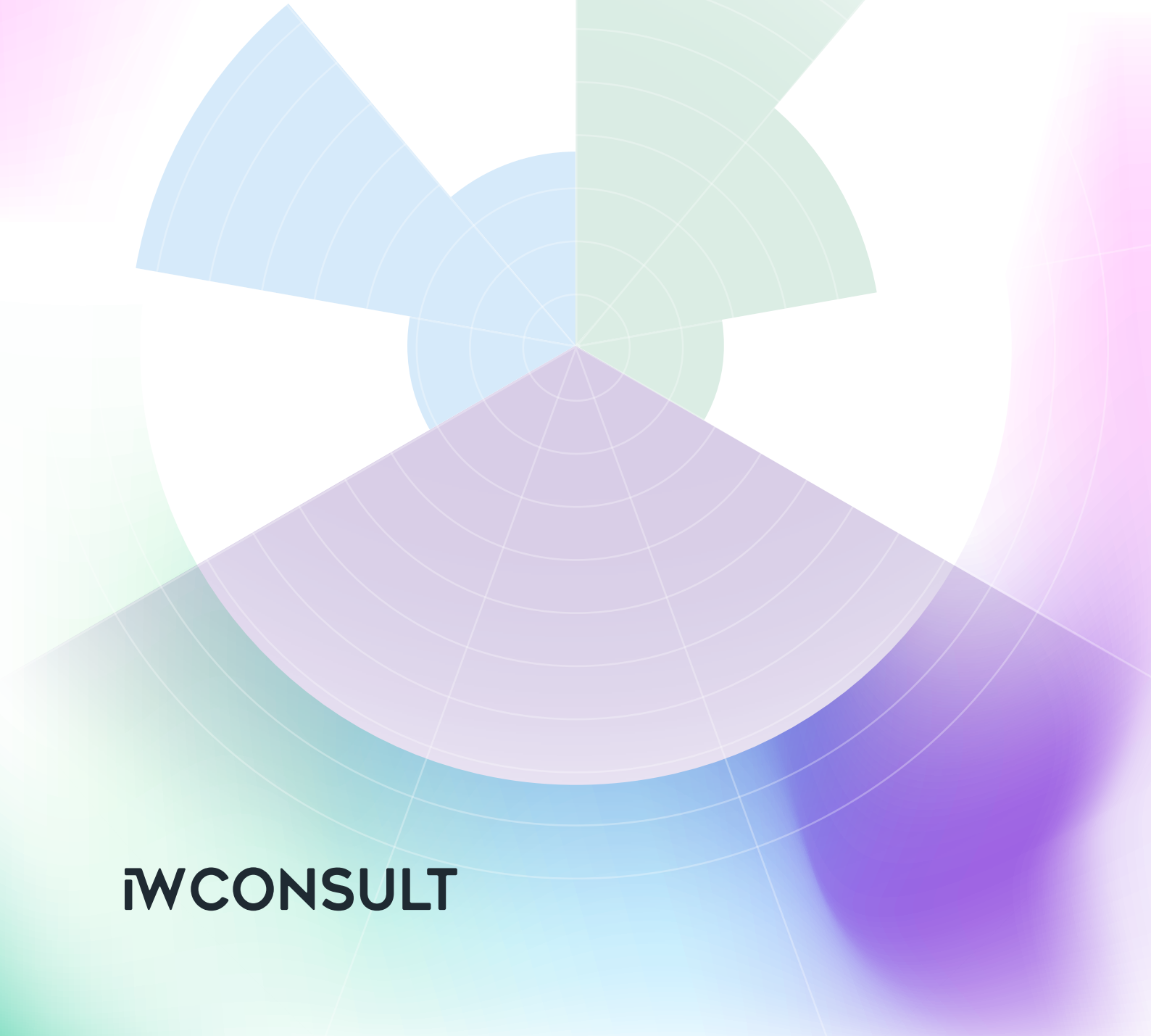
What If?

An Outline of Economic Potentials for Germany



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01 - Executive Summary

Germany, renowned for its engineering prowess and industrial excellence, is at a critical juncture where it is facing serious economic challenges. Despite past successes, the German economy, and particularly the industrial sector, is struggling with complex regulation, declining innovation, infrastructure gaps, high costs and worsening labor shortages.

Shaken up in 1999 by The Economist as the 'sick man of the euro' (The Economist, 1999), Germany managed to return to a growth path from 2005 onwards thanks to institutional reforms and innovative strength. Over the past decade, the country has capitalized on these reforms. Now it is crucial for future competitiveness to preserve Germany's specific strengths, such as engineering expertise, innovative strength and a strong SME sector, and to create revolutionary solutions and stimulate a new mindset with a Roadmap 2030, which outlines concrete steps to be taken to increase competitiveness.

The study looks at potential areas for more economic activity and possible opportunities. The focus is on three key areas that are central to increasing competitiveness and productivity: innovation, digitalization and education. Without innovation, in particular, it will not be possible to master today's most pressing social, economic and technological challenges. Very specific factors are identified for which the growth potential is calculated. Tapping into these areas of potential would result in more than 410 billion euros in additional gross domestic product (GDP), which corresponds to an increase of more than 10 percent (Figure 1-1). These empirical results highlight the areas where political action is required. Further elaboration is necessary to translate these empirical results into a political roadmap that takes account of the political circumstances.

Status Quo – Germany is losing competitiveness

Germany's competitiveness presents a mixed picture: While it continues to perform well in some areas, there is considerable room for improvement in others. Various rankings show that Germany has slipped from the top positions in terms of global competitiveness in recent years (IMD, 2023, 2024).

Germany's economy has also been characterized by a slow decline over the past few years. In 2023, the German economy shrank by 0.3 percent. With a forecast growth rate of 0.3 percent in 2024, Germany ranks second to last among the EU member states in the European Commis-sion's forecast (European Commission, 2024a). This highlights the need for comprehensive political measures to secure future prosperity. The danger of Germany entering an accelerating negative economic spiral must be averted.

Without innovation, it will not be possible to master today's most pressing social, economic and technological challenges.

Areas of Potential

More than 410 billion euros through innovation, digitalization and education

The economic potential areas identified in this study are created by estimating the correlation between competitiveness indicators and GDP per capita using elasticities. This quantitative measure is widely used in economics; elasticities are measured in percentage changes, which makes them comparable across different factors with different units of measurement. An elasticity indicates in which direction and by how many percent a factor changes when another factor increases by one percent.

The potential space analysis is based on the characteristics of specific factors in comparable countries and what would happen if Germany became one of the frontrunners. This opens up potential areas of more than 410 billion euros in additional GDP. Looking at specific factors for the areas of innovation, digitalization and education, which are particular important for a country's competitiveness, countries such as South Korea, the USA and Israel, but also Australia, Estonia and Iceland emerge as frontrunners. They have found particularly good ways to be more innovative and more digital, and in doing so have made outstanding use of the knowledge, learning and impetus of the local population and new arrivals. Each of these countries excels in a specific aspect of innovation, digitalisation or education. If Germany were to be inspired by the strengths of these frontrunners and implement appropriate measures in the areas identified, this could generate a new spirit of optimism.

The Potential of Innovation

Overcoming chronic venture capital weakness

Innovation remains the cornerstone of Germany's future economic success. Only through innovation will it be possible to master the most pressing social, economic, ecological and technological challenges of our time and to maintain or even strengthen competitiveness. Germany has always been one of the world's leading innovation nations, particularly in the industrial sector, and benefits from its technical expertise and engineering knowledge.

However, innovation activity in the German economy has declined in recent years (Bolwin et al., 2023). Particularly in the field of new technologies, Germany is struggling to keep up with the leading countries. Another obstacle is the comparatively low level of venture capital investment, which hampers the commercialization of innovative technologies. Germany has considerable economic potential if it were to achieve the same level of innovation activity as the frontrunners:

Germany's GDP per capita could be ...

→ 8.5 % higher

if it were to reach the level of Japanese patent activity (per capita). Germany is lagging far behind, particularly regarding promising technologies in the fields of information and communication technology and artificial intelligence. Japan recently patented almost four times as many patents in these areas (187 applications per million inhabitants) than Germany (50 patents per million inhabitants).

→ 3.7 % higher

if it were to reach the level of U.S. investment in venture capital (as a proportion of GDP). Germany not only accounts for only one-ninth of U.S. venture capital investment (as a share of GDP), and the trend has been declining in recent years. Compared to the record year 2021, the amount invested in Germany in 2023 has fallen by 65 percent (Prüver, 2024).

→ 3.2 % higher

if it were to reach the U.S. level of spending on research and development (as a proportion of GDP). Amazon invested around 86 billion euros in research in 2023 alone, Alphabet 45 billion euros and Meta 39 billion euros. The German company with the highest research spending is VW with 15.8 billion euros (company data).

The Potential of Digitalization

Accelerating the development of digital capital stock

The use of digital technologies such as artificial intelligence (AI) has great potential to significantly increase the productivity of the economy and thus boost competitiveness. Germany's future competitiveness increasingly depends on its ability to pursue digital and data-driven business models. Despite considerable technological progress, German companies often lag behind when it comes to digitalization. Some of the main reasons for this are the inadequate digital infrastructure, the lagging digitalization of public administration and the shortage of IT specialists. In recent years, the U.S. has invested significantly more in building up its digital capital stock in the form of data centers, software or computer equipment and is also a leader in the field of AI. Germany has a lot of catching up to do in both areas.

Germany lags behind other leading industrialized nations when it comes to investment in information and communication technologies relative to GDP. Improvement in the following areas offers significant economic potential:

Germany's GDP per capita could be ...

→ > 10 % higher

if it were to match the proportion of ICT investments in U.S. GDP. In the USA, the capital stock of software goods, databases and other IT equipment has increased by more than 850 percent since 1995, while in Germany it has only grown by around 300 percent (EUKLEMS, 2024).

→ 5.9 % higher

if it reached the level of newly financed AI companies per capita in Israel. Israel is the country with the third largest venture capital investment in generative AI start-ups after the USA and China – more than 2.2 billion euros since 2021 (Shmulovich, 2023).

→ 2.8 % higher

if it were to achieve South Korea's level of digital future viability. South Korea is set up for the future thanks to a digitalized public administration and a public data platform, particularly in areas such as bureaucracy and legal framework conditions.

The Potential of Education

Universities as a gateway to economic growth

Well-trained specialists, such as engineers, have long been one of Germany's strengths and contribute to innovation, progress and competitiveness. This makes the challenge of a growing shortage of skilled labor, exacerbated by demographic trends and declining education levels and limiting Germany's economic potential, all the greater. By 2030, the volume of labor in Germany is estimated to decline by 3.2 million due to demographic changes (Hüther et al., 2021). The less qualified this smaller labor force is, the more difficult it will be to increase productivity levels.

Overcoming this challenge requires a multi-layered approach. This study highlights the potential of three levers: improving IT education, attracting more international students and increasing the labor force participation of foreign-born individuals. There is potential for improvement in Germany, above all in the labor market participation of foreign-born individuals and in the targeted immigration of skilled workers, for example via universities. The results show considerable economic potential for Germany if it were to reach the level of the top performers in the indicators analyzed:

Germany's GDP per capita could be ...

→ **> 10 % higher**

if it were to reach Australia's level in terms of the proportion of international students. Germany excels at keeping students in Germany after graduation and integrating them into the labor market, which ensures that future skilled workers are brought to Germany at an early stage (Geis-Thöne, 2022).

→ **> 10 % higher**

if it were to reach Estonia's level of graduates in information and communication technologies (as a proportion of all graduates). Estonia pursues an educational approach that includes IT education from an early age and thus promotes digital skills in the population at an early stage.

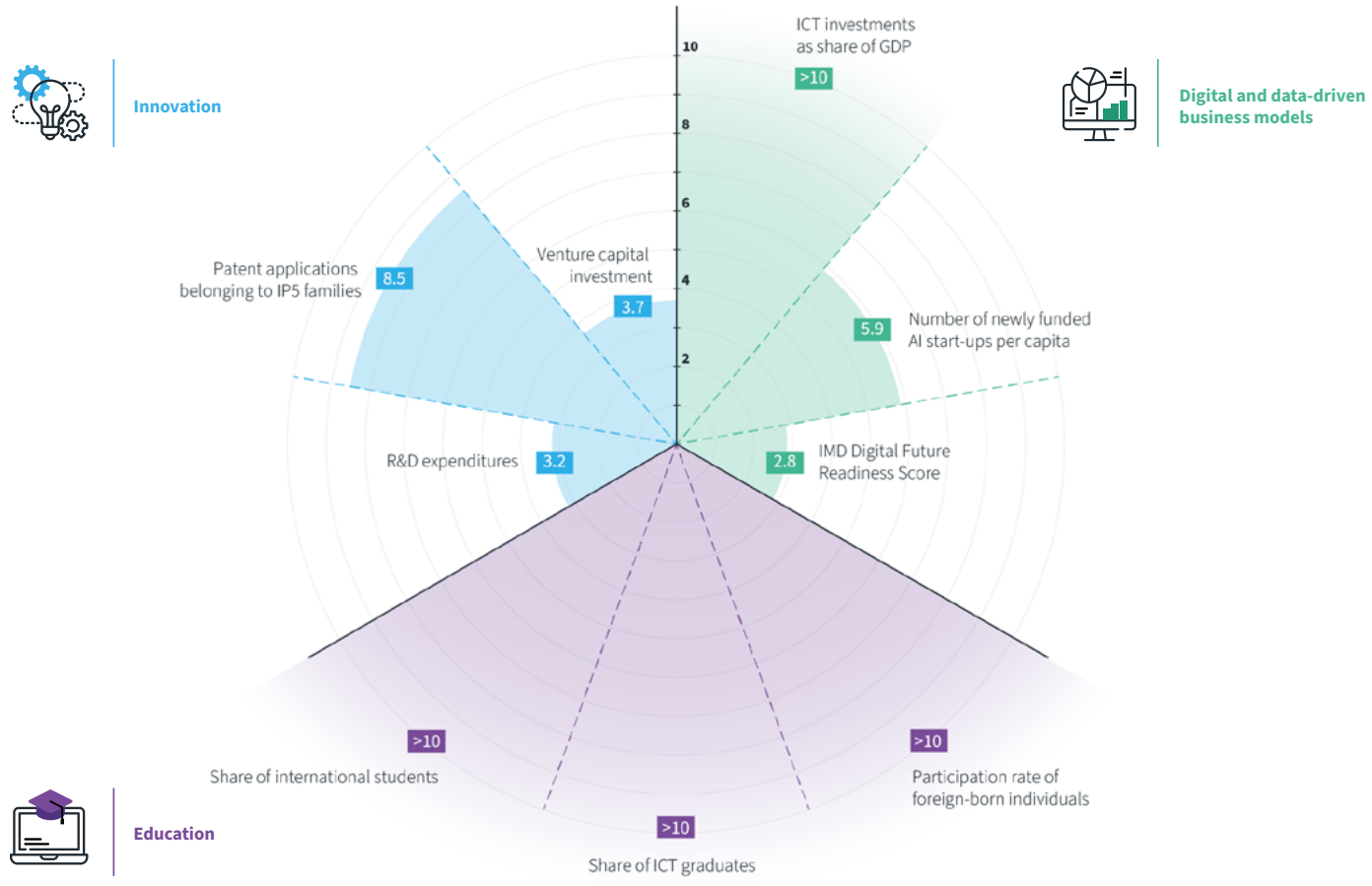
→ **> 10 % higher**

if it were to reach Iceland's level of labor force participation among foreign-born residents. In Germany, the difference in the labor force participation rate between native-born and foreign-born individuals is 7 percentage points, significantly higher than in Iceland (1.6 percentage points), Canada (0.1 percentage points) and the UK (1.3 percentage points) (OECD, 2023a).

