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Digitalisation: Much ado about nothing or is there more to come?

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Digitalisation and Industry 4.0 are raising high expectations among the public, as well as serious concerns. If we believe the disturbing predictions, artificial intelligence and digital networks will lead to revolutionary innovations in almost all sectors. They will result in accelerated productivity leaps and disruptive structural transformation. A large section of the labour force must fear for their jobs. Global competition is pushing this trend. Income from work is increasingly losing macroeconomic significance. This is threatening the financing of our social systems. And all of this will happen soon.

Contrasting with this dramatic scenario, developments so far give good reason to remain calm. Employment levels have broken records even though digitalisation has advanced in great strides in the past three decades. Studies by renowned research institutions estimate that while more than one tenth of today's jobs could fall victim to automation in the next 20 years, even more new ones could be created. The much-cited Oxford Study, according to which half of all jobs may vanish, appears little realistic when we check the underlying assumptions.

The German economy hardly appears to be experiencing an accelerated structural transformation that is eroding job security and requires workers to adapt increasingly faster. Quite the reverse is true, in fact: Sectoral structural change has slowed down further in the past ten years and the economic structure is currently more stable than it has been in the previous years since the 1970s. That has created a high degree of job security – not for everyone but for a large portion of the labour force. There has also been a significant increase in upskilling and in-house continuing education and training, however. This suggests an increased need for many workers to acquire skills and adapt. By automating relatively simple tasks, digitalisation is creating more high-skilled employment. The increased need for upskilling is expected to continue.

Incomes from work are not diminishing either. Employees' gross earnings have grown across all skill groups in the past ten years. The wage share has increased again significantly since its low of 2007. Last year it was higher than in the Federal Republic of Germany of 1970. Earnings of highly qualified workers have risen above average as a result of labour market shortages. That has widened income gaps, setting incentives for workers to pursue further training. The clear increase in the share of highly trained workers suggests that the incentives have worked. That trend is also likely to continue, as the need for highly trained workers is expected to continue rising while the supply will decrease in the long term. Real earnings have also increased for low skilled workers with low income. In cities with fast-rising rents, however, that situation may be different.

Revolutionary effects on labour productivity and economic growth have also failed to materialise so far. Economic growth is good but not overwhelming and labour productivity is growing at a much slower pace than in the 1990s. With a view to the future, Germany should seek to achieve higher productivity growth because unless countermeasures are taken, the demographic trend will lead to growing skills shortages and serious financing shortfalls in social insurance schemes from 2030.

German companies, the federal, state and local governments and the EU are well advised to advance Digitalisation 4.0 with renewed vigour. Need for action exists in three main areas:

- More investment and innovation. Too many German companies are still exercising restraint in this field. In order to remain competitive and meet the demographic challenges, an investment and innovation initiative like the one launched by the US and China will be required.

- Expansion of digital infrastructure, with broadband networks, online services of government agencies and digital interconnection for data exchange being the main priorities.

- Promotion of (digital) education and further training. Here the federal and state governments and the social partners must collaborate to ensure that all population groups can benefit from digital progress and the resulting prosperity gains.

The digital revolution is already well underway

The digital revolution started in the 1980s. At the time, manufacturers such as Apple, Atari, Commodore and IBM brought the first affordable PCs to market. In 1993 the European Organization for Nuclear Research CERN made the World Wide Web public. In the past 30 years, chip makers have increased microprocessor computing power more than 20,000-fold.

Today most households are active in social networks, do

their banking online or make purchases through the internet (Figure 1). Most businesses use CRM or ERP software to manage client relations and the deployment of human and physical resources.[1] Social media marketing has also significantly gained in importance in the past few years. Big data analyses, on the other hand, are currently common almost exclusively in large enterprises.

So the digital revolution has brought enormous changes to our daily and working lives already. If the idea of exponentially accelerating change is correct, this should have made a spectacular imprint on aggregate economic development particularly in the past few years. In the following we demonstrate that this can hardly be evidenced for Germany. We will fact-check three popular myths on digitalisation.

Myth 1: Most employees must fear for their jobs as a result of digitalisation

In 2013 a study created a great stir and much concern around the world: C. B. Frey and M. A. Osborne, two digitalisation experts at Oxford University, warned of a high risk that 47% of all jobs in the US would be lost to automation in the next ten to twenty years.[2]

On behalf of the German Federal Ministry of Labour, the Centre for European Economic Research (ZEW) examined to what extent this alarming scenario can be applied to Germany.[3] The institute analysed 700 occupational groups for their likelihood of disappearing as a result of automation. The result: According to the ZEW study, **there is a high risk (> 70%) for less than 12% of the labour force that their job will be replaced by automation in the near future.** The number of tasks that can be automated is higher but most occupations involve a wide range of tasks and digitalisation means new tasks are being added. A number of reasons indicate that the Oxford study greatly overestimates the risk of job losses from digitalisation.

