WORKING PAPER

Future of manufacturing

Germany: Policy developments on apprenticeship

Adaptation of national apprenticeship systems to advanced manufacturing

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Contents

Introduction

Scope of the research

This country report is part of the study 'Policy developments and practices of apprenticeships in selected EU Member States and world competing regions' carried out in five EU(Denmark, Germany, France, Ireland and Italy) and two non-EU countries (Australia and the USA). This study is conducted in the frame of the Pilot Project 'The Future of Manufacturing', proposed by the European Parliament and delegated to Eurofound by the European Commission (Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs).

One of the objectives of this study is to provide an analytical overview of apprenticeship systems in the selected countries and to review changes to the current systems following labour market shifts, changes in employment, career and mobility patterns and technological and structural change. Particular emphasis is placed on the impact of new technologies and the need for a high skilled and adaptable workforce in manufacturing and advanced manufacturing.

This research is carried out in response to the increasing interest in apprenticeships among policy makers to tackle skills mismatches but also to integrate young people into the labour market. The appeal of apprenticeships is also growing particularly in a context where new technologies are transforming work organisation and production processes across all sectors, particularly manufacturing.

The findings from this research will feed the policy discussions around the role of apprenticeships for the future of manufacturing and inform policy making in the context of current or planned reform of apprenticeship systems and the necessary links to be established between education/training and industrial policies.

Report structure

With a view to investigating country specific issues, the first section outlines the wider economic and labour market context in which the national apprenticeship system operates. The links between education/ training and industrial policies are also explored.

The second section describes the key features of the national apprenticeship system, including the regulatory framework, the governance structure, and the financing mechanisms. It also provides some statistical data on apprenticeships and pinpoints the key challenges to the implementation and the development of the current apprenticeship system.

The focus of the third section is specifically on the role of apprenticeships in relation to the advanced manufacturing industry in Germany. It examines the main requirements arising from technological change in manufacturing and it explores recent reforms on apprenticeship systems together with the key drivers behind these policy changes. In doing so, it identifies success factors and barriers to the implementation and the development of the current apprenticeship provision.

This country report is based on a literature and document review, as well as on qualitative semi-standardised interviews with selected key actors and stakeholders, namely the Federal Ministry of Education and Research (BMBF), the Federal Institute for Vocational Education and Training (BIBB), the employer organisation Gesamtmetall and the chemical trade union federation IG BCE (see list of consulted stakeholders in annex 2).

Key terms at a glance

Apprenticeship or 'dual' VET is a defining feature of the German education system and is a highly attractive pathway for young people entering the labour market. The attractiveness for companies has also been highlighted as one of the main reasons that Germany has been quite successful in school-to-work transitions and integrating young people into the labour market and keeping youth unemployment low (see for example Hanushek, 2017; Zentrum für Integration und Bildung, 2016).

A key feature of the apprenticeship system is its consensus-based and the practice- orientated mode of governance as well as shared responsibilities of all relevant actors. This has contributed to a robust and stable institutional and regulatory framework.

Advanced technologies, namely digitalisation and computerisation have a strong impact on the VET and apprenticeship practice in manufacturing industries. Challenges are related to the regulation of occupations, existing curricula, cooperation between companies and VET schools as well as learning methods. These challenges have been addressed by a number of recent initiatives of public actors as well as social partners and larger companies in the manufacturing sector. These, however, do not refer to 'advanced manufacturing' as such but the broader concept of 'digitalisation of industry' or simply Industrie 4.0.

Economic and labour market context

Economic and employment role of manufacturing and key trends

With a turnover of more than €1.9 trillion as well as over seven million persons employed in 2015 the German manufacturing sector occupies the leading rank in Europe according to Eurostat data. This is also illustrated by the fact that in 2013 around 30% of the total value added of manufacturing in the EU28 was generated in Germany. In 2015, the industry contributed 25.9% to the national value added in Germany.