Figure 1-1
Economic potentials – Overview

Economic potential for Germany: Elasticity of real GDP per capita with respect to the predictor, combined with the percentage difference between the top performer's score and Germany's score. Analysis for 48 countries associated with the OECD.

% of real GDP per capita



Source: Own calculations based on Maslej et al., 2024; OECD, 2023a, 2023b, 2023c, 2023d, 2023e, 2024, model: Two-way-fixed effects (time and country fixed effects)

Recommendations
Fields of action to realize economic potential

A total potential of more than 410 billion euros in gross domestic product (GDP), which corresponds to an increase of more than 10 percent (Figure 1-1), could ideally be realized by improving the framework conditions. The areas should not be viewed as isolated segments but as interrelated. For example, an increase in immigration could significantly benefit the innovation ecosystem, and an increase in the number of IT graduates would increase the pool of available human capital for emerging technology start-ups. Therefore, it is important to note that the economic potential figures cannot simply be added, as there are overlaps and relations between the indicators.

Germany needs a Roadmap 2030, which outlines concrete steps to be taken to achieve a higher competitiveness, to provide new impetus and open up areas of potential. The results show which levers offer great potential to increase the competitiveness of the German economy and put it on a higher growth path. This study provides initial impulses that should be supplemented and deepened in further contributions. These should also incorporate the assessments of policymakers and experts and discuss in-depth analyses of promising solutions in other countries and their adaptation to Germany.

The following recommendations for action are intended to provide initial impetus and fuel the debate on how Germany can once again become a frontrunner to safeguard the prosperity it has built up in recent years. They describe steps that can be implemented in the medium and short term to help exploit the economic potential of innovation, digitalization and education.

A total potential of more than

410 bn €

in additional gross domestic product (GDP) could ideally be realized.

Recommendations

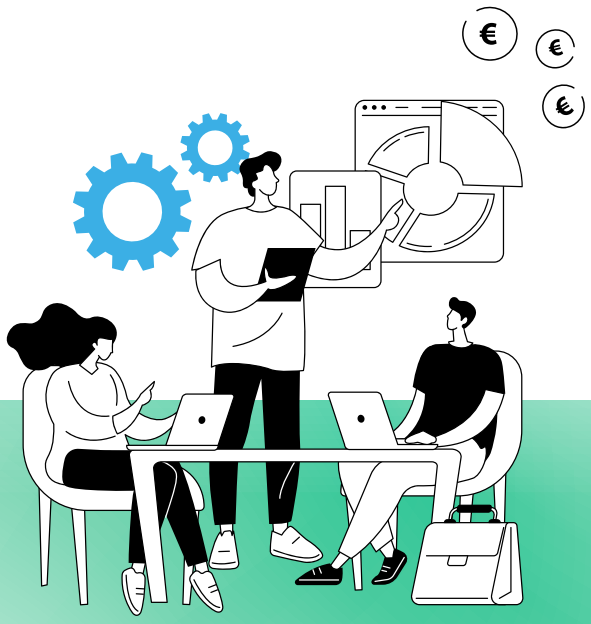
Potential of Innovation

→ Increase venture capital financing:

Institutional investments should be promoted through better risk sharing between public and private investors, as well as start-up funds for smaller investors. Additionally, more family businesses and private funds should be included. For example, greater involvement of pension funds in venture capital financing can contribute to an increase. Between 2017 and 2021, only 4.3 percent of venture capital financing in Germany came from pension funds (Dahmann et al., 2023), while in the USA, the share is around a quarter (Redstone, 2023).

→ Introduce start-up visas:

Start-up visas are essential to attract international entrepreneurial talent with strengths in building innovative, scalable and digital business models. Priority should be given with these visas to founders whose business models are innovative, scalable and digital – especially those who specialize in the use of data and the implementation of new technologies.



→ Mobilize the state for innovation:

In the USA and Israel, successful cooperation between the state and research institutions, particularly in military and defense-related research, has driven technological leadership. Adapting this approach to Europe involves establishing EU-funded technology parks and innovation centers. These centers would foster synergies between universities, start-ups and established industries, accelerating the transition from academic research to market-ready products through enhanced collaboration. Europe should support high-risk, high-reward projects in strategically important areas like renewable energy, digital security and AI.

→ Reduce bureaucracy and enhance efficiency through subsidiarity and increased autonomy:

Subsidiarity in public governance empowers local authorities to make decisions tailored to their specific contexts, enabling quicker and more relevant responses to local needs. This approach fosters innovation by allowing local experimentation through real-world labs and sandboxes, where new ideas can be tested with minimal risk and scaled up if successful. In the corporate sector, subsidiarity involves shifting some regulatory responsibilities from central authorities to individual companies, promoting self-regulation and accountability. Common in Anglo-American contexts, this method grants businesses operational freedom with subsequent audits, reducing administrative bottlenecks and encouraging a more dynamic and responsible business environment.

Recommendations

Potential of Digitalization

→ Implement super depreciation:

The super depreciation for digital goods planned by the 'traffic light coalition' must be implemented quickly to promote ICT investments. More computers, the latest software and data centers play a decisive role in exploiting the potential of digitalization.

→ Set up a digital agency:

Administrative digitalization must be accelerated. Other countries with strong digital ecosystems, such as the Baltic states or South Korea, are leading the way: A digital administration must be a pioneer and can generate positive impetus for the digitalization of companies. A digital agency that coordinates digitalization efforts in the federal states and ensures uniform standards and procedures reduces fragmentation in the system and increases efficiency. In this context, it should also be discussed how regulatory issues can be streamlined, for example by the federal government taking over tasks that are currently regulated by the federal states.

→ Reduce bureaucracy, initiate a change in mindset:

A 'bureaucracy advisory board' should work together with entrepreneurs to identify the burdens that arise from regulation in order to find a constructive way to implement regulations as intelligently as possible. So-called 'Practical checks' by the Federal Ministry of Economics and Climate Protection are a step in the right direction, but should be consistently expanded, consolidated and applied at the European level. The competitiveness check for European laws, announced by EU Commission President Ursula von der Leyen, must be implemented swiftly.

→ Accelerate the data ecosystem:

More German companies, especially SMEs, would participate in the data economy if access were simplified and complexity reduced. To achieve this, the existing regulatory framework needs to be reduced and bureaucratic requirements simplified in the medium to long term. Currently, there are still too many legal uncertainties regarding data sharing and data protection. In the short term, pragmatic approaches should be explored, best practices in other countries analyzed and adapted and practical use cases and legal aids, such as model data contracts, should be offered. The framework conditions must be made as clear and attractive as possible so that European companies can also benefit to a greater extent from the opportunities offered by digitalization.

→ Complete the digital single market:

The scaling of successful European start-ups often fails because the European single market does not yet have the strength of the USA. The EU institutions should agree on an ambitious, Europe-wide roadmap for the further integration of the internal market. The centerpiece should be support for companies in setting up data rooms in order to strengthen industrial expertise as a key comparative advantage. In addition, the harmonization of the legal framework for digital services should be driven forward.

Recommendations

Potential of Education

→ **Introduce a learning platform:**
The foundation for well-trained specialists is formed in schools. Early skills development is best promoted through individualized learning that incorporates digital learning platforms. Providing materials for teachers on the use of digital media and online-based learning would be a first step towards improving the quality of education in Germany.

→ **Facilitate the recognition of foreign qualifications:**
To make Germany more attractive for highly qualified immigrants, it is necessary to further improve and facilitate the recognition of foreign professional qualifications. The connection of the federal states to the central online recognition system 'Anerkennung in Deutschland' and the associated online application process should be expedited for as many professions as possible in order to standardize and simplify the process.

→ **Strengthen the brand of German universities:**
Compared to leading American universities like MIT, German universities have significant potential to enhance their international reputation through targeted branding and marketing strategies, attracting more international students. Increasing the number of English-taught undergraduate programs could reduce language barriers and make German universities more accessible and appealing globally. Additionally, developing robust alumni networks to leverage alumni as brand ambassadors and promote the high quality of education can further support the overall branding strategy and make German higher education more attractive worldwide.

The recommendations for action describe feasible steps that can be taken in the short and medium term to realize the economic potential identified in this study. This document serves as a foundation and invites stakeholders to engage in a constructive dialogue on how best to exploit the identified opportunities for growth and improvement. Germany is at a crossroads and has the opportunity to redefine its economic heritage for the 21st century. By fostering innovation, a skilled and diverse workforce and creating a favorable environment for digital transformation, Germany can unlock its enormous economic potential. This study serves as a call to action for policymakers, business leaders and other stakeholders to jointly chart a course towards a bright future for Germany.

02

The Economic Development in Germany

Achievements and Challenges

02 - The Economic Development in Germany

Achievements and Challenges

In 1999, The Economist famously referred to Germany as the ‘sick man of the euro’ (The Economist, 1999). High unemployment, low productivity and lack of economic growth were the problems at the time.

The federal government responded by instituting significant reforms, which despite being criticized, helped change the trajectory of the German economy over the following decades. The financial crisis of 2008 and 2009 took its toll on Germany, but the economy recovered relatively well and quickly, to the surprise of many observers. By the early 2010s, Germany was once again considered a successful economy (van Baal & Lichtblau, 2012), benefiting society at large.

In 2024, Germany is at a crossroads again. The issues the economy faces are different than 25 years ago – an inadequate physical and digital infrastructure, high costs and taxes, shortages of skilled workers and bureaucratic and regulatory burdens for firms are prominent examples (Flechtcher et al., 2024). To change its economic trajectory once more, Germany must address these, which presents a significant political and social challenge. Taking on this challenge and advocating for change requires a clearer view of the potential outcomes.

This study represents an attempt to outline the potential for the German economy to grow and overcome economic stagnation. It does not aim to ‘rub salt into the wound’ or delve into the intricate details of the problems the economy faces, but rather to indicate what might be possible if certain conditions were different. The study aims to add insights to the discussions and decisions in Germany and beyond by suggesting opportunities for improvement.

Many such decisions are not limited to Germany but take place at a higher level in the European Union. While we focus on Germany as the largest economy in Europe, the issues and recommendations covered in the study require a broader, European perspective. We hope to provide insights that resonate both in Berlin and in Brussels. If the German economy performs well, the European Union will also benefit, and vice versa.

The approach taken in this study

The study proceeds empirically by analyzing data for a range of countries and applying the results to the situation in Germany. Our estimations are based on data from OECD member countries, its accession candidates and its key partners, totaling 48 nations. We focus on OECD members and associated countries to avoid comparing Germany with nations at very different stages of development. Based on the empirical analysis, the study provides estimates showing how economic performance might change if the circumstances in Germany were different. The study is not intended to establish causal relationships but rather to illustrate, in an econometric or statistical manner, the range and scope of potentials for the German economy. To highlight examples (in diagrams), we focus on a subset of the 48 nations: the G7 countries, China and India. The latter two are often considered rising and important international competitors. Although their stages of economic development are quite different from Germany, spotlighting their situation is insightful.

After briefly reviewing the macroeconomic development in Germany in the remainder of this chapter and thus setting the stage for the study, the following chapters are devoted to different factors associated with economic performance. We begin by covering the 'big picture' by analyzing relatively broad measures of competitiveness. Subsequently, we delve deeper into specific areas, focusing on innovation, skilled workers and digital and data-driven business models.

> If the German economy performs well, the European Union will also benefit, and vice versa.

Operationalizing economic performance

A country's economic performance determines its citizens' standard of living: How many and which goods and services are available? How comfortable and financially secure is life? How well are we equipped to solve problems that require funds to address? When an economy performs well, the answers to these questions become easier. While high economic performance is not all that matters, it offers many advantages. A sound economic foundation implies greater possibilities in numerous areas, including the resources available to respond to opportunities and threats, both on a private and public level. A well-performing economy is in the interest of all its members.

