Artificial Intelligence –Measuring Potential Impacts on the Labour Market. The case of Germany

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Table of Contents

1 Introduction

AI-based systems use techniques such as machine learning and deep learning to automate complex tasks such as pattern recognition, language processing, trend analysis, and decision-making with the help of large amounts of data. Prerequisites for development and application are high computing power, availability of large amounts of data, and new algorithms. A wide application across all economic sectors and private areas is expected. The spread of chatbot applications have reached already a large number of users.

In the 2010s, the label “industry 4.0” emerged. What has started in the 2010, is now intensified with the application of AI technology. In these early days, industry 4.0 referred to the interactive integration of analogue production with the digital world via internet of things, robotic or digital platforms (Wolter et al. 2015). With the development of AI technology, the concept of industry 4.0 enters a new, “intelligent” era, in which machines receive the ability to mimic human capabilities such as logical thinking, learning, planning, and creativity (European Parliament 2023).

The extent to which automation of industry effects the labour market has received in the past a lot of attention amongst economist (Frey & Osborne 2013, Bowles 2014, Autor et al. 2014, Bonin et al. 2015, Dengler & Matthes 2015). The era of AI technology is intensifying the debate. Yet, the current research on this aspect is divers and partly contradictory. The OECD (2023) expects that AI significantly expands the range of tasks that can be automated beyond routine and non-cognitive tasks and impacts nearly all sectors and occupations. According to IMF (2024), 60% of jobs will change due to AI. 50% could benefit from it, the rest would be automated away. Others, like IWK (2026) argue that particularly white-collar professions are strongly affected by AI. And that there will be no impact on overall employment. At the same time, PWC (2026) found out that globally, most companies (56%) see no advantage in AI. Only 12% have so far successfully reduced costs and increased sales. A genuine business case is still rare. CEOs expect AI to lead to a decline in employee numbers, particularly in junior positions.

Therefore, there is still a high level of uncertainty regarding the future impact of AI technology on the labor market. Does AI replace or complement human labor? And what does it mean in an economy as Germany which is phasing a significant decline in population in the upcoming years?

This paper tries to contribute to the ongoing discussion by examining the potential impact of AI on economic growth and labour market by applying scenario analysis. In particular, it explores the various effects AI could have on different industries and skill levels in the German labor market over the next 15 years.

2 Methodology

We have approached this question by applying a macro-econometric input-output-model INFORGE (Interindustry Forecasting Germany) for Germany in combination with scenario analysis.

The economic model INFORGE follows the INFORUM modelling philosophy (Almon 1991) which characteristics are bottom-up construction and total integration (Becker et al. 2022). A bottom-up approach means that each economic sector is modelled individually, and the macroeconomic aggregates are derived by definition (Meyer et al. 1999). This approach ensures that each economic sector is embedded in the economic context and that intersectoral

dependencies are explicitly considered. Full integration describes a highly endogenous and simultaneous model structure that accounts for sectoral interdependencies, income generation and distribution across the various institutional agents (households, NGOs, firms, and the government), government redistribution effects, as well as household income allocation for various goods and services. Over time, INFORGE has become a highly interdependent econometric model that accounts for the relationships between submarkets and macroeconomic cycles. As a macro-econometric input-output model, it is empirically driven. The behavior of economic sectors, private households, NGOs, firms, and the government is modelled using time-series regressions based on official data from the Federal Statistical Office. Econometric models such as INFORGE thus undergo an extensive validation process, since their ex post calibration relies on a much larger amount of historical data.

INFORGE has a lot of similarities with CGE models – e.g. the level of disaggregation, similar datasets, non-linear functions and simultaneous solution. The difference may lie in their theoretical fundaments. INFORGE assumes bounded rationalites, sticky prices and imperfect competition. Production is influenced by both – supply and demand. Companies set their selling prices based on both their cost structure and the prices of competing imports—the response of consumers to these prices, as reflected in their purchasing decisions, then determines production output. Behavioral hypotheses are generally not assumed without verification, but must withstand econometric tests (Meyer et al. 1998).

Current technological developments such as artificial intelligent have no sufficient reflection in historical data. Therefore, an empiricial model cannot reflect economic impacts or developments of the introduction of such a technology. That is why, new developments have to be integrated differently. In such a case, usually scenario techniques are applied in order to separate one effect of other parallel developments. Such a “what-if” analyses is applied in this paper: We compare two scenarios in which one baseline scenario extrapolates known and observable developments as projected from the macro-econometric model INFORGE. The baseline projection from the 8th wave of the BIBB-IAB Skills and Occupation Projection (QuBe baseline projection) is used as the reference scenario (Maier et al. 2024). The other scenario (AI-scenario) assumes a ramp-up in AI development and AI application. The input-output approach allows for the targeted placement of a set of AI-related assumptions generated from industry-specific observations. The model relationships remain unchanged, so that any differences in the results can be attributed solely to the AI-specific assumptions. In this paper we show differences between the two scenarios at a given point in time.

3 AI in Germany

The idea of AI is older than expected. The word “artificial intelligence” was first mentioned in 1955 in a workshop contribution with the titel „A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence“. It was this workshop which is called nowadays the birth of artificial intelligence. Since then, work on AI was in process with better and worse success. High expectations were followed by unfilled promises.