The turnover of the manufacturing sector increased by 3.7% between 2008 and 2015 and the number of persons employed increased by 2.2% between 2008 and 2015 (table 1). In 2015, there were nearly 160,000 more persons employed in the manufacturing sector than before the great recession in 2008. It should be noted that Germany is the only EU Member State, apart from Slovakia, that achieved an increase in overall manufacturing employment in this period. According to 2015 Eurostat LFS data, the share of manufacturing in total employment was nearly 20%.

Table 1: Number of enterprises, turnover and persons employed in the German manufacturing sector, 2008-2015

	2008	2009	2010	2011	2012	2013	2014	2015	2008/ 2015
No. of enterprises in thousand	195	180	209	208	204	203	213	212	+8.5%
Turnover in billion €	1,871	1,548	1,750	1,956	1,967	1,975	2,021	1,940	+3.7%
No. of persons employed in millions	7.1	6.7	6.9	7.1	7.2	7.2	7.3	7.3	+2.2%

Source: Eurostat, Annual detailed enterprise statistics for industry, NACE section C, 2017

Also, Germany is the largest centre of high-tech manufacturing employment in the European Union, employing around 27% of the total high-technology manufacturing workforce in 2015. [1]

In 2014, there were around 8,800 enterprises generating a turnover of €121 billion. Although there has been a sharp decline in the turnover due to the global crisis in 2008, it has increased steadily since then, reaching a growth rate of 21.3% for the period 2009- 2014. The increase in employment in high-tech manufacturing was much stronger than in manufacturing as a whole. Since 2008, it has increased by more than 7% and reached nearly 650,000 in 2015 according to Eurostat. High-technology manufacturing in 2015 accounted for 1.6% of the total employment in Germany.

[1] In order to compile statistics on high-tech economic activities, Eurostat uses an aggregation of the manufacturing industry according to technological intensity and based on NACE Rev.2. for compiling aggregates related to high-technology, medium high-technology, medium low-technology and low-technology. The list of NACE groups can be found on the Eurostat website: http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:High-tech_classification_of_manufacturing_industries.

Table 2: Number of enterprises, turnover and persons employed in the German high-technology manufacturing sector, 2008 - 2014

	2008	2009	2010	2011	2012	2013	2014	2015	Change in %
No. of enterprises in thousand	7,89	8,76	8,98	8,54	8,25	8,71	8,83	---	13.3
Turnover in million €	128,409	99,861	108,936	116,857	113,476	118,229	121,114	---	21.3 (since 2009)
No. of persons employed in thousands	605.6	639.2	617.9	619.3	617.2	667.4	659.3	649.6	7.3

Source: Eurostat, High-tech statistics employment (2016) and economic data (2017)

Overview of industrial policy initiatives addressing advanced manufacturing

The term ‘advanced manufacturing’ is less used and known in German policy debates and public initiatives fostering the use of new technologies and the digitalisation of the economy. Within the industrial policy debate, a much more prominent term has been ‘High-Tech’ and increasingly the broader concept of ‘Industrie 4.0’. This term currently is the main reference used by all political parties, social partners as well as governments at federal and regional level as a key to current and future industrial competitiveness and the main driver for innovation.

Whereas ‘advanced manufacturing’ (see European Commission 2014a; Ship et al., 2012) refers to the application of new, cutting edge technologies, techniques and respective skills (such as advanced robotics, 3D printing, new materials, nanotechnologies, micro- and nano-electronics, industrial biotechnology or photonics), Industrie 4.0 is a broader term that relates to more comprehensive and system-related changes.

Industrie 4.0 has been defined as the entire digitalisation and interconnectedness of value chains in the manufacturing industry through the use of information and communication technologies (ICT). Software intensive embedded systems (cyber-physical systems, CBS) and an ‘internet of things and services’ furthermore enable for new monitoring and control methods as well as real-time decision processes in complex production systems across the entire value chain (Spath, 2013).

Thus, the concept of Industrie 4.0 goes beyond mainly technology-driven changes. It also addresses organisational and business-related aspects of new production systems. From this holistic perspective, the key challenge emerging in the context of ‘advanced’ or ‘smart’ manufacturing has to be seen in the optimal cooperation of humans, machines and IT-systems. Production technologies, production processes and organisation as well as human resources development are therefore regarded as equally important within the Industrie 4.0 concept (BMBF, 2015a).