A prime indicator of economic performance and the standard of living in a nation is real Gross Domestic Product (GDP) per capita. It measures the inflation-adjusted value of all final goods and services produced in a country per member of the population. This value, in turn, determines average income. When GDP per capita rises, people have access to more goods and services, including everyday consumption goods, and better healthcare, for example. In fact, a higher GDP per

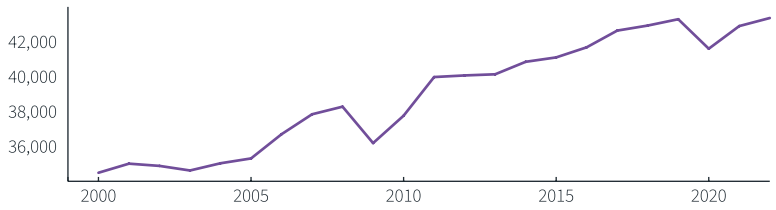
capita correlates with a greater life expectancy among the countries in our sample. Achieving a higher GDP per capita is not an end in itself, but a means to provide for a country's citizens. Hence, even though GDP per capita is an imperfect indicator of a society's well-being (there is no single perfect indicator), it is still informative and the most widely used such indicator.

Figure 2-1 shows that the development in Germany since 2000 (the year after the famous 'sick man of the euro' aphorism) has been positive: GDP per capita has increased substantially. On the other hand, as Figure 2-2 indicates, the development in several other nations has been even more favorable. For China and India, this is partly a catch-up effect, as these countries began at a substantially lower starting point. However, GDP per capita in the United States has also grown more than in Germany. More importantly, these time series naturally refer to the past (comparable data for real GDP per capita is available until 2022), and the more recent development has not been satisfactory. In 2023, the German economy Germany shrank by 0.3 percent (Statistisches Bundesamt, 2024b). With projected growth of 0.3 per cent in 2024, Germany ranks second to last among the EU member states in the EU Commission's forecast (European Commission, 2024a).

What is even more relevant is the outlook for the future. The macroeconomic situation and development – both in the future and in the past – are based on the competitiveness of Germany as a business location. GDP per capita depends crucially on a country's competitiveness – the extent to which the conditions in the country allow its members to be successful in international and domestic markets. To provide a final introductory background for our study and to prepare for the next chapters, it is insightful to analyze the development of the competitiveness of the German economy. In the following, the concept of competitiveness and its development in recent years will be discussed.

Figure 2-1
Development of GDP per capita in Germany

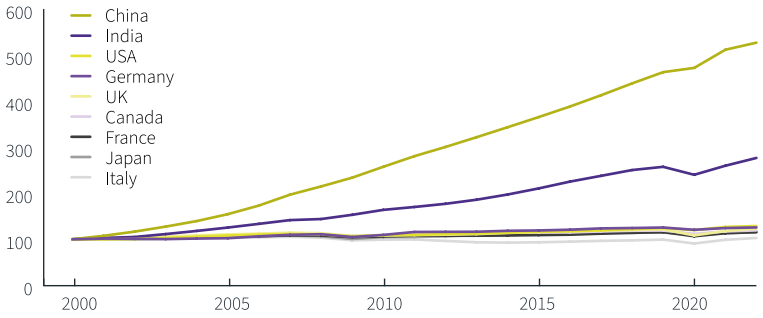
Adjusted for inflation (constant 2015 US$)



Source: World Bank, 2024b

Figure 2-2
Development of GDP per capita in selected countries

Adjusted for inflation (constant 2015 US$), absolute level of GDP per capita as an index with 2000 as base year



Source: World Bank, 2024b

With projected growth of

0.3 % in 2024

Germany ranks second to last among the EU member states.

03

Competitiveness

What We Can Learn from Others

03 - Competitiveness

What We Can Learn from Others

Competitiveness is a multi-faceted concept, and as such cannot be reduced to any single indicator such as labor costs or natural resource endowment.

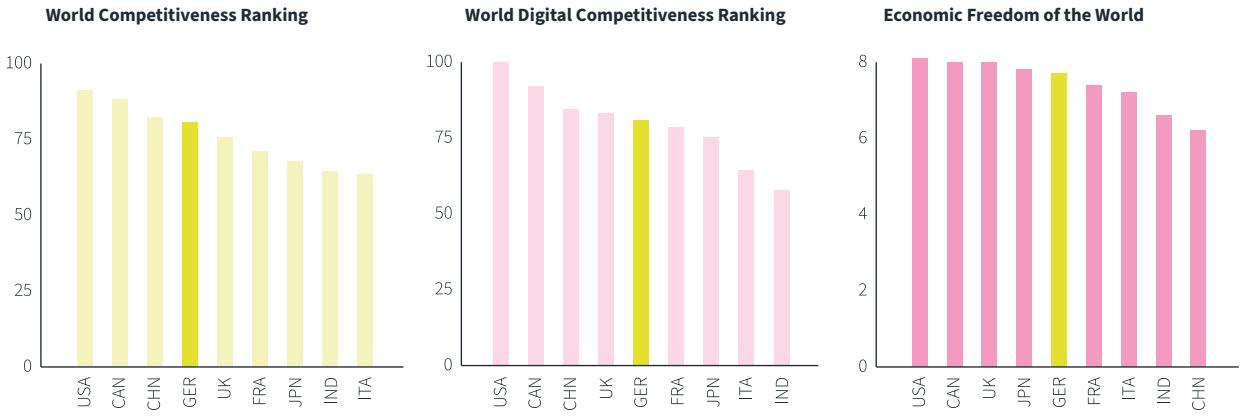
Our research design, therefore, focuses on specific, important aspects of competitiveness. On the one hand, overarching competitiveness indices are analyzed to show the development of the competitiveness of the German economy. On the other hand, the competitiveness-driving aspects of innovation, digital and data-driven business models and education are addressed in detail.

To capture the complexity of the concept of competitiveness, researchers have constructed measures of competitiveness that encompass a wide range of indicators. A well-known measure is regularly published by the International Institute for Management Development (IMD) in its World Competitiveness Ranking. The IMD also offers a more specialized data source, the World Digital Competitiveness Ranking. In light of the high and growing importance of digitization, it is indispensable to also analyze this data source. As a third measure of competitiveness, we analyze data on the Economic Freedom of the World, made available by the Fraser Institute. Economic freedom is not the same as competitiveness, but its measures have a strong conceptual bearing on it. By analyzing these three data sources, we aim to provide a relatively broad, yet detailed, picture of the development in Germany. According to these measures, Germany has a relatively competitive economy. Among the 64 countries covered by the IMD in 2023, Germany ranks 22nd in the World Competitiveness Ranking and 23rd in the World Digital Competitiveness Ranking. The Fraser Institute covers 165 countries in its report from 2023 (with data relating to 2021), and Germany also ranks 23rd. While not amongst the countries with the highest competitiveness, Germany is far from being among those with the lowest. However, recent developments have not been promising (Figure 3-1). In the World Competitiveness Ranking, a decline has occurred since 2017. In the World Digital Competitiveness Ranking, despite a temporary rebound in 2022, the situation in Germany is substantially worse in 2023 than it was in 2019 and the preceding years. The Economic Freedom of the World report shows a steady decline since 2014.

Figure 3-1
Changes in the competitiveness of the German economy

Sources: Gwartney et al., 2023; IMD, 2023b, 2024

Figure 3-2
The competitiveness of the German economy - Current state



Sources: Gwartney et al., 2023; IMD, 2023b, 2024

The picture is mixed when comparing Germany with the group of comparable and competing countries such as the G7, China and India (Figure 3-2). For example, Canada and the United States consistently show higher scores than Germany, whereas the opposite is true for France and Italy. Both are relevant comparisons, and one might be tempted to only relate Germany to countries in proximity. However, given the international aspirations of many German companies and the almost global mobility of capital, a broader perspective is paramount. In addition, the observation that Germany still has a relatively competitive economy needs to be interpreted against the background of the decline in recent years (as shown in Chapter 2).

Both the relative position of Germany and the decline over the last few years suggest that there is room for enhancement – in other words, there are economic potentials for Germany that can and, in light of national and global challenges, need to be tapped. The next chapters outline these potentials with a focus on three main drivers:

→ **Innovation:**
Innovation is crucial for enhancing a country's competitiveness and ensuring its future prosperity, as it is essential to address pressing social, economic and technological challenges. However, innovation activity in the German economy has declined in recent years (Bolwin et al., 2023). An improvement in this area offers economic growth potential.

→ **Digital and data-driven business models:**
Germany's future competitiveness is increasingly linked to its ability to exploit digital and data-driven business models. Despite significant technological advances, German companies often lag behind in terms of digitalization. Tapping into new fields of technology such as AI applications opens up a realm of potential for economic growth.

→ **Education:**
Highly educated professionals such as engineers have long been one of Germany's strengths, contributing to innovation and progress. This makes the challenge of a growing skills shortage, exacerbated by demographic trends and declining levels of education, all the more acute. Improvement in this field will lead to economic growth.

Methodology

In this study, we estimate the economic impact of different indicators, using current panel data on these indicators and GDP per capita. Throughout the study, GDP per capita is measured in constant 2015 U.S. dollars (World Bank, 2024a) to adjust for inflation. The data covers a set of up to 48 countries and 27 years. There is variation in the precise number of countries and years included in each estimation because of differences in data availability. For reasons of comparability, the analysis is restricted to emerging and advanced economies and comprises the set of OECD countries plus their key partners (Brazil, China, India, Indonesia, South Africa) and accession candidates (Peru, Argentina, Bulgaria, Croatia, Romania). All available years are included in the estimation.

We estimate two-way fixed effects models (time and country fixed effects). This approach enables us to isolate the effect of the indicators on GDP per capita from general developments in economic performance over time across countries and time-invariant differences between countries. Broadly speaking, the method allows us to compare the economic development over time in countries that perform better on the indicators with the development in countries that perform worse. Differences in GDP per capita are attributed to differences in the indicators. We use log-log and log-level specifications. This implies the estimation of elasticities (log-level: semi-elasticities). The resulting coefficient indicates the percentage change in the response variable when the predictor variable increases by one percent (log-level: one unit). We only report results that have a p-value less than 0.05 (statistically significant results). For p-values less than 0.01, we refer to the respective elasticity as ‘highly’ significant.

Three related methodological points concerning the estimated elasticities and semi-elasticities are important to note: First, they cannot be added, since there are overlaps and relations between the indicators. Second, they cannot be interpreted as causal effects because they represent statistical associations. Third, they do not explicitly model the development within a country over time. When an indicator changes, GDP per capita cannot be expected to change immediately. Instead, a change in an indicator may put a country on a different growth path, which will affect GDP per capita over time.

The method is discussed in more detail in the Appendix.

04

Innovation

Embracing Risk for the Technologies of the Future

04 - Innovation

Embracing Risk for the Technologies of the Future

Innovation is of fundamental importance to drive a country's competitiveness and secure its future prosperity (OECD, 2015). Without innovation, it will not be possible to master today's most pressing social, economic and technological challenges.

Bringing about innovation requires various players, most notably research organizations and companies. The latter are particularly relevant in bringing innovative ideas to practice. An idea itself is not enough: it is often necessary to overcome serious obstacles to effectively realize and harness the potential of good ideas.

In this light, this chapter considers the role of innovation in spurring economic performance and growth. By focusing on indicators of innovation that cover both the production of good ideas and their implementation in practice, it takes a holistic approach to innovation. It first provides a characterization of the innovation landscape and its recent development in Germany. Three key indicators of innovation are presented in this context.

To uncover the connection between these indicators and GDP per capita, we estimate elasticities (for our methodological approach, see the box on page 20). This quantitative measure is widely used in economics. One reason for its broad applicability is that elasticities are measured in percentage changes, which makes them comparable across variables with different units of measurement. An elasticity shows in which direction and by how many percent a response variable changes when a predictor variable increases by one percent.

Characterization of the innovation landscape in Germany

Germany has always been among the leading innovative economies in the world, in particular within traditional sectors such as automotive, mechanical engineering and manufacturing, leveraging its engineering prowess and industrial expertise. However, more recently, the innovation landscape in Germany has encountered some significant challenges. One challenge concerns innovation in modern technology areas, such as information and communication technology (ICT) and artificial intelligence (AI), which are key to future value creation in a country with relatively high production cost and limited natural resources. In these areas, Germany shows difficulties in keeping pace with other global leaders. Insufficient investment in such areas risks a loss of technological sovereignty in the future (EFI – Expertenkommission Forschung und Innovation, 2024).

Additionally, there remains a gap between academia and industry, impeding the commercialization of innovative technologies (Bundesministerium für Wirtschaft und Klimaschutz [BMWK], 2021). A lack of venture capital investment is a hurdle in this regard. As a third important challenge, Germany's traditional strengths in incremental innovation pose hurdles to embracing radical innovation, particularly in rapidly evolving sectors like AI and ICT. The conservative nature of many German companies and a culture of risk aversion often inhibit the adoption of disruptive technologies and business models. Companies often rest on the laurels of past successes (Naudé & Nagler, 2021).