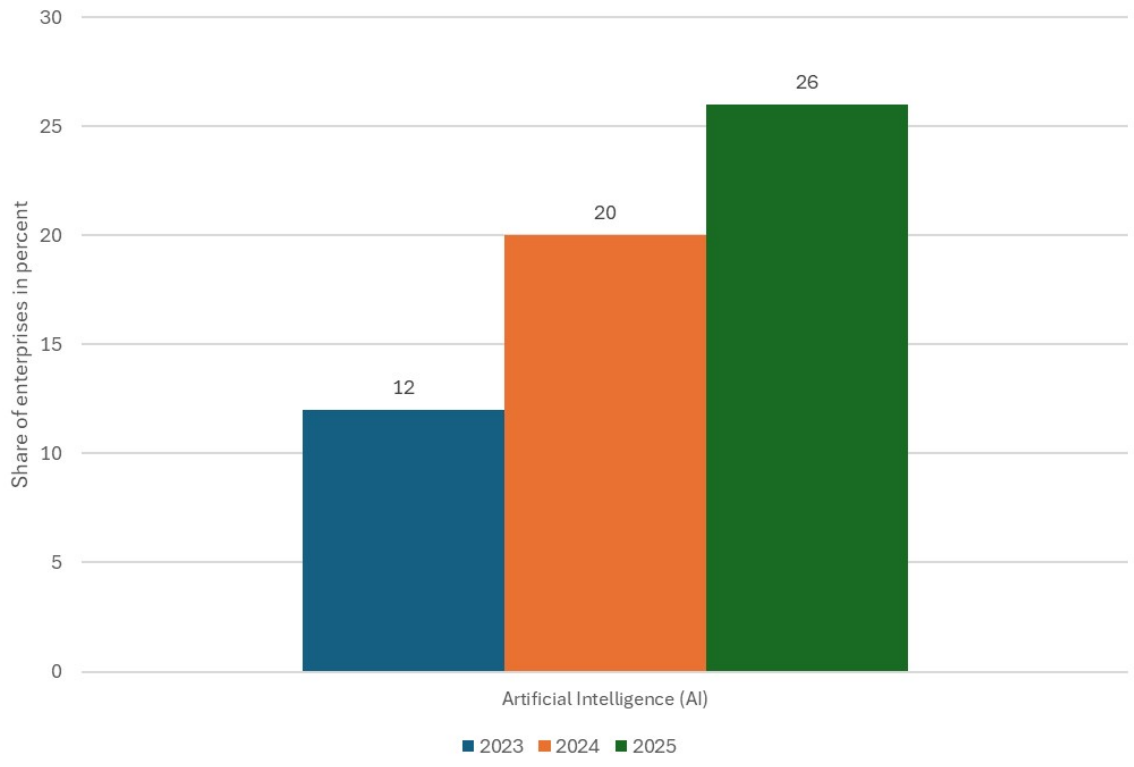
The first chatbot can be trace back to 1965 called ELIZA and was developed by Joseph Weizenbaum. ELIZA was able to imitate human conversation based on pre-written manuscripts. In 1995, the next chatbot was developed called ALICE by Richard Wallace. ALICE already used the world wide web to collect and process a large number of data. In 2006, a break-through of Deep Learning technology was reached. Geoffry Hinton published his ideas about training networks with graded layers. This approach allowed machines to learn complex and hierarchical

illustration of data. Until 2011, application of computers intelligence (Deep Blue in 1997 or Watson in 2011 – both developed by IBM) was limited to challenge chess world champions in this rather logical, rule-based board game. Also in 2011, however, Apple introduced SIRI and placed a virtual assistant within the operational system and made it accessible to millions of users. Finally, in 2020, OpenAI introduced GPT-3 – the earliest example of a large language model. It was able to generate human-like text, lead conversation, translate languages or generate creative texts. Ever since, the development of new generative AI accelerated and entered the private, public and business sector. Hence, the development of artificial intelligence began in the past, but only since a couple of years, its development has accelerated. The technology has scaled and diffused. Yet, it is still not clear, how AI will affect the economy and society.

Until today, the technological advantage of AI is rare to be found in the balance sheets. AI maybe mainly used as a strategy leverage to sell existing products to a higher price. According to a MIT study from 2025, only 5% of all observed AI application in companies have a measurable contribution to profit (Handelsblatt 22.8.2025: 6). However, the promise of AI application is huge. Companies primarily aim to use AI to increase productivity and efficiency and to develop new or partly-new products and services to increase sales and turnover.

At the meantime, the AI penetration differs greatly among economies, sectors and companies. Although, the data case is limited and different studies report different degrees of penetration, the statistical bureau of Germany, offers a dataset on AI usage in Germany and specific branches. In average, every fourth German company applies AI technology (see Figure 1. The share increased within two years very rapidly by 14 percentage points. Despite that speed in AI application, there are still many companies for which AI is not yet a topic of concern. However, this data must be used and interpreted with care. Artificial intelligence can be labelled differently. And the data does not reveal, with how much intensity AI is applied in companies.

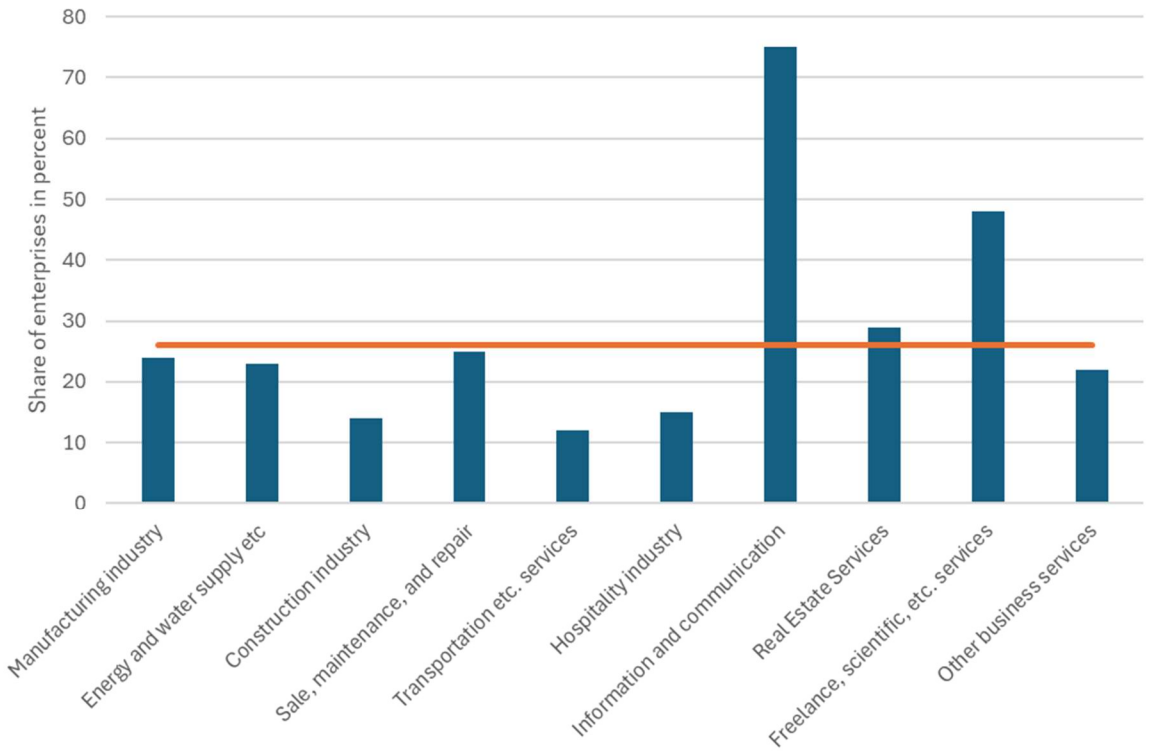
Figure 1: AI Application in Germany



Source: Destatis (2025)

