility of technical automation of jobs is taken into account, while the creation of modern tasks and the adaptation potential of the employed are not considered.

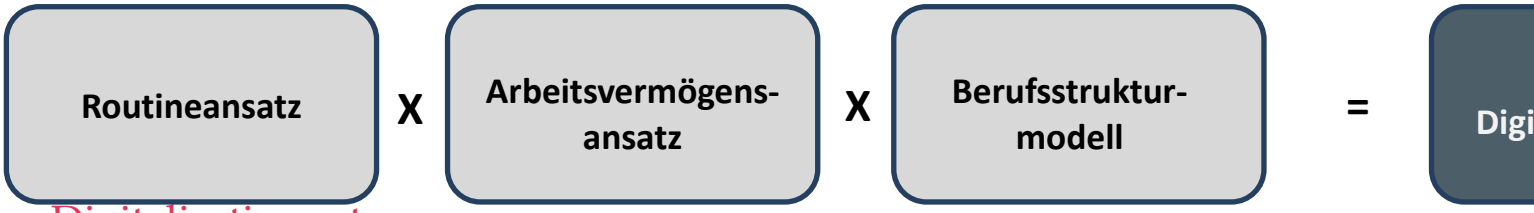
In order to take into account this criticism, our model factors in the significance of practical knowledge by integrating the aspects of labour capacity approach. Humans use practical knowledge to deal with situational complexity and uncertainties. This can hardly be replaced by machines. This approach allows for a weighing of jobs in view of their labour capacity by considering diverse indicator, which shows the ability of the employed to overcome uncertainties and complexities in the respective professions. The absolute value of labour capacity of a job also reveals the share and importance that tasks with higher complexity in the respective occupation take. This approach also makes it possible to arrive at conclusions about which tasks, qualifications and lastly which job fields will be particularly in demand in a work environment characterised by digitalisation.

Contrary to pure task-based approach, in this way, it is possible to forecast not only the probable negative impact automation has on jobs but also the induced employment growth due to digitalisation. The connection between task-based and labour capacity approach allows for a quantification of digitalisation effects and reduces possible false predictions and overestimation of the task-based approach by including experience and labour capacity.

In this way, the current model combines the best of both approaches.

Contrary to what has been repeatedly claimed, digitalisation is not happening today or tomorrow. Rather, it is a phenomenon that has shaped our economy and society for many decades, perhaps in a less intensive way than today. This means that it is possible to derive conclusions about tendencies of future structural occupational change processes as a result of digitalisation today, based on past development For this reason, an **occupational structure model** has been integrated. This identifies past development and adaptive processes in view of job structures, where local and sector-specific characteristics of the German labour market can be recorded.

The combination of task-based and labour capacity approach in connection with the occupational structure model allows for the calculation of a specific **digitalisation coefficient** for each profession. For one, this includes the direction of impact of digitalisation, meaning if demand growth or decline is to be anticipated for the respective job and also, the relative efficiency – that is the sensitivity of a profession to digitalisation.



Digitalisation rate

The digitalisation rate is a measurement of the fundamental occurrence of digitalisation in the economy and society. Thus it has the same level of effect on all professions and could be interpreted as a general efficiency of digitalisation. How strongly digitalisation impacts the labour market depends not only on how fast the process of increasing digitalisation occurs. Possible various trajectories are modelled using three possible scenarios, a basic scenario as well as a scenario for a weaker or stronger future digitalisation rate.

Depending on how digitalisation develops in future, this means particularly, according to which trajectory the digitalisation rate takes (depicted by the various scenarios), the peak digitalisation rate will be at different points in time.