In the following discussion, data on innovation is presented to illustrate these points and characterize Germany's current state of innovation. In our analysis, we focus on the following three key indicators of innovation:

- → **Expenditures on research and development (R&D)**
- → **Patent applications belonging to the patent families of the five largest intellectual property offices (IP5) [1]**
- → **Venture capital (VC) investments**

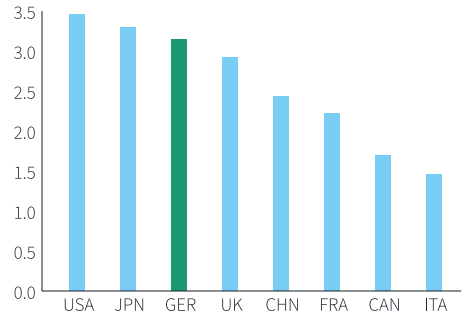
These indicators reflect different elements of innovation. Expenditures on R&D cover innovative activities very broadly and characterize the input side of innovation. The measure includes various types of research and development (basic research, applied research, experimental research) as well as R&D undertaken by a range of key players for innovation (business enterprises, government, higher education institutions and private non-profit organizations). In contrast to innovation input, patents provide a measure of tangible output of innovation efforts. Only innovative outputs that are deemed sufficiently novel and with enough economic potential are brought to application at one of the IP5 offices. Focusing on the IP5 offices ensures international comparability and raises the quality threshold for patents as an indicator of innovation. Finally, venture capital investments focus on bringing innovative ideas, often surrounding very recent technological advancements, into business practice. This provides a measure of investments in emerging technologies and the potential for scaling innovation efforts in the translation from innovation to application (Kaplan & Lerner, 2010).

Considering R&D expenditures, Germany invested USD 134.5 billion in 2021. Figure 4-1 shows R&D expenditures as a percentage of GDP for Germany as well as the reference group of G7 countries plus China and India. In absolute terms, Germany ranks fourth in the world for R&D expenditures, behind the U.S., China and Japan. The United States is far ahead of Germany with R&D expenditures about six times the amount of Germany's. Taking the size of the economies into account, Germany's R&D expenditures correspond to 3.14 percent of its GDP, ranking it third across the reference group of countries. The relative investment in R&D is also much closer to that of the U.S. (3.46 percent) and Japan (3.30 percent). While this demonstrates Germany's commitment to investing in innovation, it also shows that there is still some potential to increase R&D expenditures as a means of promoting innovation.

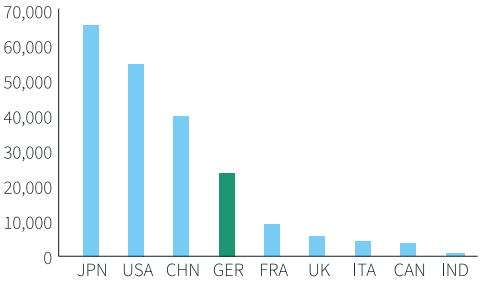
Figure 4-1
Innovation – Current state

The results are shown for all countries in the set of similar and competing countries (G7 + CHN + IND) for which data is available. Figures at the current edge.

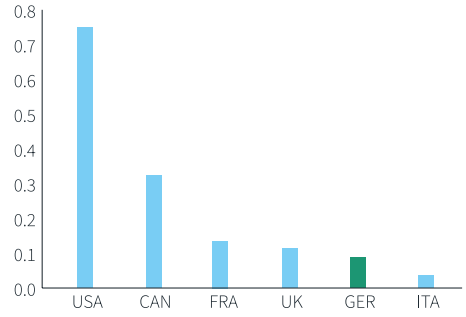
R&D expenditure (% of GDP) (2021)



Patent applications to IP5 (2019)



VC investment as percentage of GDP (2022)



Sources: OECD, 2023d, 2023e; World Bank, 2023

1) These five IP offices are the U.S. Patent and Trademark Office (USPTO), the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO) and the National Intellectual Property Administration in China (CNIPA). A patent application counts as part of the IP5 families if it is protected in at least two IP offices worldwide, one of which is among the above-mentioned IP5 offices.

With regard to patents, Germany filed 23,650 applications belonging to the IP5 families in 2019.[2] Figure 4-1 shows patent applications for Germany and the reference group of countries. This puts it in the fourth position among the reference group, substantially behind the world leader Japan, which filed 65,903 patent applications, the United States with 54,711 patent applications and China with 39,996 patent applications. Globally, South Korea is also ahead of Germany with 25,898 patent applications. Even taking the size of the countries into account, Germany filed 285 patent applications per million people, which corresponds to about half the relative number of patents filed by Japan (520 patent applications per million people). This indicates significant room for improvement in terms of innovation output for Germany.

Concerningly, the picture looks worse for Germany when focusing on patents in the technology areas of AI and ICT, which will be of increasing importance in the future (Figure 4-2). Japan, the United States and China filed five times as many ICT patents than Germany in 2019 and more than four times as many AI patents than Germany in 2017 (with Japan and the U.S. exceeding Germany's number of patents by almost a factor of seven). The trend of patent applications in these technology areas also demonstrates that the leading players are rushing ahead while Germany stays behind. While China and the United States, for example, increased their ICT patent applications by 373 and 64 percent, respectively, over the previous ten years, Germany's patent applications increased by only 20 percent over the same period. The discrepancy is even larger for AI patents. China's patent applications in 2017 were more than eleven times higher than in 2007, while the United States increased its patent applications by 125 percent. Over the same period, Germany's AI patent applications increased by a relatively meagre 50 percent.

Venture capital investments in 2022

Germany

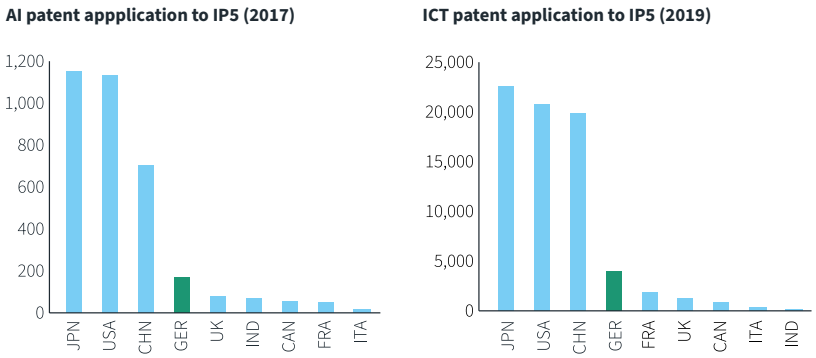
3.6 bn US$

United States

190.5 bn US$

Figure 4-2
Innovation – AI and ICT patent applications to IP5

The results are shown for all countries in the set of similar and competing countries (G7 + CHN + IND) for which data is available. Figures at the current edge.



Source: OECD, 2023d

In terms of VC investment, the U.S. is significantly ahead of all other countries. Germany invested 3.6 billion U.S. dollars in venture capital in 2022, while the United States had VC investments of 190.5 billion U.S. dollars. Even as a percentage of GDP, the U.S. has about nine times the level of VC investment compared to Germany, as the bottom diagram in Figure 4-1 demonstrates. In relative terms, Germany only ranks fifth in the reference group of countries, with an investment of less than 0.1 percent of GDP. There is, therefore, substantial scope for increasing VC investments in order to facilitate a better transition from innovative ideas to marketable products.

Impact of innovation on economic performance

Successful innovation is a crucial driver of economic performance and growth. Innovative companies create value through innovation by improving their production processes, organizational

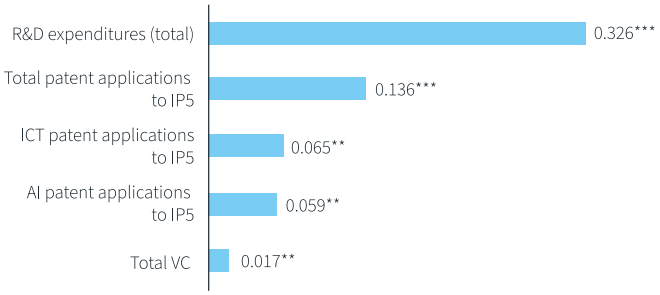
2) Patent data typically has a significant time lag in public availability due to legal delays in publishing patent information.

performance and launching new products and services. This makes them more competitive, creates employment and translates into better economic performance and higher growth on the level of the whole economy. Early and modern economic growth theories emphasize the role that innovation and investing in innovative activities play in advancing technology, creating value and spurring growth (Solow, 1956; Romer, 1990; Acemoglu et al., 2018; Aghion et al., 2021).

We estimate the impact of innovation once again using current panel data on the indicators of innovation outlined above and GDP per capita. Across all indicators of innovation, we identify a strong and significant relationship between innovation and GDP per capita. The results are shown in Figure 4-3 and represent elasticities, that is, the percentage change in GDP per capita as the innovation indicators are increased by one percent. The largest elasticity identified is the effect of R&D expenditures on GDP per capita. For a one percent increase in R&D expenditures, GDP per capita increases by 0.316 percent. Patents also show a strong effect: A one percent increase in the number of total patent applications results in a 0.136 percent increase in GDP per capita. The corresponding elasticities for ICT and AI patent applications are 0.065 and 0.059 percent, respectively. Finally, venture capital investments significantly affect economic performance. As VC investments increase by one percent, GDP per capita increases by 0.017 percent.

Figure 4-3
Innovation – Effects of indicators on GDP per capita

Estimated elasticities between different predictor variables and real GDP per capita | **: Statistically significant, ***: Highly statistically significant | Analysis for up to 48 countries associated with the OECD



Source: Own calculation based on OECD, 2023d, 2023e; World Bank, 2023; Model: Two-way-fixed-effects (time and country-fixed effects)

What if?
An estimate of economic potentials

Using these elasticities, the economic potential for Germany arising from advances in innovation can be estimated. Across all indicators of innovation considered, we estimate how large Germany's GDP per capita would be if Germany was as innovative as the world's leading country in the dataset for each indicator. Table 4-1 shows the level of Germany's R&D expenditures, patent applications and VC investment, as well as the level of the top performer for each indicator for the most recently available year.

These significant potential gains in economic welfare highlight the role that greater innovative activity can play for the German economy. It is important to note that the underlying calculation takes the relative level of the top performer (indicated in brackets in Table 4-1) as a reference point. For example, we do not assume what would happen to the German GDP per capita if it matched the total amount of R&D expenditures of the U.S. Instead, we consider what would happen if Germany spent the same share of its GDP on research and development as the U.S. We therefore take into account differences in the mere size of the German economy (or population) and that of the top performer for a fair and realistic comparison and estimation of economic potentials.

Broadly speaking, the economic potentials are a product of the previously estimated elasticities and the distance to the top performer.[3] Both a larger elasticity and a larger distance to the top performer therefore imply greater economic potential for Germany. This explains why the economic potential for R&D expenditures is the lowest despite having the largest elasticity. As a share of GDP, Germany is already relatively close to the United States, although there is much room for improvement in comparison with the top performer with respect to patent applications and venture capital investments.

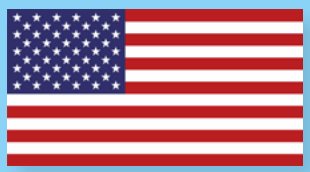
Table 4-1
Innovation – Economic potential for the German economy

Economic potential for Germany: Elasticity of real GDP per capita with respect to the predictor, combined with the percentage difference between the top performer's score and Germany's score | Analysis for 48 countries associated with the OECD

Predictor	Germany's score	Top performer (year)	Top performer's score	Economic potential for Germany (% of real GDP per capita)
Patent applications belonging to IP5 families	23,650 (285 per million people)	JPN (2019)	65,903 (520 per million people)	8.5
Venture capital investment	USD 3.6 billion (0.09% of GDP)	USA (2022)	USD 190.5 billion (0.75% of GDP)	3.7
R&D expenditures	USD 134.5 billion (3.14% of GDP)	USA (2021)	USD 806.0 billion (3.47% of GDP)	3.2

Source: Own calculations based on OECD, 2023d, 2023e; World Bank, 2023

3) Technically, this is not precisely how economic potentials are estimated, but the intuition still applies. The elasticities that indicate percentage changes in GDP per capita as innovation indicators change by one percent are approximations stemming from a log-log specification of the two-way fixed effects regression model. The percentage approximation works well for small changes and can therefore be applied to the elasticity estimates. However, the approximation does not work well for larger changes. Some of the changes required to lift Germany to the level of the top performers are very large. For example, Germany and the United States differ in their level of venture capital investment by a factor of more than eight. To estimate accurate economic potentials, the underlying log-log specifications are therefore used and the final estimates are converted to percentage changes.



United States -
Pushing disruptive innovation by being willing to fail

Challenge

Funding instruments and budgets for innovations exist worldwide, but they are typically limited to research and development projects with a manageable level of risk. However, disruptive innovations, which offers the largest economic potential by facilitating technological leaps, often require experimental and highly risky research.

Solution

The Defense Advanced Research Projects Agency (DARPA) was founded in 1958 by the U.S. Government with the explicit aim of promoting technological disruptions. In this vein, the agency funds high-risk, high-reward R&D projects, knowing that many of them are bound to fail. By embracing risk, DARPA encourages researchers to pursue bold and unconventional ideas that have the potential to bring about technological breakthroughs. In addition, DARPA organizes challenges and prize competitions in specific technology areas with a focus on ambitious ideas and rapid technology transfer potential. As of today, DARPA remains a key agency driving innovation in the U.S. Its budget was USD 4.7 billion in 2022 (DARPA, 2023).

Result

DARPA has been instrumental in pioneering innovations such as wireless data transmission, GPS, the internet and drones. Moreover, DARPA funded research has laid the groundwork for recent breakthroughs in the field of machine learning and artificial intelligence. Besides the financial support that DARPA provides for risky ideas, it is also an integral part of the U.S. innovation policy, ecosystem and start-up culture that embraces high risk in the pursuit of technological breakthroughs.

05

Digital & Data-driven Business Models

Unlocking the Future with Investments and AI

05 - Digital & Data-driven Business Models

Unlocking the Future with Investments and AI

The development and implementation of digital and data-driven business models are essential for maintaining and enhancing a country's competitiveness and economic prosperity.

The digitization of the value chain, the use of data ecosystems, AI and other data-driven instruments enable companies to both increase their productivity in the production process and invent new products or services (Dirk et al., 2022). New digital products and services have the potential to attract new customers and therefore stimulate a country's economic activity, while higher productivity leads to a more competitive economy.