Until now, it is the information and communication sector that uses and applies AI technology the most (see Figure 2). It is especially this sector, that develops and uses AI technology. However, it is more interesting in which sectors AI diffuses as an application for improving production processes or the provision of services. Beside the information and communication sector, it is the sector of professional, scientific and technical services, that use AI technology the most. Followed by real estate services and wholesale and retail services. Yet, it is not the manufacturing industry, the energy sector or the logistic sector where AI technology is widely spread.

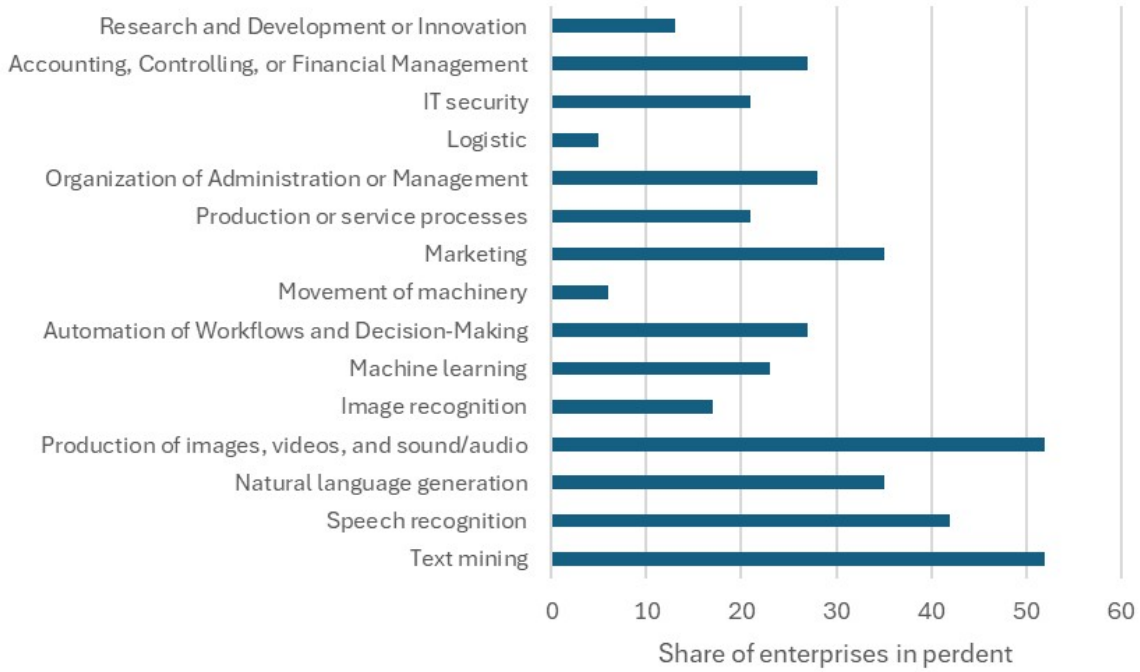
Figure 2: Application of AI by industrial sectors



Source: Destatis (2025)

It is the knowledge-based industries that make most use of AI technology nowadays. That collides a lot with the AI tools that have been used so far (see Figure 3). Until today, AI is mainly used as a tool for processing texts, languages, pictures or videos. Tools that are mainly used in such knowledge-based sectors. Tools for movement of machines, for logistic purposes or for production or innovative processes are less widely applied.

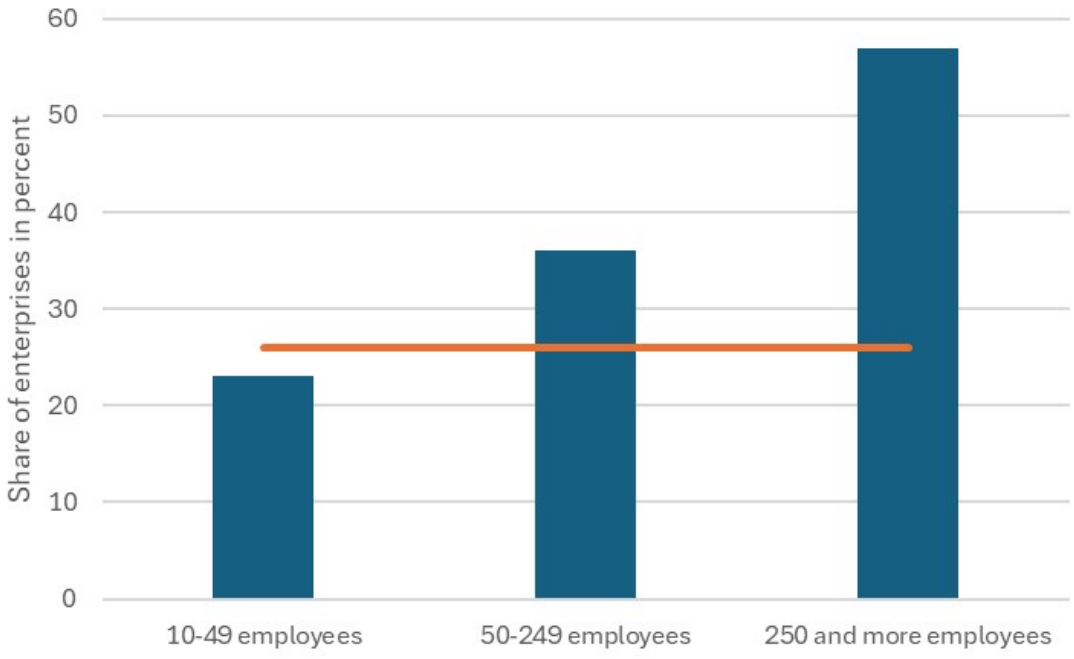
Figure 3: AI applications in use



Source: Destatis (2025)

The uneven distribution of AI application cannot only be found between sectors and AI tools, but also between size of companies (see Figure 4). Especially large companies act as pioneers in AI application, whereas small and medium sized companies adapt AI in a significantly slower pace. This uneven diffusion reinforces structural differences between company sizes and sectors.