Industrie 4.0 not only refers to industrial policy orientations (where it has been developed in the context of the German ‘High-Tech-Strategy’ (BMBF, 2006; 2007). From the beginning it was also closely linked to labour market as well as vocational education and training policies (BMBF, 2010). The employment and VET dimension of Industrie 4.0 and the digitalisation of the economy as a whole has become more significant in recent years. Other related concepts are Arbeit 4.0 (Work 4.0) referring to new forms of work and employment in the context of a digitalised workplace as well as the future of good working conditions in general and Berufsbildung 4.0 - or VET of the future - comprising screening of selected apprenticeships and skills requirements where processes are already affected by digitalisation, elaboration of a framework for minimum standards for media competence and identification of sectors, areas of activity and professions particularly affected by digitization (BIBB, 2016c). These concepts reflect the need to make comprehensive adjustments as regards the regulation and public policies in both areas. In spring 2015, the Federal Ministry of Labour launched a broad stakeholder debate involving political parties, social partners, research and academic institutions as well as civil society organisations on the future of work or 'Work 4.0' (see BMAS, 2015; BMAS, 2016).

The industrial policy strategy for fostering the transition towards Industrie 4.0 (BMBF, 2015a) is based on a broad alliance of key actors in manufacturing, electronics and IT, such as the employer organisations BITKOM (Federal Association for Information Technology, Telecommunications and New Media), VDMA (German Engineering Federation) and ZVEI (German Electrical and Electronic Manufacturers' Association). Also trade unions, such as the metalworkers union IG Metall, are actively involved as key stakeholders. These actors in cooperation with the federal government as well as the metalworker trade union IG Metall in 2013 established a joint platform Industrie 4.0 (www.plattform-i40.de) aiming at exchanging good practices, experiences and providing information on innovative projects and activities. In April 2015, the platform was expanded - with more stakeholders from companies, associations, unions, science and politics joining.

Social partners in the manufacturing sector are deeply involved in the strategies and design of conditions for the future of manufacturing and the introduction of advanced manufacturing technologies. This is not only in relation to the Industrie 4.0 initiative but also in the context of managing technology driven changes. The Federal Minister for Economic Affairs and Energy, the Chairman of the German Metalworkers' Union (IG Metall) and the President of the Federation of German Industries (BDI) initiated the *'Alliance for the Future of Industry'* in November 2014. In addition to the founding partners, several industrial and employer organisations as well as trade unions are involved[2]. The Alliance aims at designing a new industrial policy and supporting manufacturing in Germany (BMWi, 2016a). Five working groups are developing recommendations for actions in various fields. One of these, namely the 'future of work' working group, aims at strengthening qualifications and dual apprenticeships, ensuring the supply of skilled manpower and supporting the reconciliation of family and working life. Among other activities, a joint paper was published by the Alliance in 2017 recommending the extension of career guidance in schools and strengthening of education in the so-called MINT subjects (mathematics, information technology, natural sciences and technology), supporting the permeability of the educational system, the flexibility of training regulations, the modernisation of equipment of vocational schools and a continuous update of teachers' pedagogical and technical skills (BMWi and Bündnis Zukunft der Industrie, 2017).

[2] The full list of members is available at https://www.buendnis-fuer-industrie.de/das-buendnis/wer-wir-sind/

Employment and training challenges linked to technological change and automation

The widely discussed work of Frey and Osborne asserts that a large share of jobs in the U.S. labour market face the risk of becoming substituted by machine work ('computerisation') (Frey and Osborne, 2013). In particular, jobs with middle qualification profiles will be at risk. This has triggered similar research on the impact of digitalisation on work and future employment developments.

However, recent studies on employment effects of computerisation came to quite different estimations in regard to substitution effects, depending on the methodological approaches taken. While studies based on the Frey and Osborne calculation model found similar high shares of substitution effects (Bonin et al, 2015), other research studies that adopted a different methodological approach (based on looking into occupations and the respective sub-tasks that could be substituted by computers and machines) came to much more modest results regarding gross effects (Dengler et al, 2014) [3].