With this in mind, this chapter focuses on the relevance of ICT investment and AI start-ups for improving economic performance. In addition, an index that measures countries' future digital readiness is also considered. The potential economic impact of digital and data-driven business models via these indicators is calculated as in the previous chapter.

Characterization of the digital landscape in Germany

With respect to the development of the IT capital stock, which includes capital goods such as data centers, software and computer equipment, Germany is lagging behind immensely. Since 1995, the difference in the growth of the IT capital stock between Germany and the US has been 566 percentage points (EUKLEMS, 2024). Over the last two decades, all major European countries have built up a significantly lower IT capital stock than was the case in the USA. Various studies attribute this as a reason for the lower productivity growth compared to the USA at the start of the millennium (Gordon & Sayed, 2020; Schivardi & Schmitz, 2020). Consequently, digitalization remains a challenge for many companies in Germany. Even in 2024, every second company still has problems coping with digitalization, according to a survey by bitkom (bitkom, 2024b).

This fits in with the results of the digitalization index, which shows that the level of digitalization of companies in Germany has only increased slightly in recent years. The digitalization index measures the level of digitalization in the German economy. It provides a comprehensive picture of the status quo of companies' digitalization and the environment in which they operate. (Büchel et al., 2023). Some of the main reasons for this are the inadequate digital infrastructure, the lagging digitalization of public administration and the shortage of IT specialists. In the IMD Digital Competitiveness Ranking, Germany is only in 23rd place out of 64, and in the Technology sub-index, which covers regulatory aspects and infrastructure, Germany is only in 34th place (IMD, 2023).

The digitalization of companies is one of the prerequisites for the application of artificial intelligence and the development of new business models (Engels, 2023). Contrary to the economic trend, the ICT sector in Germany is expected to

see an increase in turnover of 4.4 percent in 2024 (bitkom, 2024a). The implementation of artificial intelligence, in particular, is accompanied by the hope that the stagnating productivity growth will pick up speed again. Business with AI platforms is projected to grow by 38.3 percent to 1.4 billion euros (ibid.). Nevertheless, Germany's ICT sector is only growing slowly in a global comparison. Growth of 6.4 percent is expected in the USA, while the EU, excluding Germany, is set to grow by 5.9 percent in turnover (bitkom, 2024a).

Even beyond that, the literature shows that investments in IT have a positive impact on productivity and profitability. Hadi et al. (2023) demonstrate that within an industry, the profitability of companies increases with the level of IT investment. Young companies in Europe with the highest productivity growth invest significantly more in intangible assets, such as software and data-bases (Barrela et al., 2022a). To illustrate the catch-up potential and future potential of the digitalization of the economy and the development of digital and data-driven business models, three indicators are analyzed in more detail:

- → **Investments in information and communication technologies**
- → **Number of newly funded AI start-ups**
- → **IMD Digital Future Readiness Score**

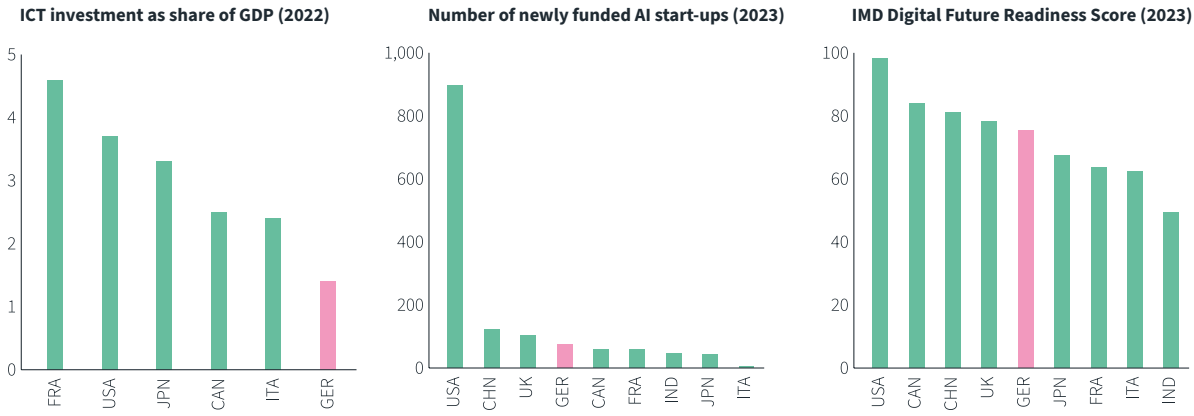
Germany is in last place among the leading industrialized nations in terms of investment in information and communication technologies as a proportion of GDP.

Figure 5-1 shows that Germany is in last place among the leading industrialized nations in terms of investment in information and communication technologies as a proportion of GDP. While Germany invested around 1.4 percent of GDP in this area in 2022, the figure was 4.6 percent in France and 3.7 percent in the USA in 2022.

Investments in themselves are not a means to an end. They should lead to an increase in productivity and enable the use of new technologies. Young companies that invest significantly more in intangible assets are often also more productive (Barrela et al., 2022a). In the euro-zone, however, the productivity drivers are getting

Figure 5-1
Digital and data-driven business models - Current state

The results are shown for all countries in the set of similar and competing countries (G7 + CHN + IND) for which data is available. Figures at the current edge.



Sources: IMD, 2023; Maslej et al., 2024; OECD, 2024

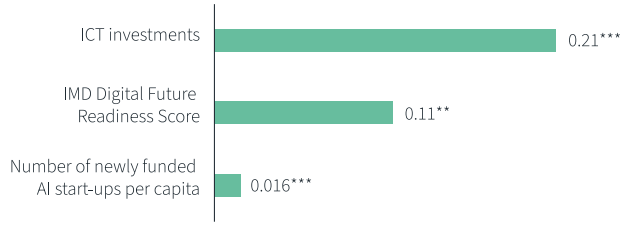
older: the average age of the companies in the top 5 percent with the highest productivity increased from 14 years to 20 years between 2006 and 2018 (Barrela et al., 2022a). This makes it all the more important that the current high level of investment in AI start-ups also flows to Germany in order to rejuvenate the corporate landscape and bring new technologies to the masses. Chapter 4 has shown that Germany is far behind the leading nations in AI research and development in terms of patent applications, but nevertheless has some research outcomes. However, the results of this research also need to be put into practice. This requires more investment, forward-looking framework conditions and more start-ups in this field. The number of newly funded AI start-ups serves as an indicator of the innovation climate and the adoption of new technologies by the economy and companies. With Aleph Alpha and Helsing, Germany has a great beacon of hope in the field of generative AI. However, if we also look at the number of newly funded AI start-ups, Germany lags well behind the USA, China and the UK. The USA, in particular, with 897 newly funded start-ups in 2023, is well ahead of the other nations. Germany has 76 newly funded start-ups in the field of AI in the same year (Maslej et al., 2024, Figure 5-1).

Beyond the funding of new companies, the digital future readiness of the German economy must improve. In the IMD Digital Future Readiness Index, Germany only achieved 75.5 out of 100 points, placing it in the middle of the leading industrialized nations. The USA, China, Canada and the UK are ahead of Germany. The index shows how well a country is doing in terms of adapting technologies, entrepreneurial agility and regulatory framework conditions for the use of IT applications. One of the indicators represents the level of digitalization of public administration, where Germany lags far behind the rest of the EU. Improving this would significantly reduce the bureaucratic burden on companies and citizens, which causes high costs and thus reduces competitiveness (Hüther et al., 2023).

In the IMD Digital Future Readiness Index, Germany only achieved 75.5 out of 100 points

Figure 5-2
Digital and data-driven business models – Effects of indicators on GDP per capita

Estimated elasticities between different predictor variables and real GDP per capita | **: Statistically significant, ***: Highly statistically significant | Analysis for 48 countries associated with the OECD



Source: Own calculations based on IMD, 2023; Maslej et al., 2024; OECD, 2024, model: Two-way-fixed effects (time and country fixed effects)

Impact of ITC investments, AI start-ups and future readiness on economic performance

The impact on economic strength was also analyzed for these indicators. The estimates for the indicators show a clearly positive correlation with GDP per capita. The results are shown in Figure 5-2. ICT investments show the greatest elasticity. If ICT investment increases by one percent, GDP per capita increases by 0.2 percent.

The IMD Digital Future Readiness Score also correlates significantly with GDP per capita: a one percent improvement in the score is accompanied by a 0.11 percent increase in GDP per capita. The smallest coefficient results from the estimate of the number of newly funded AI start-ups per capita. An increase of one percent is accompanied by a per capita GDP increase of 0.01 percent.[4]

4) The estimation was carried out using models that take into account the influence of up to four previous years as well. The correlation with economic performance is not only observed in the same period, but also with a time lag for all indicators.

What if?
An estimate of economic potentials

Table 5-1 shows the significant economic potential for Germany if it were to reach the same level with respect to digital and data-driven business models as the top performers.

Once again, it should be noted that the framework conditions in these areas of potential differ between Germany and the leading countries. In addition, investments in ICT, for example, cannot stand alone. Studies show that this alone does not ensure greater efficiency for companies. A high level of human capital and the right management are also required to invest in the right assets (Anderton et al., 2023). Nevertheless, this analysis shows that there is potential for growth in Germany in improving the digital landscape and especially these indicators.

The size of economic potential for ICT investment shows that an increase in investment activity, in particular, can strengthen growth for Germany.

Only through investment can new technologies be implemented in companies and their promise of higher productivity be realized. Creating a sustainable framework for digitalization also contributes to economic performance, as the analysis of the IMD Digital Future Readiness Score shows. The right framework conditions can also help foster innovation and enable new business models. The example of AI start-ups illustrates once again the importance of innovation for the future viability of an economy, as has already been shown in the previous analyses. Start-up activity, which is often the result of research and development, contributes to competitiveness and economic performance.

Table 5-1
Digital and data-driven business models – Economic potential for the German economy

Economic potential for Germany: elasticity of real GDP per capita with respect to the predictor, combined with the percentage difference between the top performer's score and Germany's score | Analysis for 48 countries associated with the OECD

Predictor	Germany's score	Top performer (year)	Top performer's score	Economic potential for Germany (% of real GDP per capita)
ICT investments as share of GDP	1.5	USA (2022)	3.7	>10
Number of newly funded AI start-ups per million people	0.91	ISR (2023)	4.59	5.9
IMD Digital Future Readiness Score	75.5	KOR (2023)	100	2.8

Source: Calculation based on IMD, 2023; Maslej et al., 2024; OECD, 2024

South Korea -
Data Dam as path to efficient data integration and utilization

Challenge

South Korea is one of the leading nations in the field of e-government and the data economy. The country faces the increasing challenge of standardizing, efficiently managing and using the considerable amounts of data generated in various government agencies, public institutions and private networks. Relevant data is often stored in isolated silos, making it difficult to share and analyze. The accessibility and linking of this data harbor great potential for both the public and private sectors.

Solution

As part of the Digital New Deal, the Korean Ministry of Science and ICT (MSIT) initiated the Data Dam project in 2020. As part of the project, data generated via public and private networks are collected and standardized. This will create a data platform that enables public authorities and companies, especially SMEs, to share, analyze and use data securely. This data will be used to train AI applications and develop innovative products and services based on AI.

Result

The implementation of the Data Dam project has had a significant positive impact on the competitiveness of South Korean companies in the field of AI. The improved availability and quality of data facilitate the development of AI applications and innovative solutions based on them. The data market has grown by more than 18 percent, and more than 28,000 new jobs have been created in the companies that use this data platform, according to the MSIT (Ministry of Science and ICT, 2024). The data collected are crucial for the development of smarter national AI systems and the creation of new jobs in innovative and data-driven sectors of the future.

06

Education

Securing the Future with Integration and Learning

06 - Education

Securing the Future with Integration and Learning

Every economic activity is - sometimes more, sometimes less intensely - based on the labor force and their qualification.

To enable as much economic activity as possible, the labor force of an economy basically must meet two different requirements: workers must have the skills required by the companies, and they must be present in sufficient numbers and in the right place. As digitization progresses, the need for ICT qualifications is becoming ever greater. Furthermore, foreign skilled workers are becoming increasingly important for Germany due to the demographic transition.

Given these findings, this chapter analyzes the importance of students and immigrants for economic activity, emphasizing the role of education. To address this, the labor market participation of non-natives is considered, alongside the proportion of international students and the share of ICT graduates. Their potential economic impact, which hinges on the educational and professional learning opportunities provided, is calculated as in the previous chapters.

The skilled labor gap has grown disproportionately in recent years in digital occupations and will increase to up to 128,000 jobs by 2027.

Characterization of the skilled workers situation in Germany

3.2 million working hours by 2030 is the estimated decline in the volume of work in Germany due to demographic change (Hüther et al., 2021). This figure is an impressive illustration of the challenges currently facing the German economy. The declining volume of work is increasingly becoming a factor that is holding back economic growth and innovation. In its long-term forecast, the German Council of Economic Experts (Sachverständigenrat) sees a negative contribution to growth from the labor factor as a result of this declining volume of work (Sachverständigenrat, 2023). In addition, technological progress, digitalization and the growing use of AI are increasing the demand for highly qualified specialists.

Technological developments in recent decades, particularly in the field of automation and AI, have led to a shift in demand in the labor market: while automation processes have traditionally replaced the activities of low-skilled workers, the demand for highly skilled workers has increased significantly with the use of AI. The skilled labor gap has grown disproportionately in recent years in digital occupations and will increase to up to 128,000 jobs by 2027 (Burstedde, 2023). The growing shortage of skilled workers in technical professions is also an obstacle to the important process of innovation, which is discussed in Chapter 4. Anger et al. (2023b) estimate that an increase in R&D expenditure to 3.5% of GDP would require an additional 50,000 people with a STEM (Science, Technology, Engineering and Math) qualification.