Figure 4: Application of AI by firm size



Source: Destatis (2025)

Overall, there is a clear trend toward increased use of AI – however it is very concentrated in larger companies and in knowledge-based sectors and applied AI tools are very much limited to text mining, speech recognition or creation of images, audio and videos. Instead, physical AI – which stands for the link between hardware and AI – is not yet widely applied and lacks behind the average development of AI tools. However, the potentials are large for physical AI. According to a survey commissioned by the consulting firm FTI-Andersch, 59 % of the industrial companies surveyed expect AI to significantly transform organizational structures and processes. They see the greatest industrial potential primarily in quality assurance (40 %) and predictive maintenance (36 %). (Handelsblatt 17.4.2026: 32). Product digitization with AI is a crucial development not only but especially for the mechanical engineering industry.

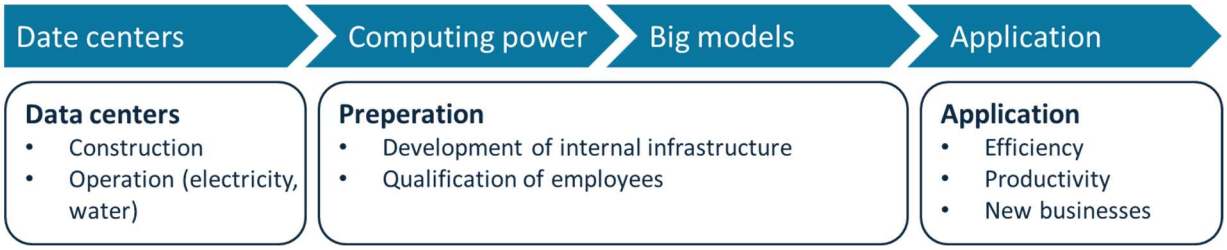
4 Setting the scene

To enable valid conclusions about the impact of AI on the economy and the labor market, well-founded assumptions must be made. From the previous chapter, we know that AI is already applied in many sectors, but the pace and penetration of AI differ largely. At the same time, we do not know in which intensity AI is used and to which extent it impacts productivity or turnover. Studies suggest, that until today, it is only a small number of cases, in which AI is contributing to economic development.

The four phases of AI-cycle (see Figure 5) can be divided into computing power, data centers, big models and application. You must go through all four phases in order to reap the benefits of AI evolution. We have compiled the four phases in the following assumptions:

- The necessary infrastructure must be in place. This applies to the availability of sufficient computing capacity in data centers.
- Upfront investments must be made in the industries so that AI technologies can be deployed in the first place. This includes, among other things, significantly more computing power and suitable software. There is a high demand for expertise in data collection, data storage, data management, and data utilization within companies. It requires training of employees on AI applications.
- The impact of AI deployment will vary by industry. In some industries, material savings can be achieved, while in others, productivity gains or new sales opportunities can be realized. Depending on the industry, only some or all of these effects may be present.
- AI is being developed and applied in many countries. Other countries are also developing and applying AI. It is assumed that the local effects there will be similar to those in Germany. These have corresponding effects on German import prices.
- The industry perspective is important in all four phases of AI cycle. When considering the deployment and impact of AI technologies, there will be different intensities and speeds at which industries adapt AI-technologies and AI-applications. We differentiate between four path of penetrations and four levels of AI intensity – whereas both go together. A high path of penetrations also means a high level of AI intensity.

Figure 5: Four phases of AI cycle

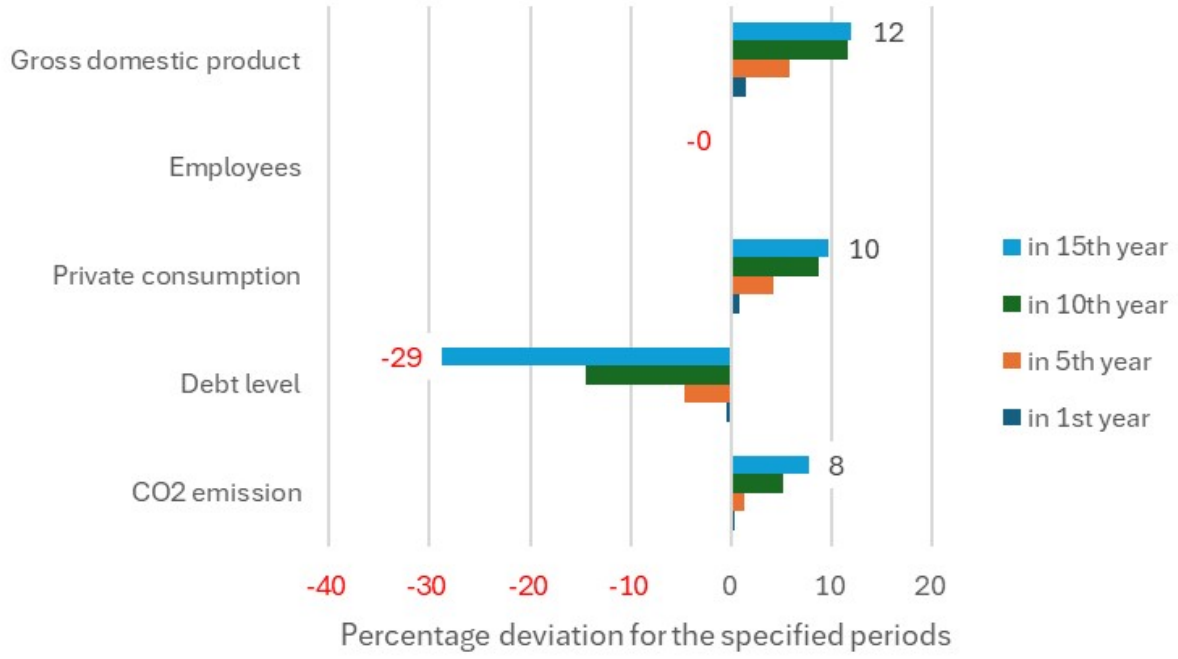


Source: own illustration

5 Results

Under the given premises, AI can achieve significantly higher value creation in the medium and long term with almost the same amount of labor as in the reference scenario, which is the result of the productivity increase. If the general population benefits from the higher added value, consumption opportunities increase. However, if the use of low-emission technologies does not increase beyond what is currently foreseeable, emissions will also rise (see Figure 6). Although in total the labour market effects are small. There are substantial shifts between economic sectors, skill levels, and occupations to be expected. This structural change is increasing over time when AI technology is getting increasingly integrated and widely used throughout the economy.