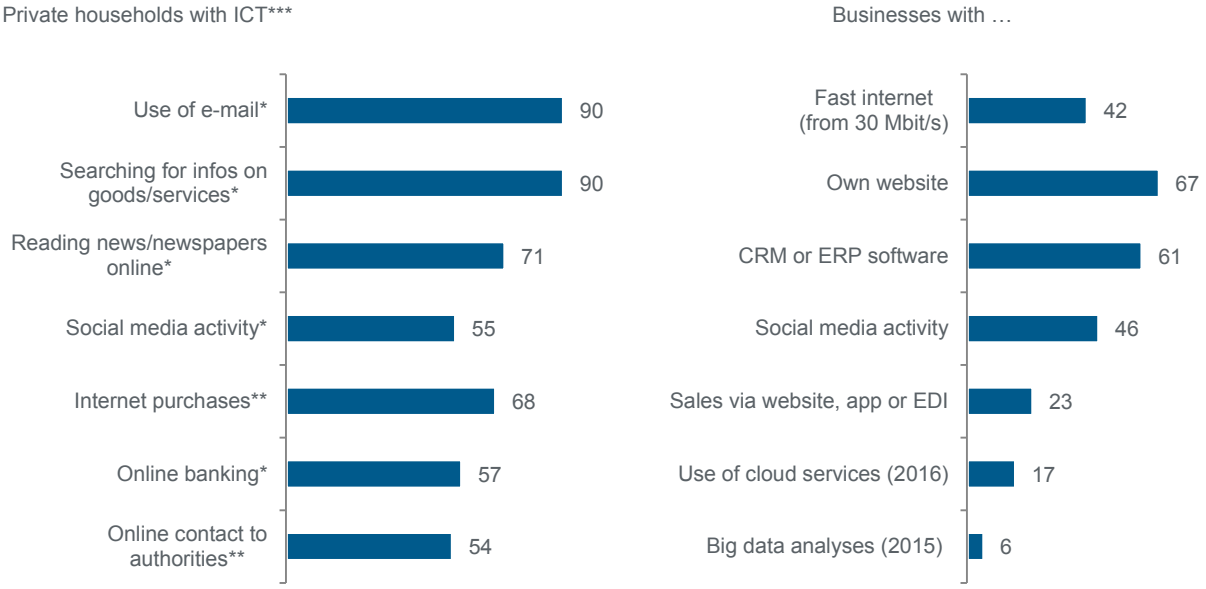
One major reason is that the Oxford researchers' prediction was based on the assessment by technical experts of what will be technologically feasible in the future. Under the 47% scenario, lorry, bus and taxi drivers would be replaced by autonomous vehicles. Bakers, chefs, waiters, salespersons, bricklayers, joiners, roofers and even fashion models would be replaced by robots or machines. The list illustrates a major problem with predictions of employment effects of digitalisation.

Already today, technology would make it possible to have restaurants in which patrons sit at a table, select a meal from a digital display, pay with card and wait for a robot to bring food prepared by machines. But is that supposed to be our future? In order for digital innovations to gain a foothold, people must accept them. They also have to be profitable and lawful. The Oxford scenario also ignores the fact that workers adapt to their jobs flexibly and take on new tasks. And finally, innovators and workers have to be found who possess the necessary expertise and test and implement what is feasible, as well as providers of capital who share in the risk.

The Oxford study is based on data from the year 2010. Developments to date are in line with the significantly less dramatic assessment by the ZEW. Both in the US and in Germany, employment has grown dynamically since 2010 and a slump is not foreseeable for the coming years.

Figure 1: Digital technology use in households and businesses

Shares in per cent, 2017



Notes: * In the last 3 months. ** Within the last year. *** ICT = information and communication technology. 90% of all private households have a computer and 96% a mobile phone.

Source: Destatis

However, that does not rebut the study. After all, the researchers did not commit to the time horizon. Ten to twenty years was merely stated as a possibility. Nor does C. B. Frey really expect mass technological unemployment in the foreseeable future.[4]

The Oxford study led to a variety of studies on the impact of digitalisation on labour market developments. A key finding is that **a commitment to training and lifelong learning will presumably become even more important**. Tasks performed by low-skilled low-wage earners in particular are deemed to be potentially easy to automate. Their unemployment rate is already a depressingly high 18% in Germany. And the number of persons of working age without formal qualifications has remained steady on a high level of around 7 million in the past ten years. In order to reduce unemployment, educational and labour market policy makers will have to continue working on building the skills of young people and motivating low-skilled workers to upskill.