This makes it all the more important to expand the domestic pool of skilled workers by investing in education and training, and by fostering and directing specialized skills in future-oriented

areas. From the perspective of companies in Germany, this includes IT experts, in particular. The majority of all companies expect demand for IT experts to increase over the next five years, with innovative companies expecting this especially (Anger et al., 2023b). Furthermore, the number of skilled workers must be sufficient. One further lever for addressing the challenge of skills shortages in general and in digital occupations, and for increasing medium- and long-term growth potential, lies in the immigration of skilled workers and their successful integration into the labor market.

In the following discussion, data on different aspects are presented to illustrate these points and characterize Germany's current state of integration and education with focus on ICT. In our analysis, we focus on the following three key indicators:

- → **Labor market participation of foreign-born individuals**
- → **Proportion of students from abroad**
- → **Share of ICT graduates**

The labor market participation of foreign-born individuals is a key indicator of successful integration into the labor market and reflects the extent to which the employment potential of people who have come to Germany from abroad is being exploited.

In Germany, three out of four migrants participate in the labor market. This share has remained more or less unchanged in Germany since 2011. In an international comparison of leading industrialized countries, Germany ranks fourth behind typical immigration countries such as the USA, the UK and Canada, but ahead of Italy and France. In Canada and the UK, the proportion is almost 80 percent. In the UK, in particular, the proportion has risen by more than 5 percentage points in recent years. Moreover, the difference in labor market participation between people born domestically and those born abroad is much smaller in these countries. While the difference in Germany is more than 7 percentage points, it is only 0.1 percentage points in Canada and 1.4 percentage points in the UK.

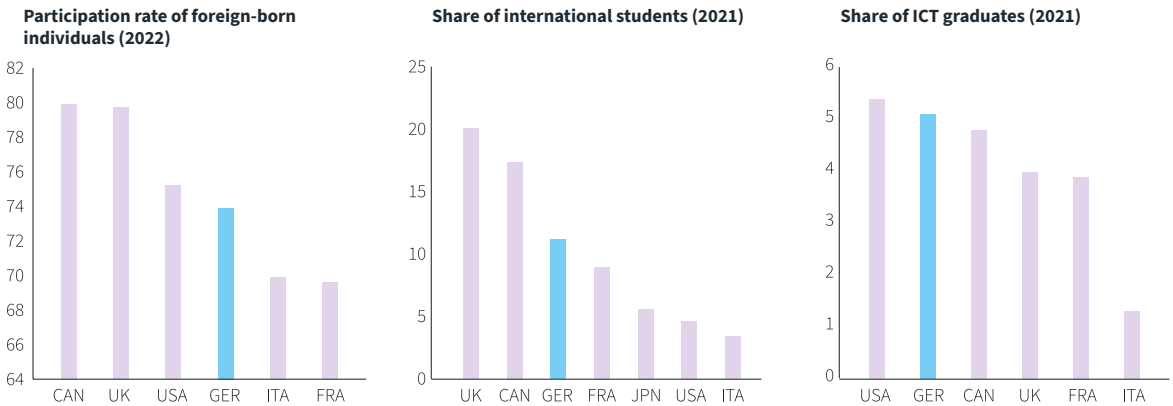
In addition to general participation in the labor market, the qualifications of immigrants are also important. The immigrant population in Germany is disproportionately low skilled or only employed in simple unskilled jobs. In 2022, 15.6 percent of the labor force with a history of immigration worked as unskilled workers, compared to 4.7 percent of the labor force without a history

3 out of 4

migrants participate in the labor market.

Figure 6-1
Education - Current state

The results are shown for all countries of the set of similar and competing countries (G7+CHN+IND) for which data is available.



Source: OECD, 2023a, 2023b, 2023c

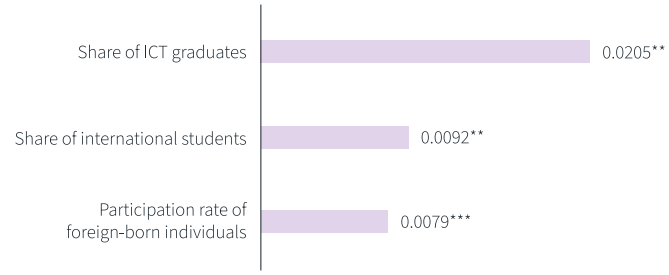
of immigration (Statistisches Bundesamt, 2024a). To come to a higher participation of foreign-born individuals, it is important to upskill these individuals and attract skilled workers from abroad.

Universities play an important role in attracting more skilled immigrants to Germany. Immigration via universities creates medium and long-term growth potential if graduates can be retained in the country. Immigrants who have graduated in Germany are more likely to be employed in roles appropriate to their qualifications than those who came to Germany after graduating from university (Geis-Thöne, 2022). Germany shows a positive trend here: since 2013, the share of international students has risen by around 4 percentage points to 11 percent. However, the gap between Germany and the leading countries is still large. The UK and Canada lead the comparison of countries in terms of the proportion of international students, with the UK having the highest proportion at 20 percent.

The importance of immigration via higher education is growing, not least in view of the digital transformation. Those who immigrate via higher education are more likely to have a degree in STEM subjects than other graduates (Anger et al., 2023a). As Germany is only in the middle of the OECD countries in terms of the number of academics with ICT degrees in the working-age population (OECD, 2022), this path offers opportunities for improvement. However, it is also important to exploit domestic potential. The next generation of employees should be trained for this. A look at the share of ICT graduates in 2022 shows that Germany is in a good position. With a share of around 5.1 percent of graduates in computer science, Germany has the second-highest share among the leading industrialized nations after the USA. Only the USA has a higher figure at 5.4 percent. The proportion of IT specialists in the labor force could therefore grow in the coming years.

Figure 6-2
Education – Effects of indicators on GDP per capita

Estimated elasticities between different predictor variables and real GDP per capita | **: Statistically significant, ***: Highly statistically significant | Analysis for up to 48 countries associated with the OECD



Source: Own calculations based on OECD, 2023a, 2023b, 2023c

Impact of integration and education indicators on economic performance

The indicators analyzed show a positive, significant correlation with GDP per capita. The results are illustrated in Figure 6-2 and show the semi-elasticities, i.e. the percentage change in GDP per capita when the indicators are increased by one percentage point. The share of ICT graduates has the greatest elasticity on GDP per capita. If the proportion of ICT graduates increases by one percentage point, GDP per capita increases by 2.05 percent. The proportion of international students also shows a strong correlation to GDP per capita: an increase in the proportion by one percentage point is accompanied by an increase in GDP per capita of 0.93 percent. If the participation rate of foreign-born students increases by one percentage point, GDP per capita rises by 0.79 percent.[5]

5) The estimation was carried out using models that take into account the influence of up to four previous years as well. The correlation with economic performance is not only observed in the same period but also with a time lag for all indicators.

What if?
An estimate of economic potentials

Using these elasticities, an area of economic potential can be calculated for Germany by strengthening integration, targeted immigration and IT education. For all three indicators, the reaction of per capita GDP in Germany is estimated if Germany were to reach the level of the world's leading country in the data set for the respective indicator. The economic potential is more than 10 percent GDP per capita growth in each case, if it were to reach the level of best-performing country.[6]

The assumption that Germany could reach the level of the top countries is a useful thought experiment to show the potential areas of education and integration. However, it should be noted that the top countries in the respective indicators have different socio-economic, cultural and political conditions. For example, Iceland, as an island, has different migration conditions than Germany. Furthermore, Germany is only slightly behind the USA in second place among leading industrialized nations in terms of the proportion of ICT graduates and is therefore already well placed. Nevertheless, this analysis shows that there is potential for improvement in the medium and long term, especially when compared to the leading country, Estonia.

These results show the need for a strategic orientation of German education and integration policy to realize the full economic potential. Strengthening IT education, attracting international students and integrating foreign-born skilled workers are not only socially desirable but also represent important levers for sustainable economic growth. In the medium to long term, significant impetus for increasing productivity can be expected from a comprehensive improvement in the training of young IT professionals.

Additionally, the immigration of skilled workers into the labor market has the potential to offset somewhat the decline in the working population and also have a positive effect on innovative capacity and, thus, on overall economic performance. In view of the global competition for talent and rapid technological developments, it is essential for Germany to create attractive conditions that allow it to be at the forefront in international comparison.

Table 6-1
Education – Economic potential for the German economy

Economic potential for Germany: Elasticity of real GDP per capita with respect to the predictor, combined with the percentage difference between the top performer's score and Germany's score | Analysis for 48 countries associated with the OECD

Predictor	Germany's score	Top performer (year)	Top performer's score	Economic potential for Germany (% of real GDP per capita)
Share of international students	11.2	AUS (2021)	21.9	>10
Share of ICT graduates	5.1	EST (2021)	10.1	>10
Participation rate of foreign-born individuals	73.9	ISL (2022)	88.8	>10

Source: Own calculations based on OECD, 2023a, 2023b, 2023c

6) We capped the reported value because, although the results indicate a strong potential, the specific value may be a statistical outlier. Therefore, we only specify a lower bound.

Estonia -
Digital learning for a digital nation

Challenge
Estonia, a small nation with no natural resources, has become one of the leading digital nations through early investment in digitalization. However, this transformation comes with challenges, in particular the growing need for digital skills among the population and the need to attract and develop a skilled workforce in the IT sector.

Solution
In addition to the early provision of internet access in schools and the launch of the digital textbook eKool, Estonia has stepped up its efforts in digital education through the ProgeTiger program. Launched in 2012, the program aims to inspire and educate children and young people in information and communication technology from an early age. The program provides access to digital knowledge and skills from pre-school age and encourages teachers to make greater use of technology – including coding and robotics – in their teaching. It achieves this by providing learning materials and training programs that teach teachers how to effectively integrate digital tools into their teaching. The learning processes are adapted to the age of the children and include the use of digital media as well as programming and robotics.

Result
99 % of Estonian kindergartens and 98 % of comprehensive schools have participated in ProgeTiger activities within the first nine years. As a result, the education system is laying the groundwork for training workers in information and communication technologies. Estonia is the European leader in this field. In the EU, the share of university degrees in ICT is around 4 %, while in Estonia it is more than 10 %.

07

Recommendations

Fields of action to realize economic potential

07 - Recommendations

Fields of action to realize economic potential

The analysis presented in this study shows that Germany has lost competitiveness in recent years, as described in Chapters 2 and 3. At the same time, this study not only indicates that there is room for improvement but also analyzes important factors for possible progress.

The crucial role of innovation, the creation of favorable conditions for digital and data-driven business models and a highly skilled workforce in promoting competitiveness is underlined by their positive impact on economic growth, as shown in the analyses. The recent stagnation or decline observed in these key areas opens up an opportunity for significant improvements and consequently for the promotion of economic growth.

Figure 7-1 illustrates the economic potentials that are emerging in the areas analyzed. A total potential of more than 410 billion euros in gross domestic product (GDP) could be realized by improving the framework conditions. These areas should not be viewed as isolated segments but as interrelated. For example, an increase in immigration could significantly benefit the innovation ecosystem, and an increase in the number of IT graduates would increase the pool of available human capital for emerging technology start-ups. The following recommendations should also be seen from this perspective. The recommendations outlined address various aspects and can help unlock the potential of several areas.

A total potential of more than

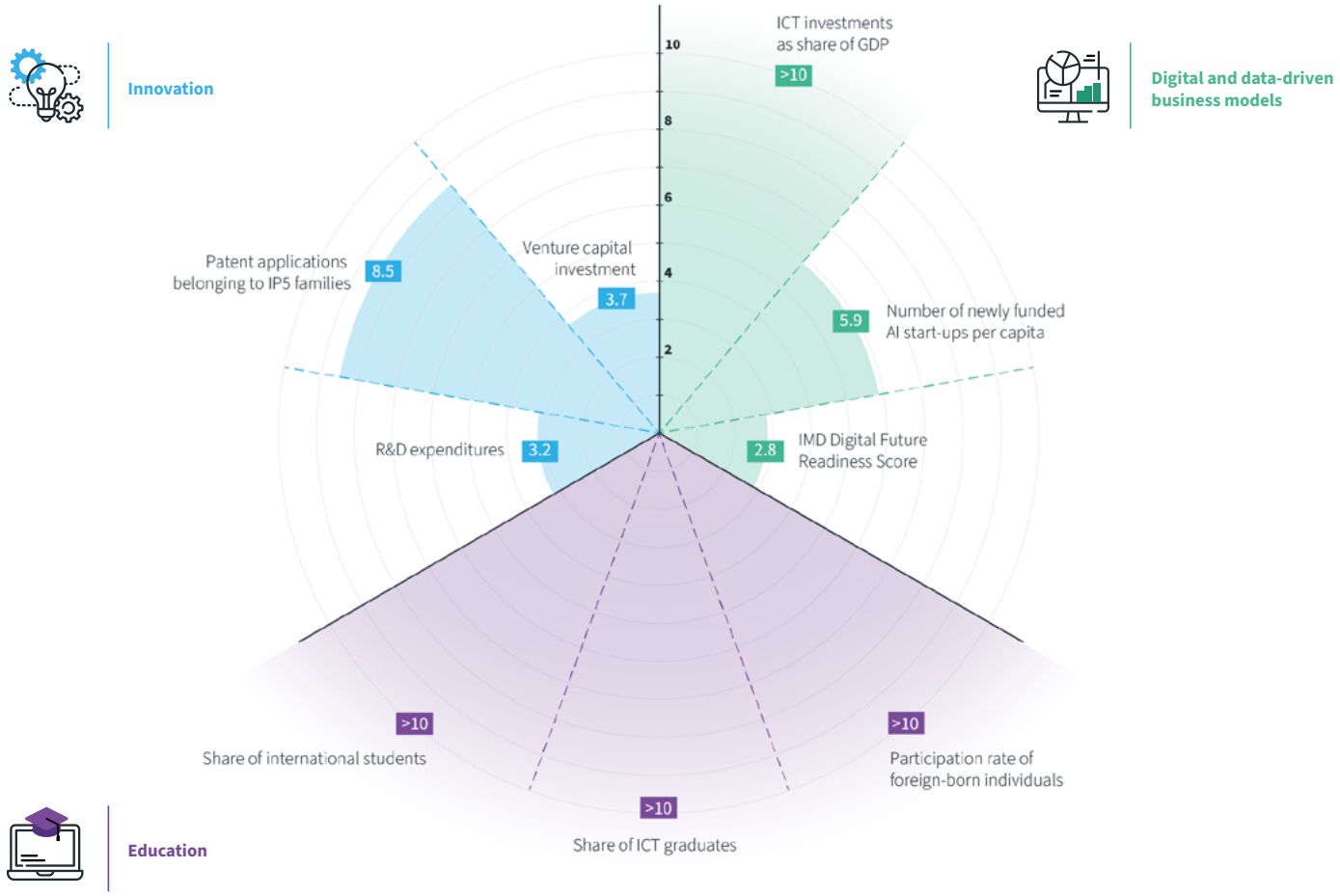
410 bn €

in additional gross domestic product (GDP) could ideally be realized.