Figure 6: Overview of the AI scenario's impact on value added, jobs, consumption, debt levels, and CO2 emissions. Percentage deviation from the reference scenario

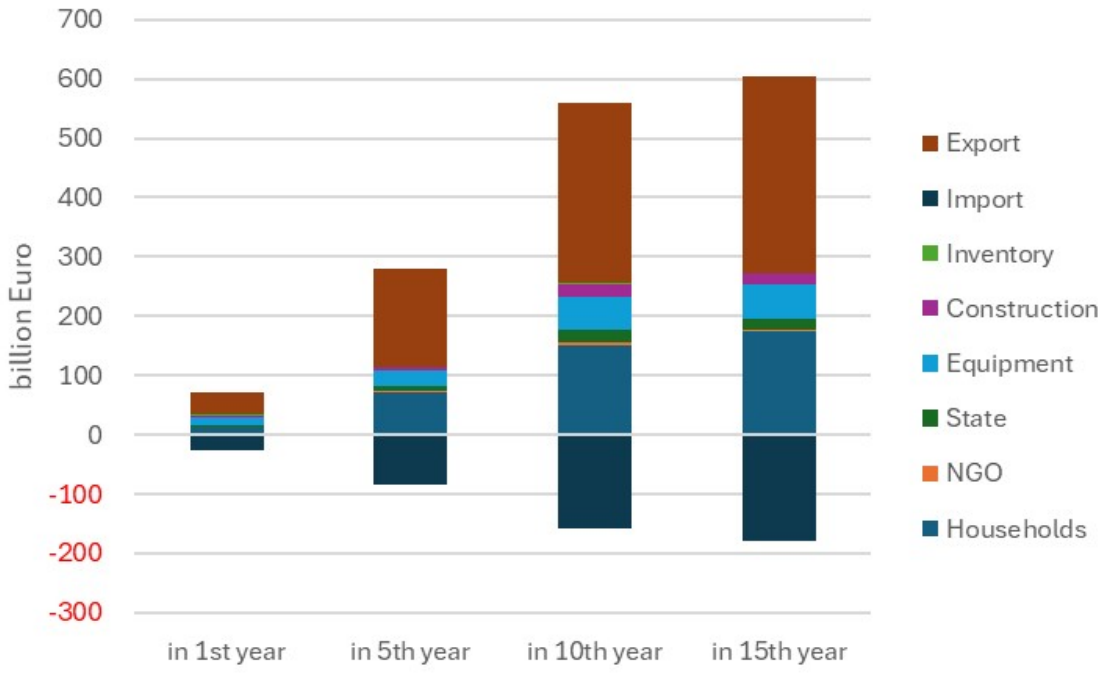


Source: Zika et al. (2025)

If AI development and integration were to accelerate, annual economic growth could be 0.8 percentage points higher on average than in the baseline scenario. Cumulatively over the next 15 years, this could generate 4.5 trillion euros in additional value added. The reasons for the higher gross domestic product in the AI scenario lie primarily in material savings in production

processes, the new business opportunities created by AI, and higher labor productivity. On the expenditure side, higher imports of goods and services from abroad have a negative effect on GDP in the AI scenario – which results despite lower import prices from the external dependency of AI technology. The remaining expenditure components, on the other hand, contribute to a significantly higher value added (see Figure 7). This applies particularly to exports, which benefit both from new business models and from lower price levels combined with greater competitiveness. Household consumption also rises due to spending on (new) products and services at lower prices. Furthermore, through the development of an AI infrastructure, capital investment contributes to higher GDP in the AI scenario, whereas construction investment and government spending exhibit exclusively price-induced effects.

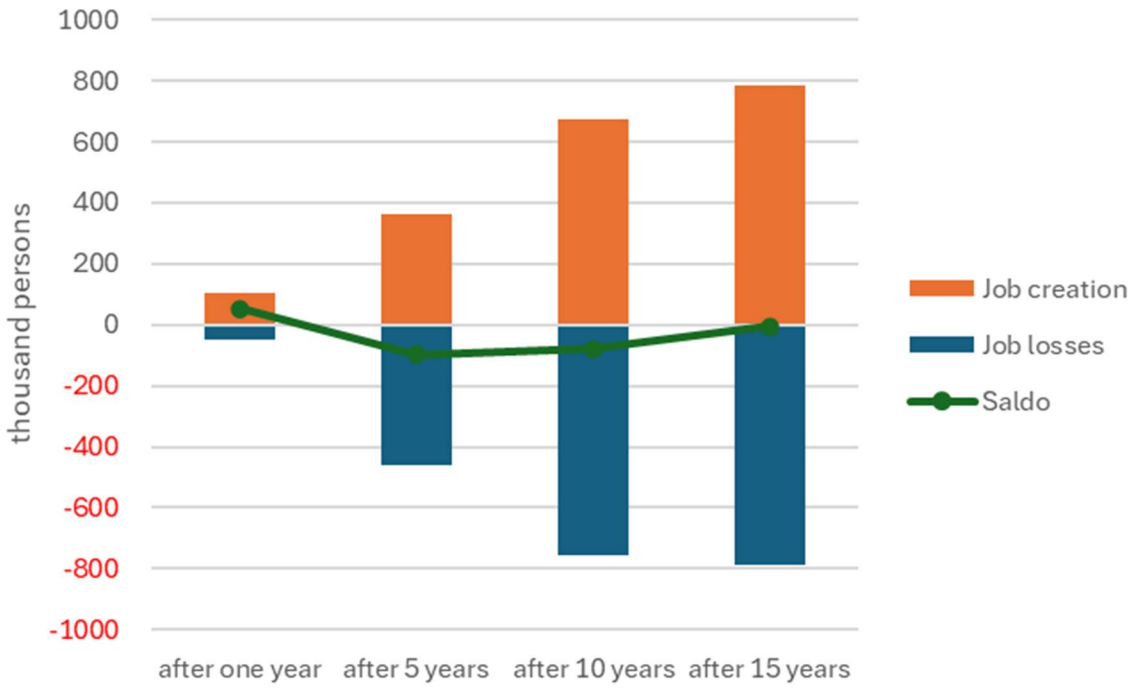
Figure 7: Impact on the components of price-adjusted gross domestic product. Deviation from the baseline scenario in billions of euros