In the coming years, digitalisation may create as many new jobs as it replaces

According to an estimate by the IAB from the year 2016, advances in technology could replace 1.5 million jobs by the year 2035. Over ten years, that would affect 3% of the labour force. **This means 97% of the labour force would keep their jobs.** The estimate also expects the number of new jobs created to equal the number of jobs replaced.[5] [6]

The loss of jobs is an inevitable side-effect of technological progress that enables higher prosperity in the future. Advances in technology have always eliminated jobs and that in large numbers:

- In 1950, **agriculture** employed 5.1 million people, or 23% of the working-age population of the Federal Republic of Germany. They planted grains with their hands, their ploughshares were drawn by oxen and horses and they collected potatoes with baskets and milked cows with buckets. The post-war skills shortage prompted farmers to quickly advance mechanisation. In 2017, a mere 1.4% of the labour force in Germany, or 0.6 million people, were still employed in agriculture. Harvesters, combines and milking machines, which are many times more productive, took over heavy physical labour.

- In 1950, 345,000 workmen with pit ponies and pneumatic drills were still toiling underground in Germany's **mining sector**. Damage to wrists and arm joints as well as black lung disease were regarded as occupational illnesses and deadly mass accidents caused by pit fires, mine collapses and firedamp explosions were occupational risks. In 2017, only 1,700 miners were still working underground. Machines excavated the coal, firedamp was pumped out and fatal accidents were very uncommon. Germany's last hard coal mines were shut down at the end of 2018. And modern energy technology ensures that coal is being increasingly replaced by climate-friendly renewable energy.

- **Manufacturing** employed 10 million workers in 1991 but only 7.6 million in 2017. Most job cuts took place in the 1990s, especially in Germany's eastern states. Antiquated factories were shut down there and the production of outdated eastern German products such as the Trabant and Wartburg automobiles was stopped. Employment in the manufacturing sector did not rise again until 2006.

By contrast, far more jobs were created in the **services sector** than were eliminated in the other sectors. The number of workers in service occupations has grown by 9 million since 1991. The occupations that experienced the strongest growth include healthcare, nursing, education, hospitality and information technology services.

Myth 2: Digitalisation requires all employees to adapt increasingly faster to new structures

Nothing proves this proposition for the aggregate economy either. **Structural change has in fact slowed since the mid-90s** despite the digital revolution and the globalisation surge – Germany's export quota grew from 20 to 47% between 1993 and 2017. This is shown by the structural change indicator, which measures the intensity of structural change (Figure 2).

The slowdown in structural change in Germany for the past ten years can be seen both among the major economic sectors of the national accounts and in the deeper classification into 88 branches of the economy by the German Federal Statistical Office, Edition 2008 (WZ 2008). A slower structural change can be observed, not just for Germany but also for France, Spain, Italy and the EU-15 overall.

The reduced number of innovators is also indicative of a slowdown in structural change.

One indicator of restructuring within enterprises is innovation activity. This is surveyed for small and medium-sized enterprises in the KfW SME Panel. The most recent survey of 2014/2016 revealed that German SMEs are increasingly reluctant to innovate. Only 27% of SMEs were innovators during the survey period. **The rate of innovators thus fell by one third** from the high of 2004/2006. SMEs' innovation expenditure was also significantly lower in 2016 than in the preceding years.[7] The innovation survey conducted by ZEW for 2016 shows that while large enterprises' innovation expenditure has risen since the financial crisis, the share of innovators among large enterprises has also shrunk considerably.[8]

Which jobs could be replaced by machines?

The online tool 'Job-Futuromat' of the IAB provides indications as to the potential for different occupations to be replaced by technology (https://job-futuromat.iab.de/). It displays the degree to which existing technology could already automate some 4,000 occupations. Thus, in 2016 **one fourth of employees subject to social security contributions** were already working in an occupation with high substitution potential (= above 70%).[9]

Occupations that can be technically 100% automated include cashiers in retail and bookkeepers. Bakers and tax accountants are also among the occupations in which key tasks can be largely automated.

By contrast, the tasks of bricklayers, lifeguards, taxi drivers, glass and building cleaners, economists, press spokespersons and journalists can be automated to a low degree (less than 30%). These examples highlight two things:

1) **Technical substitutability does not mean substitution will actually occur.** Supermarkets in the UK have been using self-checkouts for the past 15 years and they are commonplace today. Not so in Germany. One reason is that Germans pay cash relatively often, which makes self-checkouts more expensive.[10] Such cost-efficiency calculations, but also risk considerations, customer acceptance, degree of entrepreneurial innovativeness, available expertise and venture capital as well as social considerations, play a role in deciding whether or not to automate tasks.