Figure 7-1
Economic potentials – Overview

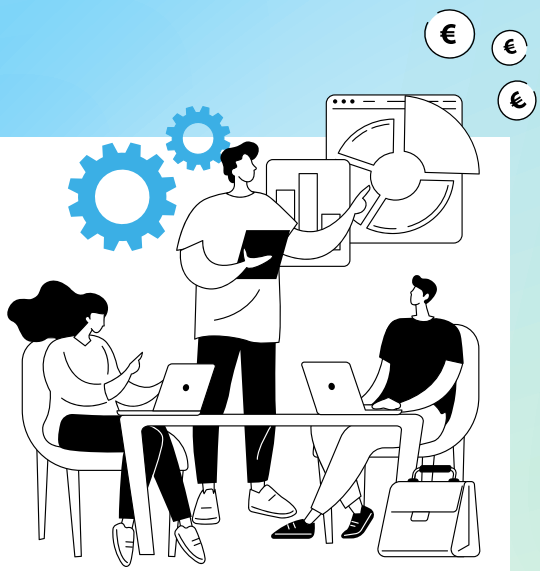
Economic potential for Germany: Elasticity of real GDP per capita with respect to the predictor, combined with the percentage difference between the top performer's score and Germany's score | Analysis for 48 countries associated with the OECD.

% of real GDP per capita



Source: Own calculations based on Maslej et al., 2024; OECD, 2023a, 2023b, 2023c, 2023d, 2023e, 2024, model: Two-way-fixed effects (time and country fixed effects)

The following aspects describe actionable steps that should be taken in the short and medium term to accelerate the realization of the economic potential identified in this study. It serves as a foundational document and invites stakeholders to engage in a constructive dialogue on the best ways to take advantage of the opportunities for growth and improvement identified.



Innovation

Venture capital

Boosting investment through a mix of private and public efforts

As this study demonstrates, venture capital investments in Germany remain substantially below the level of comparable economies, and there is significant economic potential in raising VC funding to facilitate the commercialization of innovative ideas. Despite recent efforts to increase venture capital investment, an EY study shows that total investments in German start-ups have decreased for a second year in a row (Prüver, 2024). Digital and high-tech start-ups in the growth phase are particularly reliant on high volumes of financing, which are still not available to a sufficient extent in Germany.

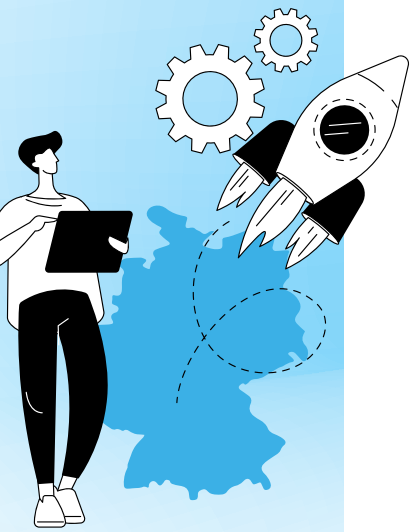
To increase venture capital available to promising start-ups, both private and public investments should be ramped up. One particularly underutilized source of funding is institutional investors, particularly pension funds. Between 2017 and 2021, only 4.3 percent of VC funding came from pension funds in Germany (Dahmann et al., 2023), while the U.S. share is about a quarter (Redstone, 2023). Drawing inspiration from the Swedish model, a long-term policy option for Germany is to introduce a funded element ('premium pension') in the state pension system, replacing a small part of the pay-as-you-go component. The funded pension system provides finance that can, in part, be invested in capital market-based products, including venture capital, that promise higher returns and boost venture capital finance in Germany.

A promising initiative already underway to increase institutional investment in the short term and expand venture capital financing more generally is the German Future Fund, launched in 2021. The Future Fund aims to provide financing for start-ups, in particular during the capital-intensive growth phase (Bundesministerium für Wirtschaft und Klimaschutz [BMWK], 2022) and is a composite of several funds with varying points of focus. Funds that are part of this endeavor have already attracted significant amounts of funding. However, in order to reach the stated objective of raising 30 billion euros for start-ups by the end of 2030, the government needs to ensure that the target group of investors, including institutional investors, family offices and endowments, find the investment options attractive (Dahmann et al., 2023). Comprehensive information and attractive risk-sharing mechanisms can bolster investor confidence to this end. Initiatives such as the Future Fund, which pool public and private investment, should also be expanded in the future as a source of VC financing.

Furthermore, pooled private investment by smaller actors can provide an important source of VC funding. In the state of Baden-Württemberg, for example, there is a venture capital fund with family-owned companies such as Trumpf as investors, which invests in deep tech start-ups. Such initiatives connect start-ups with German SMEs, providing them with the necessary capital and important market access. SMEs can benefit from innovation impulses and participate in dynamic growth stories. In the sense of a 'private start-up fund', family-owned companies could join forces and pool the necessary capital for large financing rounds. This would bring a whole new dynamic to the market.

Start-up visa

A bridge for immigration and innovation



The results of the study make it clear that innovation and the targeted recruitment of skilled labor make a decisive contribution to increasing economic competitiveness. Other countries have caught up in recent years in terms of their attractiveness to immigrants (Liebig & Ewald, 2023).

One way to utilize this potential is to increase the attractiveness for start-up founders by introducing a start-up visa. Founders with a migration background are already making a major contribution to innovation today (Kohlisch & Koppel, 2021). It is essential to strategically organize the start-up visa. Priority should be given to founders whose business models are innovative, scalable and digital - especially those who specialize in the use of data and the implementation of new technologies.

Visa candidates should be selected in close cooperation with the local start-up community to incorporate practical knowledge about the ecosystem and promising business models that the visa authorities may lack. The visa should be accompanied by a package of initial funding and mentoring – an approach that is already being successfully implemented in France. This facilitates integration and can significantly reduce the initial hurdles for founders.

The extension of the visa should be linked to the business success of the start-up. Additionally, the option of a permanent residence permit if the company is sufficiently successful can further increase Germany's attractiveness as a start-up location and secure the loyalty of start-ups to the location.

EU-funded technology parks

Mobilising the state for innovation

In other countries, especially in the USA and Israel, cooperation of the state with research institutions to broadly foster innovations is successful practice (Chapter 4). In the USA and Israel, military and defense-related research initiatives have played a significant role in achieving technological leadership. This approach can be adapted to a European context, proposing a model that harnesses similar synergies.

The European Union itself should become more active in its own research projects. The establishment of EU-funded technology parks and innovation centers could create important synergies between universities, start-ups and established industries. These centers would act as catalysts for cutting-edge research and development, facilitating the transition from academic theories to market-ready products and services. By co-locating different organizations within these parks, the cross-pollination of ideas and expertise would be enhanced, accelerating the pace of innovation.

Supporting high-risk/high-reward projects is crucial for truly pioneering breakthrough innovations. The EU-funded research projects could focus on such projects, pushing disruptive innovation. They should address specific thematic areas that have future geopolitical relevance or are crucial for the advancement of next-generation technologies. By concentrating resources and expertise on these strategically chosen topics, the European model could drive significant advances in areas such as renewable energy, digital security and AI.

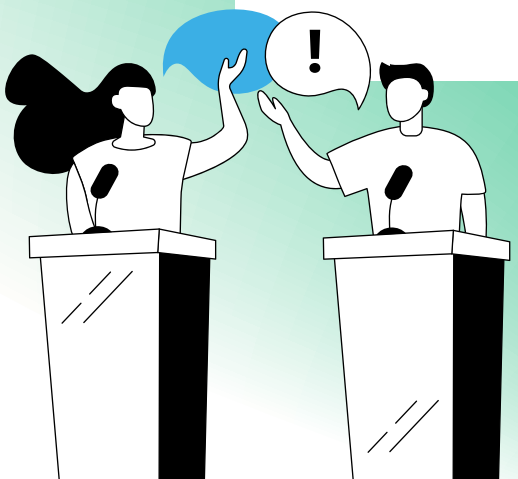
Subsidiarity and increased autonomy

Reducing bureaucracy and enhancing efficiency for companies and local governments

The principle of subsidiarity, which advocates for decisions to be made by the smallest, lowest or least centralized competent authority, is a pivotal concept in streamlining processes in both public governance and corporate practices. This approach not only fosters efficiency but also empowers local entities, enhancing their capacity to act swiftly and effectively in response to diverse situations.

Subsidiarity in public governance allows local authorities to make decisions tailored to their specific contexts, rather than awaiting directives from higher levels of government. By doing so, decisions can be made more quickly and are often more in tune with the local needs and conditions. This flexibility is essential for testing innovative ideas in localized settings, which can then be scaled up if they prove successful. Real-world labs and sandboxes provide a controlled environment where new ideas can be experimented with minimal risk, allowing for creative solutions to emerge that could be implemented more broadly.
In the corporate sector, applying subsidiarity involves shifting some regulatory responsibilities from central authorities to individual companies, thereby emphasizing corporate self-regulation and accountability. This shift is seen in practices common in Anglo-American contexts, where businesses are given leeway to operate with less immediate oversight but under the condition of subsequent audits. This method reduces bottlenecks in administrative processes, allowing for a more dynamic business environment. It encourages companies to be more responsible, knowing that while initial freedom is granted, accountability checks will follow.

Finally, this new approach to governance and business regulation could lead to a cultural shift where administrative staff engage more in shaping policies and creative problem-solving rather than being impeded by routine procedure checks. By reducing the time spent on standard procedures, employees can allocate more effort to pioneering projects that may have significant effects on society.



Digital & data-driven business models

Super depreciation for digital goods

Implementation of the coalition's plan

The potential offered by investments in IT and technological infrastructure shows the great importance of strengthening investment activity in this area (Chapter 5). Nine out of ten euros invested in Germany come from private sources (Hentze et al., 2024). To this end, companies should be incentivized to invest in these areas. In the long term, a reduction in corporation tax over a longer period of time can provide further lasting investment impetus and make Germany more attractive as an investment location (Hentze et al., 2024). A more short-term and targeted measure would be the implementation of super depreciation on digital assets. In view of the fast pace and constant development of digital technologies, faster depreciation of digital capital goods makes sense.

Software and databases, as examples of intangible capital assets, are evolving rapidly, which requires flexible tax treatment to give companies the agility they need to invest. This is already planned in the coalition agreement (SPD et al., 2021). In addition to software, hardware also plays a central role. More computers and data centers are the foundation of a digital ecosystem in which AI developments can flourish.

An immediate amortization of capital expenditure, i.e. deduction from taxable profits as a super depreciation is a lever to incentivize companies to invest more in future technologies (Clemens et al., 2021). This measure should be designed in such a way that smaller investment expenditure by SMEs is also covered by this subsidy to encourage their investment activity in this area. The implementation of this measure should not be postponed any longer.

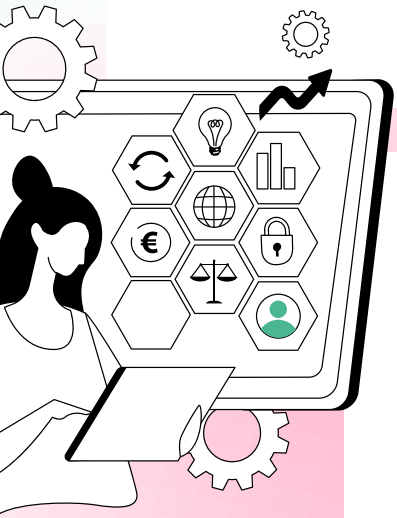
E-Government

Set up a digital agency to strengthen integration and interoperability of government systems

Bureaucratic regulations often represent a hurdle for companies, which can both cause high costs and delay transformation processes. One effective measure for reducing bureaucratic costs is the digitalization of administration, which not only improves efficiency within the authorities but also relieves companies of time-consuming processes.

In the long term, it is essential to digitize and link administrative registers in Germany. This would allow for the exchange of data across registers with the consent of the persons concerned, laying the foundation for a more efficient and citizen-centered administration. The introduction of a standardized administrative database, as exemplified by the South Korean Data Dam project, could not only simplify administrative processes but also open new opportunities for the economy and society as a whole. For example, it could lead to the development of new business models. For Germany, the creation of a central digital agency based on the Austrian model could be a key to accelerating digitalization. In Austria, the digital agency acts as an intermediary between departments, federal authorities and regional authorities. Such an institution should be established in Germany to coordinate digitalization efforts across the federal states and ensure uniform standards and procedures, which would ultimately reduce fragmentation in the system and increase efficiency.

To reduce bureaucratic costs for companies, a starting point could be to standardize the functions of the company account across the federal states. The account already enables companies to identify themselves to the authorities and offers digital communication options. However, different administrative procedures are possible between the federal states. Rolling out the functions across all federal states could reduce bureaucratic costs and ensure consistent standards.