Source: Zika et al. (2025)

The assumptions made in the AI scenario do not result exclusively in positive or negative effects on the labor market. Whereas the net balance remains rather static to the baseline scenario, the shift within the labour market is rather strong. In the first year of the AI scenario, there will be approximately 100,000 jobs that do not exist in the baseline scenario (the orange pillar on the far left in Figure 8). At the same time, around 50,000 jobs from the reference scenario are lost (blue pillar on the far left in Figure 8). On balance, this results in the creation of around 50,000 jobs in the first year of the AI scenario. Conversely, after 15 years in the AI scenario (orange pillar on the far right in Figure 8), there will be approximately 800,000 jobs that do not exist in the reference scenario, but approximately 800,000 jobs from the reference scenario will also have been lost (blue pillar on the far right in Figure 8). The net balance is thus nearly even in the 15th year of the AI scenario.

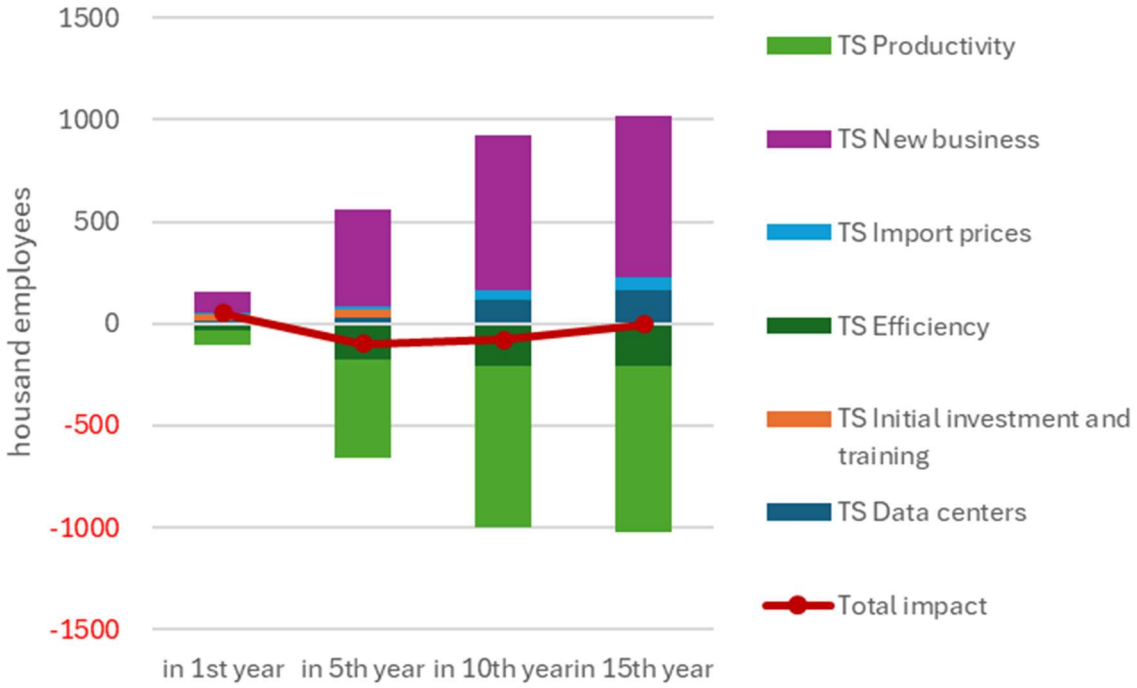
Figure 8: Impact on the number of jobs created and lost. Deviation from the baseline scenario in thousands of people



Source: Zika et al. (2025)

In the beginning of increased AI development and integration, a higher demand for labor is initially expected to provide the necessary infrastructure and carry out preparatory work such as data provision and processing, or model architecture design and development. Particularly, the development of new business models will result in a higher demand for labor. In the AI scenario, the net labor demand in the first year is therefore just over 50,000 people higher than in the reference scenario. In the medium term, labor demand will decrease due to increasing efficiency and productivity gains. Thus, the number of employed persons in the fifth year of the projection period is nearly 100,000 lower, and in the tenth year, approximately 80,000 lower than in the reference scenario. Towards the end of the projection period, however, there is potential to offset these job losses. Figure 9 illustrates the impact on the number of filled jobs. With increasing AI integration, jobs are eliminated on the one hand by automating routine tasks, but in particular also by accelerating decision-making and by automating creative and complex activities such as assisting with writing texts or coding software. The resulting increase in labor productivity thus leads to lower labor demand in many sectors. Reduced material requirements and waste, driven by greater input efficiency, also contribute to lower labor demand. On the other hand, the construction and operation of data centers, as well as the development of new business models, lead to higher labor demand. Lower import prices, as well as preparatory and continuing education measures, have comparatively low effects on labor demand. When all effects are balanced against one another, labor demand in the AI scenario remains at a similar level to that in the reference scenario in the long term. Since GDP rises simultaneously, AI development and integration can generate a significantly higher gross domestic product per employed person.