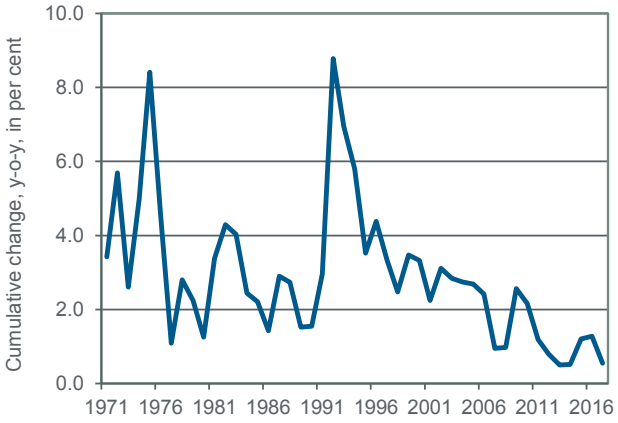
2) According to the current state of technology, **occupations that require relatively low skill levels**, such as taxi driver or building cleaner, **will survive**. However, significantly more auxilliary and specialist tasks can be automated than those of graduates. The potential for automation is relatively high in manufacturing occupations and in business-related services, and relatively low in social, cultural and medical occupations.

The data analysis also shows **that the potential for automation has increased on all skill levels from 2013 to 2016** but most of all in unskilled and specialist occupations. More than half of the core tasks in unskilled and specialist occupations can now be automated.

But humans will remain far superior to machines in many ways in the world of work for a long time to come. They will continue to be irreplaceable where goals are set and where versatility, creativity and social intelligence are required. Furthermore, humans need to feed artificial intelligence with representative data and correct faults and errors. The human brain's universal capacity for thought still remains unrivalled. In the future as well, computers and machines will continue to be tools controlled by humans.

Figure 2: Structural change has slowed down

Sectoral structural change indicator*



Note: The sectoral structural change indicator is calculated as follows: First, the shares of persons employed in each economic sector of national accounts in total employment are calculated for one year. Then the respective change of these shares in relation to the previous year is determined. Finally, the amounts of these differences are added up.

Source: Destatis, own calculations

Also lacking is evidence to support the proposition that a general shortening of product life cycles places increasingly higher demands on businesses and employees. It is true that shorter life cycles have been identified for certain models of products such as automobiles and smartphones. But there is no evidence that this affects broad sectors of the economy. Besides, shorter product cycles do not necessarily mean growing risks and demands for enterprises and employees. Companies often bring new products to market for advertising purposes without making any major changes to previous versions.[11]

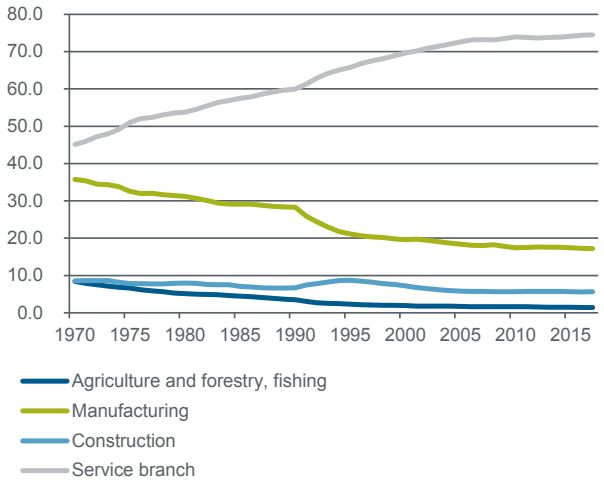
The slower growth of labour productivity and the steady employee turnover rate support the finding of slowing structural change.

Other indicators also contradict the proposition of increasingly faster structural change through digital innovation. Labour productivity growth has slowed significantly compared with previous decades and the employee turnover rate has fluctuated only slightly between 30 and 33% in the past few years. This suggests that **employment relationships remain consistently steady**.[12]

Digitalisation has induced further structural change in favour of the services sector (Figure 3). This also reduces employment risks and adaptation requirements as most service occupations prove to be stable in recessions.

Figure 3: The sectoral structure of the labour force has become more stable

Percentage share in all employment



Source: Destatis

Training and upskilling requirements, however, have risen

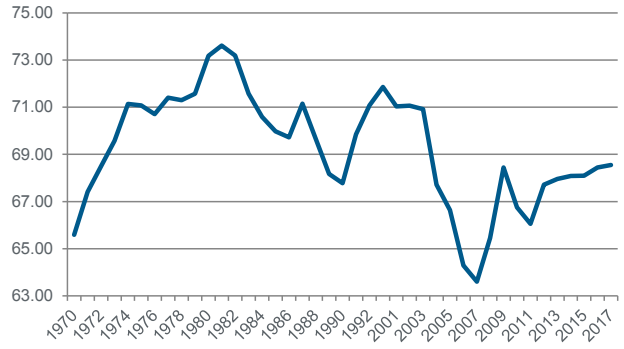
According to the Labour Force Survey of the Federal Statistical Office, 44.5% of the labour force was employed in high-skilled occupations in 2016, compared with 33% in 1992.[13] The number of persons in employment with a university degree or higher vocational qualifications has thus grown significantly (Figure 4).