This point expresses the maximum of the digitalisation rate in model theoretical terms. It corresponds to the moment, where digitalisation is fully realised and thus an additional increase in the rate of digitalisation is no longer possible or only possible marginal and results only in changes in employment which cannot be modelled.
It is difficult to say when exactly this point will be reached. The model used here orientates itself on the scientific status quo currently, after the maximum digitalisation rate will be reached earliest by 2025.[14]

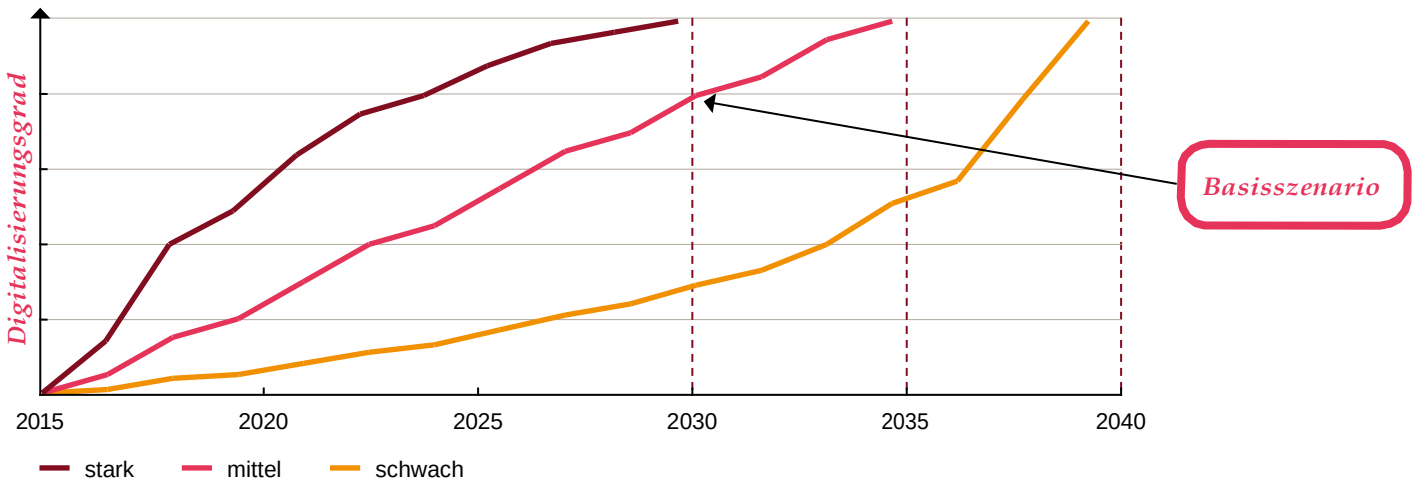
Depending on the scenario, the digitalisation rate grows with different speed and trajectory.

The **weak scenario** shows slowly increasing growth of the digitalisation rate. This means that digitalisation can act as a multiplier for further digitalisation development, which sets into motion a self-enforcing process.

The basic assumption of this scenario is that only from a certain critical digitalisation rate, the further uses of digitalisation increases exponentially (so-called network externalities). So after a weaker growth phase initially, digitalisation rises increasingly faster. The rather weaker digitalisation at the beginning results in the scenario where the maximum digitalisation rate is reached only at 2040, this means that there will be 20 more years before digitalisation in all economic sectors will be fully realised.

In the **basic scenario**, growth rate is constant. The resulting trajectory assumes that digitalisation continues in the same way in the future as it has so far. The basic scenario serves as reference or benchmark scenario and is based on the current plausible growth rate of digitalisation.

Digitalisationsgrad und Szenarien



[14] cf. IAB (2015).

It assumes that digitalisation grows gradually at the same rate, until it has been fully realised. This digitalisation progress was chosen as basic scenario, to use moderate digitalisation growth to avoid possible underestimation or overestimation of digitalisation impact. Should digitalisation develop in the trajectory as assumed in this scenario, the peak digitalisation rate will be reached in 2035. Beyond this point, there will be no further employment impact due to digitalisation.

On the other hand, the trajectory of digitalisation for the **strong scenario** drops over time. A strong initial growth follows a quick saturation, which means that digitalisation will advance very quickly in the near future. However, as a result, there can hardly be anymore further digitalisation potential that can be tapped.
This is based on the assumption that the current urgency of the issues lead to larger digitalisation investment being made in the near future and digitalisation effects being realised very fast. Subsequently to this, there could be a phase where additional investment in digitalisation will only lead to a low increase in the rate of digitalisation. Due to the higher growth rates at the beginning, the point of complete realisation of digitalisation would be reached at 2030 in the strong scenario. In line with this scenario, all digitalisation induced changes in demand will be completed already in the next 15 years.