Figure 9: Impact on the number of jobs created and lost by sub-scenario. Deviation from the reference scenario in thousands of people



Source: Zika et al. (2025)

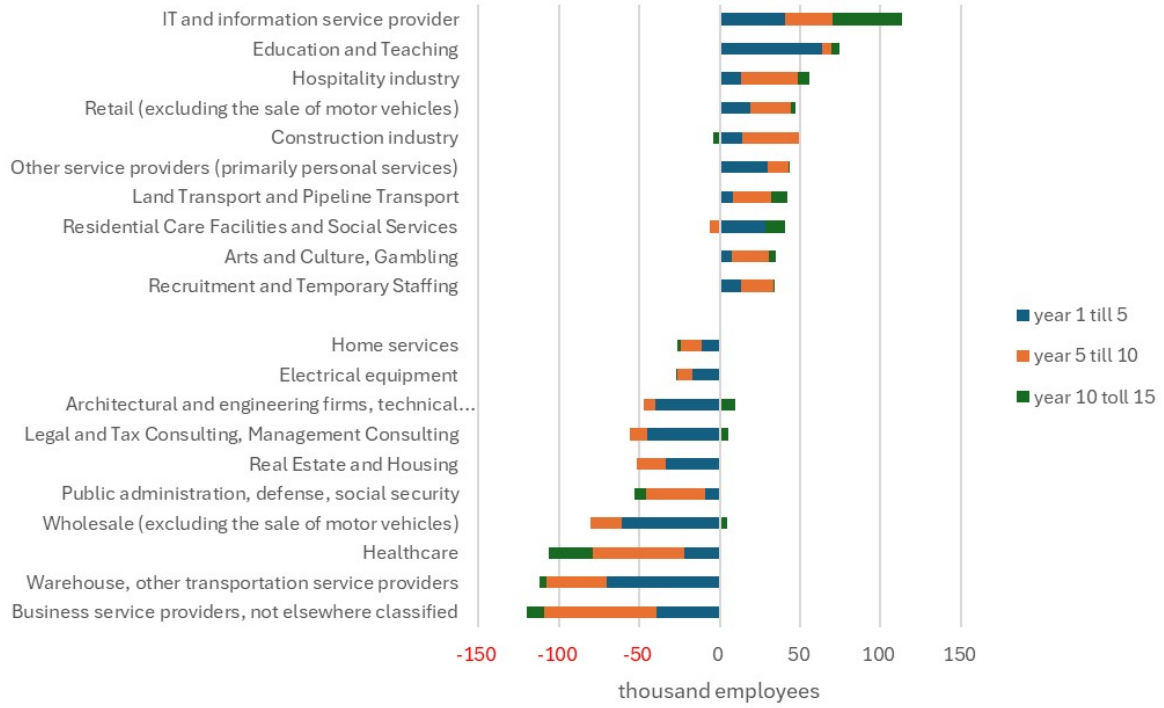
Figure 10 provides a summary of the potential effects of the AI scenario on employment figures across individual economic sectors. It shows the ten economic sectors with the largest positive effects on employment (upper part of the chart) and the ten economic sectors with the largest negative effects on the number of employed persons (lower part of the chart). These effects include both direct impacts resulting from increased AI development and integration, as well as indirect and induced effects in downstream economic sectors.

In the IT and information services sector, the number of employed persons after 15 years is approximately 110,000 higher than in the baseline scenario. This is primarily due to the construction and operation of data centers, as well as the development of new business models. Positive effects are also evident in the education and training sector, which includes, among other things, adult vocational education. Workers must be appropriately trained and upskilled both for existing work processes, which are increasingly handled with AI support, and for the development of new business models. The hospitality industry, as well as other economic sectors such as retail, personal services, and arts, culture, and gambling, benefit from spillover effects resulting from higher economic growth in the AI scenario.

Negative effects are expected primarily in the business services sector. This includes secretarial and typing services, call center operations, and credit reporting agencies. In these areas, artificial intelligence offers various opportunities to support or even automate work processes—including directly within the companies themselves. As a result, both the demand for such services and the associated need for labor will decline. In the AI scenario, the number of employed persons in business services is approximately 120,000 lower than in the reference scenario. The effects are similar for the warehousing sector, which, due to increased input efficiency, handles fewer goods while simultaneously being able to realize additional automation potential in its own work processes through AI. Lower employment figures are also expected in the healthcare sector under the AI scenario. However, this should not necessarily be

interpreted as a deterioration of the labor market situation in healthcare. Rather, scarce human resources could be better utilized in the long term, and costs could be reduced through AI-supported diagnostics and administration.

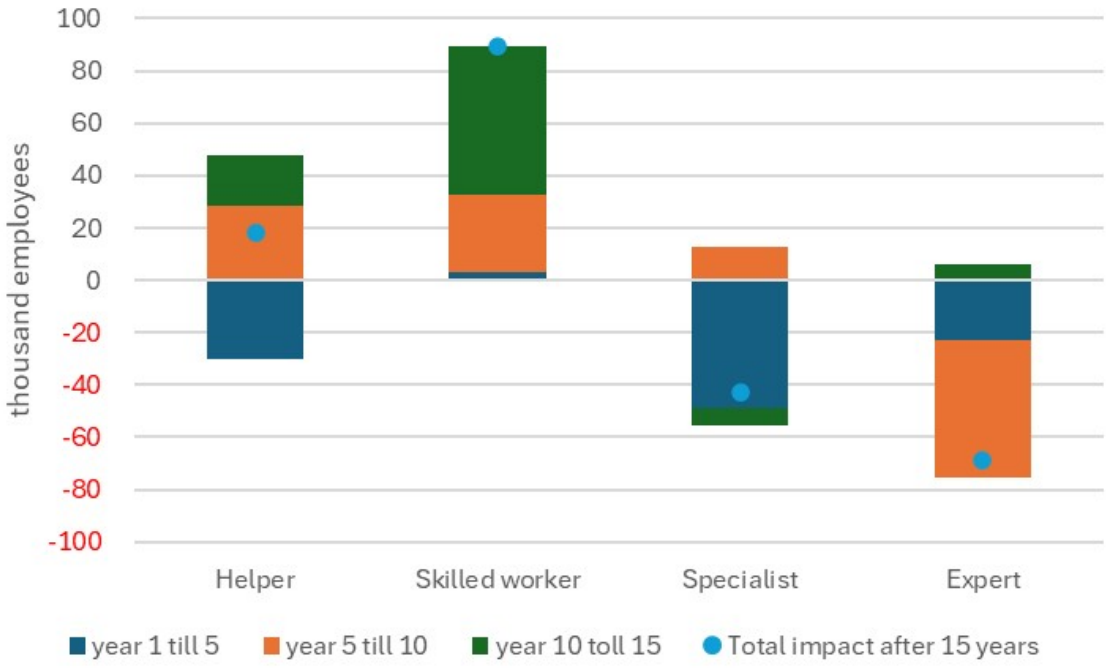
Figure 10: Ten economic sectors with the greatest absolute impact on the number of employed persons