Companies' direct expenditure on continuing training per employee has also risen significantly in the past ten years.[14] This trend is likely to continue when rule-based routine tasks and simple non-routine tasks are automated and new tasks have to be learned. What this means for employees with adaptation needs depends on the requirements. Most workers are likely to welcome a task in which they can learn something new and which offers variation, as well as the expanded possibilities provided by digital technologies.

Myth 3: Incomes from work are falling and social security schemes are losing their funding basis

The proposition of the coming decline in labour incomes also raises unnecessary concerns. Although the wage share decreased until 2007, it has recovered considerably since then. At 69%, it was on the same level in 2017 as in the Federal Republic of Germany of 1972 (Figure 5).[15] Hence there is no evidence thus far to suggest that labour incomes are dwindling as a result of labour-saving digital advances. In fact, compensation of employees has increased significantly in real terms in the past ten years. Competition over scarce skilled labour means gross wages will likely continue to rise. In the current demographic environment the skills shortage is likely to continue growing until 2030 and beyond.

Figure 5: The wage share is rising again



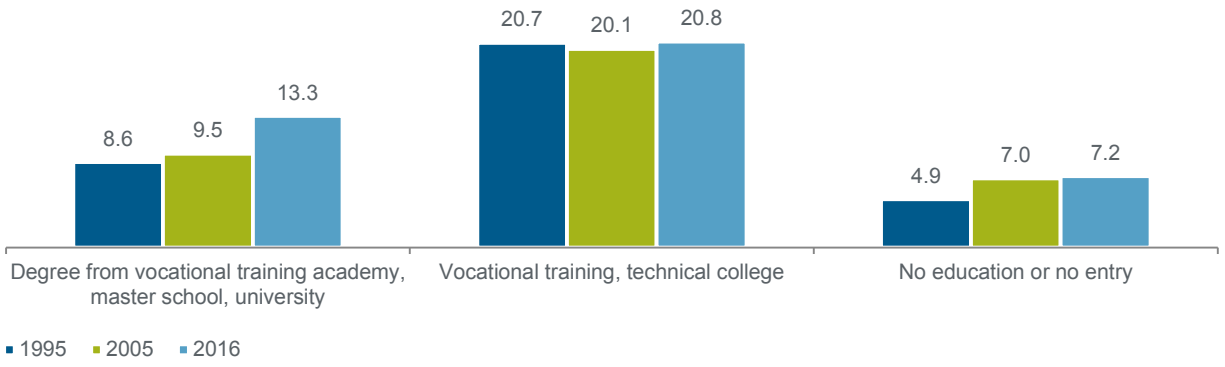
Note: The wage share was calculated here as compensation of employees in relation to national income.

Source: Destatis, own calculations

However, not all will receive an equal slice of the growth of the pie. Computers and machines controlled by them are most likely to reduce the need for workers who perform predominantly rule-based routine work and simple non-routine work. **Highly qualified employees, on the other hand, are likely to be more in demand. Their wages and salaries are thus likely to grow at above-average rates**. This wage differentiation has already set in.

Figure 4: More and more workers are highly qualified

Persons in employment, in millions



Source: Destatis

This is how Digitalisation 4.0 can further improve our work and our lives

It is safe to assume that few people in Germany would enjoy working with a Commodore 64 with 64 kb of RAM, or using a mobile telephone the size of a brick with a 20cm antenna that costs EUR 7,000. Nor will we want to use today's technology several decades from now. The new technologies that are possible and foreseeable for the future already promise further great advances:

- Collaborative robots will work together with humans and relieve them from monotonous, physically demanding and unhealthy work. In this way they will also increase productivity.

- Artificial intelligence will optimise production and ordering processes and enable products specifically tailored to individual customer requests.

- Official documents can be applied for online and approved automatically within a matter of seconds.

- Government agencies and offices will be interconnected. This will allow data to be shared and provided to users quickly. The effort of collecting data will be reduced substantially for enterprises and private households.

- 3D printers will produce parts, medical or dental prostheses with less material and effort.

- Self-driving cars, whether electric or with other alternative drive systems, will cause fewer accidents, less noise and pollution and can increase the mobility of aged persons.