Job-specific demand

The current cooperative labour research from PwC and WifOR makes it possible for the projection of labour development in nine sectors for Germany as well as the 43 job fields belonging to the sectors up to 2030. The calculated job-specific, sector-specific and year-specific labour demand in this research form the foundation in particular for the extent of the absolute digitalisation effect. The higher the absolute job-specific demand, the higher – ceteris paribus – the job-specific digitalisation effect.

The combination of these three factors (job-specific digitalisation coefficient, digitalisation rate and job-specific demand) presents as a result the job-specific digitalisation effect. This shows the induced absolute change in labour demand within an occupation, caused by digitalisation, for a certain year. It gives the absolute value of the effect and can be positive or negative, that means, both employment growth and decline

This forms the basis for all further calculations. This results in, for example, the digitalisation effects of each sector (sector-specific digitalisation effects) from the sector-specific job distribution. This means, the individual sectors have a different occupational structure respectively.

Due to the different occupational composition of the sectors, divergent sector effects from digitalisation results. The aggregation of the sector-specific effects then lead finally to the aggregate impact of digitalisation, which is the absolute demand effect caused by digitalisation (depending on the scenario chosen) across all jobs and sectors in a year.

Overall, the model allows for the forecast per year through the development of the absolute and relative digitalisation effect. This means to predict the relative or absolute impact of digitalisation on labour demand, up to the year 2030. These effects can be differentiated according to numerous jobs, sectors as well as a mixture of job and sector. In addition, the macroeconomic labour demand effect of digitalisation is computed as an aggregate result.

1 **Berufsspezifischer Digitalisierungs-koeffizient**

X

2 **Digitalisierungsgrad**

X

3 **Berufsspezifische Nachfrage**

=

Für jeden Beruf wird ein gesonderter **Digitalisierungs-koeffizient** errechnet, der die spezifische Sensibilität gegenüber Digitalisierungs-einflüssen ausdrückt.

Der **Digitalisierungsgrad** wirkt über alle Berufe gleichermaßen. Er gibt den - je nach Szenario unterschiedlichen - unterstellten Wirkungsgrad der Digitalisierung an.

Die Digitalisierung verändert das **Nachfragepotenzial (und somit indirekt das Angebot)** jedes Berufsfeldes. Das Ausmaß ist in Abhängigkeit des jeweiligen Berufs unterschiedlich stark.

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The combination of these three influence factors results in the calculation of *the job-specific digitalisation effect.*
This is computed by the digitalisation induced absolute change in demand for labour within an occupation in a particular year. This job-specific digitalisation forms the basis for further calculations. This results in for example the digitalisation effects in the sectors from the sector-specific job distribution, which means, the individual sectors have different occupational structures. Due to the varying occupational composition of the sectors, there are diverging overall sector effects in digitalisation. The sector-specific digitalisation effects as well as other results were presented in the study.

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Glossary

Labour capacity	shows the share and value of the activities with higher complexity for the respective job; requires the capability of employees to overcome the intricacies and complexities
Occupational structure model	identifies past development and adjustment processes in terms of occupational structures, this includes local and sector-specific characteristics of the German labour market
Sectors/Industries	collective term for the PwC-specific sectors examined: Automotive, Energy, Financial Services, Healthcare and Pharma, Retail, Industrial Products, Technology, Media and Telecommunications, Transportation and Logistics, Public Sector
Digitalisation	the impact of information and communication technology on the labour markets, employment and qualifications
Digitalisation contribution	share of a job (a sector) in the total digitalisation effect (in terms of amount) of all jobs (all sectors)
Digitalisation effect	job or sector-specific change in labour demand as a result of digitalisation
Digitalisation rate	degree of general digitalisation implementation in society and the economy; depends on the scenario and year and can be interpreted as basic efficiency of digitalisation across all jobs
Digitalisation coefficient	occupation-specific digitalisation coefficient reflects for one the sensitivity of a job to digitalisation influences and is also decisive for the direction of impact (positive or negative) of the digitalisation effect of a job
Labour bottleneck	occurs, when labour demand is larger than labour supply
Labour surplus	occurs, when labour demand is lesser than labour supply

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Bei den diversifizierten Forschungstätigkeiten steht neben einer starken empirischen Fundierung vor allem die Visualisierung der Wirtschaftsdaten im Vordergrund.

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