Smart regulation

Fewer and lean bureaucratic burdens

According to the National Regulatory Control Council, the cost of bureaucracy across Germany amounts to EUR 65 billion per year for the German economy alone (Nationaler Normenkontrollrat, 2023). Firstly, some of these costs could be redirected to finance innovation and investment. Secondly, the existing shortage of skilled workers would be alleviated somewhat if the employees entrusted with bureaucracy were to take on more productive tasks.

A cheap way to remove obstacles is to reduce and simplify regulations. Laws and their implementation should be less bureaucratic. For this reason, a ‘bureaucracy advisory board’ or a team from a federal ministry should work together with entrepreneurs to sound out what burdens would arise from regulation in order to jointly find a constructive way to implement regulation as smartly as possible. ‘Practice checks’ by the Federal Ministry of Economics are a step in the right direction, but they should be consistently expanded, made permanent and also applied at the European level.

Germany is a pioneer here with the practical checks, but the bulk of the regulation comes from Brussels. It is therefore crucially important to install a kind of bureaucracy advisory board there, too. This measure could be evaluated very well by determining annually how many regulations have been saved or streamlined. This, in turn, could lead to a more positive perception of necessary bureaucratic burdens.

Data economy

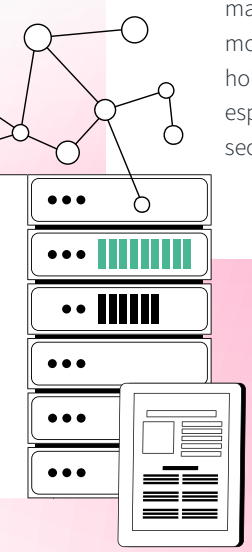
Promoting participation of SMEs

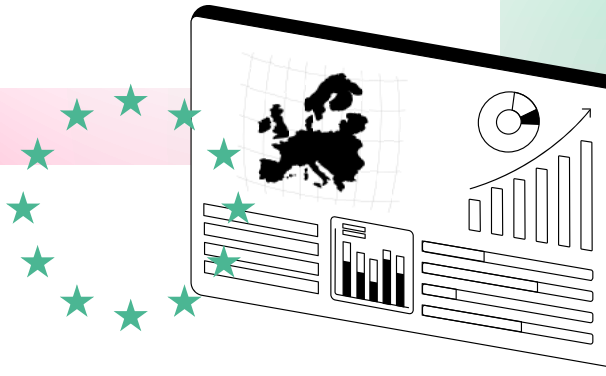
The data economy and, in particular, sharing data between companies or institutions is becoming increasingly important for the economic prosperity of a country. The term data economy in this context refers to the economic use of data and summarizes all economic activity involving the use of data and the resulting data-driven business models.

Due to data's characteristic of non-rivalry in consumption, using data as a resource much like other resources is very promising. In contrast to a classic consumption good such as an apple, the use of data by one company does not restrict the use of the same data by other companies. Additionally, the costs of duplication of data sets are virtually zero, making data as a resource even more attractive. The data economy holds great potential for Germany, especially since its strong industrial sector produces massive amounts of data every second that theoretically could be utilized. For the EU, the European Commission estimates the value of the data economy in 2025 at EUR 829 billion – up from EUR 301 billion in 2018 (European Commission, 2024b).

To participate in this growing part of the economy, German companies should manage their data, use it and share it with others – always taking necessary precautions with respect to business secrets, of course. Only if companies are enabled to become data economy ready can they develop data-based business models, scale them up and take part in data ecosystems. Germany's many small- and medium-sized enterprises need to be considered here, in particular, because only 32 % and 62 % of them, respectively, meet the requirements to be data economy ready (Azkan et al., 2024).

Besides organizational and technical barriers, legal obstacles are the main reason for companies' current reluctance to participate in the data economy (Büchel & Engels, 2022; Röhl & Scheufen, 2023). These include, for example, data protection concerns and uncertainty with respect to data ownership. The legal framework for a European data economy is in place – the challenge lies in its complexity and the necessary effort to understand the regulation and comply with it. To facilitate access to the data economy for small- and medium-sized companies, it is therefore important to reduce this complexity. In the short term, low-threshold information and the development of practical use cases and best practices that companies can easily adapt themselves can help. Further assistance in the form of sample data contracts or guidelines can counter legal obstacles.





Harmonise Europe

Completing the digital single market

The scaling of successful European start-ups often fails because the European single market does not yet have the strength that, for example, the USA with its over 330 million inhabitants has. The EU institutions should agree on an ambitious, Europe-wide roadmap for the further integration of the single market. The centerpiece should be support for companies in setting up data spaces to strengthen industrial expertise as a key comparative advantage. In addition, the harmonization of the legal framework for digital services should be driven forward. Care must be taken to ensure that bureaucratic hurdles are kept as low as possible. Observers of the German and European political and economic landscape know all too well that the desire to regulate many if not most aspects of private firms' activities may hinder economic development. A prominent example among many is the General Data Protection Regulation (Datenschutzgrundverordnung). While consumers need to be ensured of their data rights, the extent and details of the regulation represent a challenge to competitiveness (Engels & Marc, 2020; Schricker, 2018) – especially for firms that are active internationally and that (would like to) pursue innovative business ideas.

Education

Better skills

Promote education with personalized, digital learning platforms

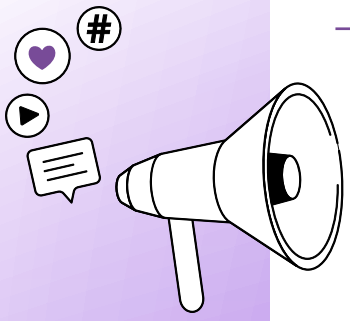
The distribution of skills is the core competence for future specialists. Germany's success is still based, above all, on the excellent training of its skilled workers. In recent years, however, educational tests such as PISA have shown increasingly poor results (Bundesministerium für Bildung und Forschung [BMBF], 2023) and companies are complaining that fewer young people are capable of training than before (Hertrich & Brenner, 2024).

One way to promote skills and interests at an early stage is to better enable personalized learning. This enables the competences and interests of pupils to be addressed in a targeted manner. These learning elements should be increasingly integrated into lessons to cater to different types of learners. To this end, content teaching should utilize different types of media and approaches such as gamification. The development of VR headsets is progressing impressively fast, so that such gadgets also increase learning fun and success. Equal opportunities in the German education system can also be strengthened through the further dissemination of learning platforms focusing on digital skills that can be used by participants for learning free of charge and at a low threshold with learning incentives for the participants. Such a platform that complements the existing school system should be free and accessible to everyone, enable personalized and self-directed learning, offer educational videos and be based on current educational research findings.

One short-term measure should be to provide teachers with materials on the use of digital media and online-based learning in the classroom. A survey of teachers shows that although the COVID-19 pandemic led to an improvement in this area, it has since stagnated (Plünnecke et al., 2023). The example of Estonia shows how society and companies benefit from early digital education (Chapter 6).

Marketing initiative

Strengthening the brand of German universities



Compared to leading American universities such as MIT, German universities have significant potential to enhance their international reputation and recognition. Targeted branding efforts could raise their global profile and thereby attract more international students.

Tailored marketing strategies are essential to reach prospective students effectively. Developing campaigns that specifically target key regions and countries likely to produce the highest numbers of international students could be crucial. Such a strategic focus would allow German institutions to tailor their educational offerings more closely to the needs and preferences of these diverse student groups. Additionally, increasing the number of English-taught undergraduate programs could significantly reduce language barriers for international students. This adaptation would not only make German universities more accessible to a wider audience but also enhance their appeal as truly global educational hubs.

The development of alumni networks also plays a crucial role. By building robust national and international alumni networks, these institutions can leverage their alumni as brand ambassadors. Effective use of alumni testimonials and success stories can serve to promote the high quality of education provided and support the overall branding strategy, making German higher education more attractive worldwide.

Online application center

Facilitate the formal recognition of foreign professional qualifications

The number of skilled workers from abroad whose professional qualifications are recognized has been rising for years, apart from during the COVID-19 pandemic. In 2022, the Federal Statistical Office recorded a significant increase in recognition for the first time since COVID: 52,300 people had learned a profession abroad and had it recognized in Germany. This corresponds to an increase of eleven percent compared to 2021 (Schmetzer & Wörndl, 2023).

This development is extremely important for Germany in view of the shortage of skilled workers. To further strengthen this trend, it is necessary to speed up processes of recognition of foreign vocational qualifications and further reduce bureaucratic hurdles. One way of doing this is to promote the connection of the federal states to the central online application center for as many occupations as possible.

The recommendations outline practical steps that can be taken in the short and medium term to harness the economic potential identified in this study. This document serves as a foundation, inviting stakeholders to engage in constructive dialogue on the best ways to capitalize on growth and improvement opportunities.

Germany stands at a pivotal moment, with the chance to redefine its economic legacy for the 21st century. By promoting innovation, cultivating a skilled and diverse workforce and fostering an environment conducive to digital transformation, Germany can unlock significant economic potential. This study calls on policymakers, business leaders and other stakeholders to collaboratively chart a path towards a prosperous future for the country.

Germany can unlock significant economic potential.

Recommendations
Overview

- → **Venture capital**
  Boosting investment through a mix of private and public efforts
- → **Start-up visa**
  A bridge for immigration and innovation
- → **EU-funded technology parks**
  Mobilising the state for innovation
- → **Subsidiarity and increased autonomy**
  Reducing bureaucracy and enhancing efficiency for companies and local governments
- → **Super depreciation for digital goods**
  Implementation of the coalition's plan
- → **E-Government**
  Set up a digital agency to strengthen integration and interoperability of government systems
- → **Smart regulation**
  Fewer and lean bureaucratic burdens
- → **Data economy**
  Promoting participation of SMEs
- → **Harmonise Europe**
  Completing the digital single market
- → **Better skills**
  Promote education with personalized, digital learning platforms
- → **Marketing initiative**
  Strengthening the brand of German universities
- → **Online application center**
  Facilitate the formal recognition of foreign professional qualifications

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09 - Appendix

Methodology

This study examines the influence of different facets of competitiveness on gross domestic product (GDP) per capita (in constant 2015 US$) (World Bank, 2024a). The analysis is based on panel data covering a period of up to 27 years (1997 to 2023) and including up to 48 countries. There is some variation in the precise number of countries and years included for each estimation for reasons of data availability. To ensure comparability, the analysis is limited to emerging and advanced economies. The country set consists of OECD countries as well as their partner countries (Brazil, China, India, Indonesia, South Africa) and candidate countries (Peru, Argentina, Bulgaria, Croatia, Romania).

Econometric model: A two-way fixed effects model (country and time effects) was used to estimate the influence of the indicators on GDP per capita. This method makes it possible to isolate the specific influence of indicators on economic growth by controlling for general developments in economic performance over time (captured by time fixed effects) and time-invariant differences between countries (captured by country fixed effects). This reduces the probability that a statistical correlation is based only on a common development over time or country-specific heterogeneity, thus reducing the estimation error of the model. The econometric model can be represented formally as follows:

$$Y_{it}=\beta x_{it}+\gamma_i+\delta_t+\epsilon_{it}$$

Where Y_{it} is GDP per capita of country i in year t, x_{it} is the value of indicator x in country i at time t, γ_i is the country fixed effect, δ_t is the time fixed effect, and ϵ_{it} is the error term (clustered at the country level). For robustness checks the estimation was carried out using models that consider the influence of up to four previous years as well. The correlation with economic performance is not only observed in the same period but also with a time lag for most indicators.

Interpretation: Both the dependent variable (GDP per capita) and the independent variable were logarithmized for the estimates. This means that the coefficients are to be interpreted as elasticities, indicating the percentage by which the dependent variable changes when the independent variable increases by one percent. For individual estimates where proportions or indexes are used as an indicator, the independent variable is not logarithmized. For these variables, the coefficients are to be interpreted as semi-elasticities, indicating the percentage change in the dependent variable when the independent variable increases by one unit.

It should be noted that some of the indicators analyzed are highly correlated with each other. For example, R&D expenditures are correlated with the number of patents. High statistical dependencies between the independent variables of a regression model lead to various problems. On the one hand, there is usually great interest in interpreting the marginal effects of the independent variables. These indicate the extent to which the dependent variable (GDP per capita) changes when one (and only one) of the independent variables changes. However, for statistically dependent variables, it is not possible to keep the remaining variables unchanged. For example, if R&D expenditures increase, the number of patents also increases due to the positive correlation. Such dependencies make it difficult to select the significant variables and result in unstable point estimates of the independent variables. To address this, individual regressions were therefore carried out in which one indicator was analyzed at a time. Although this solves the problem of multicollinearity, it introduces the problem of bias due to omitted variables (omitted variable bias). Since only one indicator is included in each regression, the reported coefficient includes not only the direct effect of this indicator but also indirect effects on the economic indicator induced by correlated indicators. This implies that the effects cannot be interpreted additively.

Three related methodological points concerning the estimated elasticities and semi-elasticities are important to note: First, as reasoned above, they cannot be added, since there are overlaps and relations between them. For instance, a change in the indicator ‘ICT investments’ may have an impact on the indicator ‘number of newly funded AI start-ups’; the combined elasticity is likely to be smaller than the sum of the elasticities. Second, they cannot be interpreted as causal effects because they represent statistical associations. Although our econometric approach controls for time-invariant characteristics of countries (e.g. location) and country-invariant characteristics of years (e.g. geopolitical situation), we are cautious about interpreting the results as representing causal relationships since there may be remaining confounding variables that vary across both time and countries. Third, they do not explicitly model the development within a country over time. When an indicator changes, GDP per capita cannot be expected to change immediately. Instead, a change in an indicator may put a country on a different growth path, which will affect GDP per capita over time.