- Translation tools such as the free https://www.deepl.com/translator enable nearly flawless translations into other languages. Soon, smartphone apps will be able to translate spoken language into any foreign language, almost like the Babel fish in The Hitchhiker's Guide to the Galaxy. Language barriers with migrants could then be a problem of the past.

The list could be expanded considerably, for instance with advances in medicine or environmental technology. Some things have already become reality while others remain science fiction that could be realised some years or decades from now.

From the first quarter of 2008 to the first quarter of 2018, gross monthly earnings of managers (LG1) and key specialists (LG2) in the manufacturing and services sectors grew by a good 25% (Figure 6). For semi-skilled workers (LG4) the rise was a significantly lower 18%. However, real earnings also increased for them. Consumer prices rose by only 12.7% in the same period.

It must be noted, however, that this is an average assessment. The earnings trend may deviate considerably in individual economic sectors. In addition, real wages may rise at a lower rate or even fall in conurbations where rent increases are high if the rise in housing costs is not offset by wage and salary increases. This puts pressure on low income earners in particular.

What is also remarkable is that the earnings of unskilled workers (LG5) have been rising faster than those of skilled workers with formal qualifications. This may also be a reflection of the federal government's efforts to lift the wages at the lower margin more strongly. But there are no signs of a significant increase in gross monthly earnings of unskilled workers since the statutory minimum wage was introduced at the beginning of the year 2015.

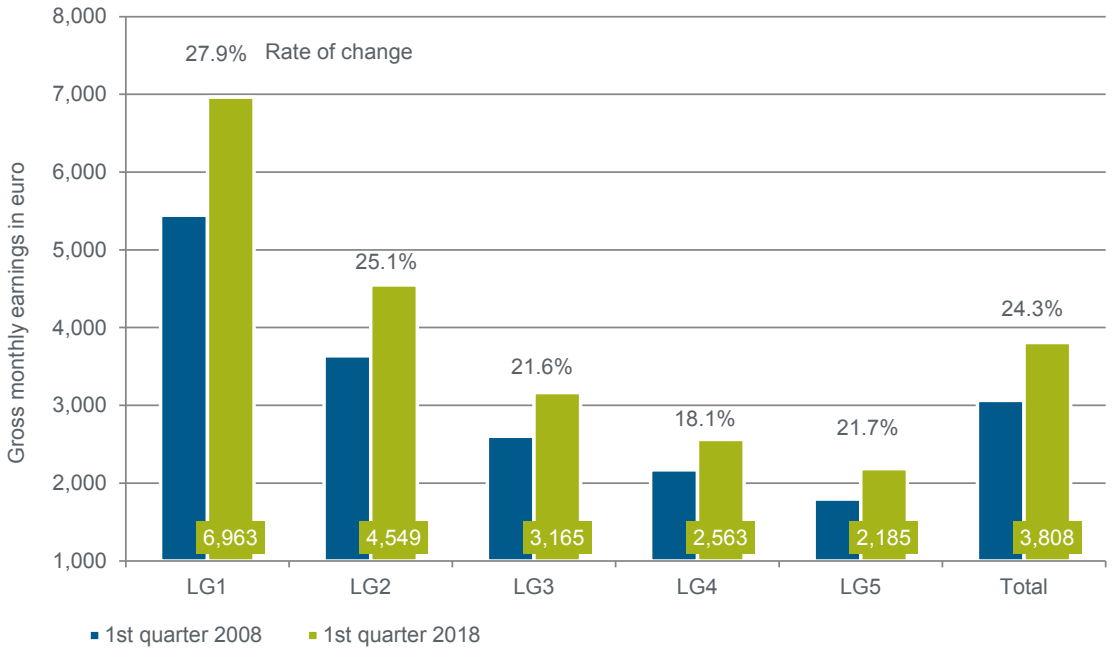
All future scenarios indicate that **education and qualifications will continue to have a growing influence on earnings potentials**. Digital education in schools and continuing education of low-skilled workers will be necessary in order for all population groups to be able to benefit from digitalisation. How employees' disposable incomes will develop will also depend on how much of their gross earnings they can take home. Regional differences in the development of rentals and real estate prices could also continue to play a significant role.