Source: Zika et al. (2025)

While an earlier scenario on Industry 4.0—which examined the effects of increasing (non-AI-based) digitalization and automation—showed that demand for unskilled and semi-skilled workers was lower, and that there was greater demand for specialists and experts (Wolter et al., 2019), the AI scenario paints a different picture. In the short term, labor demand remains higher across all skill levels than in the reference scenario. In the medium and long term, however, it is lower for specialists and experts (see Figure 11). While labor demand at the specialist level is most negatively affected in the medium term, a comparison between the AI and reference scenarios shows that, in the long term, there is primarily less demand for experts. Data on already observable effects of AI integration on employees by skill level also suggest that highly skilled jobs in particular are more affected by AI applications than by traditional, non-learning software, whereas employees with low or medium skills are less affected by AI and more by software (Fregin et al., 2023). Thus, the potential lies primarily with skilled workers large enough to benefit from increased economic activity driven by AI in the labor market.

Figure 11: Employed persons by skill level



Source: Ziak et al. (2025)

6 Conclusions

This study aims to use scenario analysis to examine the specific impact that AI could have on German economic growth and the German labor market over a 15-year period. Research on the relationship between technological change and the labor market has a long tradition in the economic and social sciences. These studies show, on the one hand, that technologically feasible substitutions of human activities by new technologies are usually never fully realized and, on the other hand, that overall employment often even increases because new activities emerge or gain in importance. This insight guided the formulation of the assumptions for an AI scenario.

The findings point in a similar direction as the results from studies on Industry 4.0 and Economy 4.0 (Wolter et al., 2015; Wolter et al., 2019). It can therefore be concluded that consistent digitalization—both in the traditional sense and AI-based—can lead to positive economic developments. Germany is considered a key market for productivity-focused AI solutions and affects as a general-purpose technology almost every industry and sector.

Productivity and efficiency gains may lead to substantial value creation. However, structural change will accelerate due to increased AI development and integration. This will lead to shifts in the labor market that: while leaving the total number of employees barely different from the baseline scenario after 15 years, changes at the industry level will be significantly. While the demand for workers in some economic sectors will increase due to the greater use of AI, jobs will be lost in other sectors. Investments, new business models, and increases in productivity and material efficiency will result in opposing and largely offsetting effects on employment. The more AI contributes to productivity gains and the fewer new or additional business models are developed, the more likely it is that jobs will be lost in a particular industry.

The AI scenario also shows that employees will be affected to varying degrees depending on the level of skill required. While in the Economy 4.0 scenario (Wolter et al. 2019) computer technologies and robotics primarily took over the tasks of assistants and skilled workers, AI applications will particularly affect the work of experts and specialists. This highlights the distinctly different applications of AI compared to robotics or cloud computing. Now, it is primarily (also) cognitive tasks that can be performed using AI and are thus replaceable in the long term. However, this may lead to the further development of tasks and skills for which highly qualified individuals are particularly well-suited (Weber, 2025).

However, the potential productivity gains from AI depend crucially on the extent to which it is adopted and integrated within an organization. The most common reasons for not using AI are a lack of knowledge and uncertainty about the legal implications (Destatis 2024). Only when AI technologies are fully embedded in business processes, they can realize their potential to increase efficiency and value creation. It is not technological capability alone that determines economic benefits, but rather the speed and depth of organizational adaptation of AI technologies. Therefore, the opportunities presented by AI are accompanied by risks. The overall modest impact on the labor market assumes that Germany does not fall behind other economies in the development and application of AI. If new business models do not materialize as modeled in the assumptions, the impact on the labor market could turn out to be more negative

The AI scenario is not intended to provide accurate and precise answers about the future of AI development, application and integration. Rather, the aim is to estimate possible magnitudes, place them in an overall context, and thereby discuss both the costs and the benefits. The AI scenario represents one possible AI future, that seems to be plausible from today's perspective. But futures will tell whether the scenario was an optimistic or pessimistic one. From today's perspective, it seems to be clear, that AI may develop differently than expected here. The technology develops fast, and new applications may develop of which we cannot think of today. Hence, different sectors and industries may be affected differently than represented here. Still. This scenario assumes an AI ramp-up to a large extent. It is assumed that AI technology diffuses widely and intensively amongst industries.

Demographic trends and the shortage of skilled workers in the labor market are increasingly slowing down growth and, consequently, prosperity in Germany. This is confirmed by the results of the eighth wave of the Skills and Occupation Projections (Maier et al. 2024). The shrinking labor supply prevents growth in employment. The limiting effect of the labor supply not only leads to bottlenecks in many sectors of the economy but also hinders economic growth. Through the increased use of artificial intelligence (AI), it is hoped that the loss of the workforce will be offset, not least in terms of value creation.

However, this success depends on certain prerequisites Are these productivity gains achievable? Are AI solutions scalable? Do AI solutions have industrial impact? Is the willingness to adapt sufficiently high? Options and recommendation for action can be followed in order to make this scenario come true:

1. Strengthening digital infrastructure
2. Promoting innovation and entrepreneurship
3. Empowering businesses to adopt AI
4. Realizing productivity and efficiency gains
5. Measuring impact and scaleability
6. Governance, data rooms and building trust

Companies must adapt to AI and deploy it quickly—with support from senior management through clear strategies, processes, and guidelines. Greater boldness on the demand side is crucial for a successful and rapid AI rollout and for harvesting the benefits that AI tools promis. To safeguard or maintain digital sovereignty, there should also be a conscious effort to rely on European providers – even though they may be yet more expensive or less sophisticated. Policymakers can establish the framework conditions—particularly in the provision and promotion of infrastructure, the offering of AI-specific (continuing) education, training and consulting programs especially designed for SME, and the setting of standards for handling AI content.

This study has not yet made any assumptions regarding the effects on individual occupations. If such effects are taken into account, the impact on structural change is likely to increase. The impact of the increased use of AI on the future occupational structure will be analyzed in a follow-up study.

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