Digitalisation provides opportunities to tackle demographic challenges more effectively

Germany is set to shrink and age significantly in the coming decade and this trend will accelerate after 2030. The updated population scenario issued by the Federal Statistical Office implies a decline of the labour force potential by 4.6 million workers by 2040 if the statutory retirement age remains at 67.[16]

Moreover, ageing and medical advances mean that employees and employers must expect their social security contributions to rise significantly. The economic debate sometimes creates the impression that the rise is sure to be limited to the relative burdens only. The Scientific Advisory Board to the German Federal Ministry of Economics wrote in its report on the statutory pension scheme: 'Assuming annual productivity growth of 1.5%, which roughly corresponds to the long-term average of the past 25 years, the purchasing power of pensions will grow ... by around 1% annually. The next generation's pensions will thus have some 30% more purchasing power than the pensions being paid out today (*our translation*).'[17]

Figure 6: High-skilled workers have the highest salary increases – a consequence of growing demand



Note on the salary group:
LG1: employees in management positions (incl. tertiary graduates with comprehensive business or technical skills, 10.4% of employees), LG2: key specialists (who perform complex tasks, usually with formal qualifications, several years of work experience, including with management tasks, 21.9% of employees), LG3: specialists (difficult specialist tasks, formal qualifications, 44.9% of employees),
LG4: trained employees (predominantly simple tasks, industry-specific tasks with up to 2 years of training, 14.9% of employees), LG5: untrained employees (simple, mechanical tasks, up to 3 months of induction, 7.9% of employees),

Source: Destatis

That is an optimistic assumption. **The growth of labour productivity and of gross national product per capita has been on a downward trend since the 1970s** (Figure 7). In the past ten years, labour productivity growth has been merely half the rate of the past 25 years. If productivity growth rates remain low, redistributions between pensioners and employees after 2030 may lead to absolute income losses in one of those population groups. It would therefore be helpful if a new digital revolution were to trigger a new growth surge and lead to stronger labour productivity growth. That will require more innovation and investment in digital technology and infrastructure that serves this purpose.

Low productivity growth rates occur particularly in enterprises that invest relatively little in product and process innovations. It is all the more worrying that the share of innovators has decreased so significantly. One reason for this is the declining start-up rate, which is leading to a lower supply of new innovative firms. Risk-taking Start-ups, in particular, are expected to introduce disruptive new-to-market innovations that create or fundamentally renew markets, thereby triggering growth and productivity surges. **An improved supply of venture capital for such business founders could thus make a major contribution to strengthening the innovative power of German SMEs**. In comparison with the US, France, Italy or the United Kingdom, state support for business innovations in Germany has thus far been low.[18]

Figure 7: Growth of labour productivity and GDP per capita are on a downward trend thus far

Variation in per cent

Source: Destatis, own calculations

Conclusion

The findings presented and developments predicted here are of course not set in stone. Trends can change and surprises are always possible. After 30 years of digital revolution, however, there are good reasons to look to the digital future with optimism and to harness the economic potential with determination. German enterprises can be expected to do this with great vigour in order to improve their competitiveness, tap into new markets and overcome skills shortages.

The federal, state and local governments and the EU have many options for contributing and creating a suitable framework for successful digitalisation. The AI strategy of the Federal Government is setting new impetus in this area and the envisaged EU plan of action can complement it. Specifically, state institutions can

- strengthen the innovative capacity of the SME sector and promote start-ups so that the share of innovators grows again

- support small and medium-sized enterprises in acquiring expertise for digitalisation. Relevant in-company continuing education and training should also be promoted

- advance digitalisation through state-funded basic research but also through international partnerships. The World Wide Web, which made it possible to share information across the globe through the internet in the first place, was invented at the European Organization for Nuclear Research CERN

- provide necessary digital infrastructure, especially by expanding broadband connections, online services of government agencies and digital interconnections

- integrate digital education into the curricula of all schools

- create favourable conditions for data collection that prevent unnecessary barriers on the one hand while ensuring compliance with the obligation to protect privacy and data. Artificial intelligence needs data in order to learn. Without it, even self-learning AI is like a blind and deaf human without a sense of touch or education

- reduce ills and risks. To achieve this, state institutions can ensure data protection and data security, protect data sovereignty, penalise corporations' abuse of power and tax evasion and regulate new technologies and business models where necessary. More attention should be paid to corporations that dominate the market with data and information monopolies because of the resulting concentration of power and possibilities to manipulate opinion and hinder competition.

- help unemployed workers find work quickly and support low-skilled workers and children from educationally disadvantaged families in keeping pace with change

- set participation in growing prosperity for all and the strengthening of social cohesion as prominent goals of Germany's agenda for the future. They are part of the guiding principle of the social market economy and constitute the foundation for stability and broad acceptance. ■

[1] CRM stands for customer relationship management, ERP for enterprise resource planning.

[2] Frey, C. B. and Osborne, M. A. (2013): The Future of Employment: How susceptible are Jobs to Computerization?, p. 44, https://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf.

[3] Bonin, H., Gregory T. and Zierahn, U (2015): Übertragung der Studie Frey/Osborne (2013) auf Deutschland (*Applying the Frey/Osborne study (2013) to Germany* – our title translation, in German only), ZEW Expertise No. 57, Federal Ministry of Labour and Social Affairs, Forschungsbericht 455, https://www.bmas.de/SharedDocs/Downloads/DE/PDF-Publikationen/Forschungsberichte/fb-455.pdf;jsessionid=3C1426C74E1FCD27AA16F61CBEF35B78?__blob=publicationFile&v=2.

[4] Cf. Frey, C. B: The Future of Work, lecture at NWX17 on 6 March 2018, https://www.youtube.com/watch?v=UiOXQOjVrKA.

[5] Zika, G. et al.: Regionale Branchenstruktur spielt eine wichtige Rolle (*Regional sector structure plays an important role* – our title translation, in German only), IAB-Kurzbericht 9/2018, http://doku.iab.de/kurzber/2018/kb0918.pdf.

[6] On the basis of a business survey, the ZEW also predicts slightly positive employment and wage effects from digitalisation on the aggregate economy by 2021.
Arntz, M., Gregorry T. and Zierahn, U. (2018): Digitalisierung und die Zukunft der Arbeit: Makroökonomische Auswirkungen auf Beschäftigung, Arbeitslosigkeit und Löhne von morgen (*Digitalisation and the future of work: macro-economic effects on employment, unemployment and wages of tomorrow* – our title translation, in German only), ZEW.

[7] Zimmermann, V. (2018): **KfW SME Innovation Report 2017**, KfW Research.

[8] Centre for European Economic Research (ed., 2017): Innovationen in der deutschen Wirtschaft, Indikatorenbericht zur Innovationserhebung 2017 (*Innovation activity in the German economy, indicator report on the 2017 Innovation Survey* – our title translation, in German only), p. 6 f., http://ftp.zew.de/pub/zew-docs/mip/17/mip_2017.pdf.

[9] Cf. Dengler, K. and Matthes, B. (2018): Wenige Berufsbilder halten mit der Digitalisierung Schritt (*Few occupations are keeping pace with digitalisation* – our title translation, in German only), IAB Short Report 4/2018, http://doku.iab.de/kurzber/2018/kb0418.pdf.

[10] Cf. Gassmann, M. (2015): Darum meiden Deutsche Selbstbedienungskassen (*Why Germans avoid self-checkouts* – our title translation, in German only), https://www.welt.de/wirtschaft/article138008528/Darum-meiden-Deutsche-Selbstbedienungskassen.html.

[11] Cf. Research Services of the German Bundestag (2016): Zur Diskussion um die Verkürzung von Produktlebenszyklen (*On the discussion about the shortening of product life cycles* – our title translation, in German only), https://www.bundestag.de/blob/438002/42b9bf2ae2369fd4b8dd119d968a1380/wd-5-053-16-pdf-data.pdf.

[12] The employee turnover rate or turnover coefficient is defined as the half-sum of employment relationships subject to social security contributions that have started and ended within a period in relation to existing employment relationships.

[13] Of these, 22.5% were technical and equivalent non-technical occupations, 17.5% graduate occupations and 4.5% managers and executives.

[14] Cf. Seyda, S. and Placke, B. (2017): Die Neunte IW-Weiterbildungserhebung (*The ninth IW continuing education survey* – our title translation, in German only), IW-Trends, 4.2017, https://www.iwkoeln.de/fileadmin/publikationen/2017/369145/IW-Trends_2017-04_Seyda_Placke.pdf.

[15] The term wage share is not used consistently. Here we refer to employee compensation in relation to national income. The Council of Economic Experts uses the labour income share. It refers to employee compensation plus the estimated incomes of self-employed persons in relation to national income. The labour income share is thus higher but follows the same long-term fluctuations. In 2017 it was as high as in 1989 and 1960. Other definitions refer to employee compensation in relation to gross national product but less frequently to gross value added. The wage share has also risen again significantly since 2007 on the basis of both GDP and gross value added.

[16] Cf. Müller, M. (2018): **Is there no end to Germany's jobs boom? What we can do now to meet our skills needs in the future**, Focus on Economics No. 216, KfW Research.

[17] Scientific Advisory Board to the German Federal Ministry of Economics (2016): Nachhaltigkeit in der sozialen Sicherung über 2030 hinaus (*Sustainability in social security beyond 2030* – our title translation, in German only), p.18, https://www.bmwi.de/Redaktion/DE/Downloads/W/wissenschaftlicher-beirat-nachhaltigkeit-in-der-sozialen-sicherung-ueber-2030-hinaus.pdf?__blob=publicationFile&v=4.

[18] Cf. Zimmermann, V. (2017): **SME Innovations: Seven reasons for the decline in the share of innovators**, Focus on Economics No. 185, KfW Research.