Similarly, the German council of high-ranking economic experts in its 2016 annual report highlighted that about 12% of all jobs are at high risk of becoming obsolete due to automation within the next ten to twenty years. Most of these jobs are in lower qualification groups particularly in manufacturing, retail and private service sectors that already today are highly automated and IT- based (Sachverständigenrat, 2016).

It should be noted that these figures only describe gross effects that must be offset by new jobs created due to digitalisation-induced developments such as the emergence of new businesses, a growing demand for IT specialists and higher qualified professionals across all occupational fields (IAB, 2015).

Recent studies however indicate that not only occupations and jobs at the lower qualification end but also medium to high qualifications face a high substitution potential, for example tool makers, machinists, metal production, media technicians, IT system-electrician (Dengler et al, 2014).

Against this background, research studies and institutions (for example, Acatech, 2016; Sachverständigenrat, 2016; Dengler et al., 2016; BIBB, 2016c; BMAS, 2016) have stressed that one of the biggest challenges will be to foster vocational career possibilities and further qualification offers for employees with only low qualifications and to adjust occupational profiles and VET programmes in order to match technological developments.

Various surveys (see for example Spath, 2013) have also highlighted that advanced manufacturing technologies and processes will challenge existing boundaries between sectors, functions and occupations, namely by increasingly linking production and knowledge-related activities, integrating various production systems and reorganising value chains. With regard to qualifications and skills, advanced manufacturing requires both an adjustment of technical skillsets (for example in the field of machine operators skills in relation to IT and electronics in combination with mechanical skills, engineering, technology and materials related skills) as well as the acquisition of transversal skills and competences such as handling of abstract information, information gathering, problems solving, communication (including in English) and teamwork skills, handling stressful situations (Abicht and Spöttl, 2012). Generally, more inter-disciplinary and cross-functional process know-how (*Schnittstellenkompetenzen*) are needed as technologies

[3] The study calculates that 15% of dependent employees have a high substitution potential in the year 2013 because they are employed in occupations in which more than 70% of the tasks could already be substituted by computers.

change rapidly and production processes are becoming more complex and connected due to the introduction of new production technologies and processes.

VET experts interviewed in the context of this study (for example at the Ministry of Education and Science, BMBF or the Federal Institute for Vocational Training, BIBB) confirmed these views and highlighted further requirements such as ‘trainability’ or the workers’ willingness to engage in continuous, life-long learning.

Continuous technological, economic and societal changes require periodic updates of existing apprenticeship and training programs, as well as the development of both new apprenticeships and new training opportunities enabling skilled workers at the various levels of qualifications to meet the requirements of a constantly changing working environment (BMBF, 2016a).

According to the interviewed experts, the impact of digitalisation and the application of advanced manufacturing technologies do not concern only certain occupations and occupational groups but it also extends to production and work processes across all occupations and economic sub-sectors.

New needs for qualification and skillsets of workers have implications for learning and training methods and formats. There is a need to supplement traditional face to face learning by new forms of learning and coaching techniques, learning by doing as well as self-learning (Acatech, 2016; Tornau, 2016).

Overview of the apprenticeship system

Definition of apprenticeship

The definition of apprenticeship in Germany matches all key elements that are also highlighted in the Cedefop definition.

> *'systematic, long-term training alternating periods at the workplace and in an educational institution or training centre, which leads to a qualification. An apprentice is contractually linked to the employer and receives remuneration (wage). An employer assumes responsibility for the company-based part of the programme'.*
>
> (Cedefop, 2015)

As the apprenticeship system is based on the key principle of alternation of learning spaces, the system normally is referred to as 'dual vocational training' (*Duale Berufsausbildung*).

According to the Vocational Training Act (*Berufsbildungsgesetz, BBiG*), the following key aspects characterise an apprenticeship:

- initial training in recognised occupations provided on the basis of initial training regulations
- duration of not more than three and not less than two years
- conclusion of an initial training contract between the apprentice and the company proving the initial apprenticeship training governed by legal provisions and principles applying to employment contracts (fixed-term in accordance with the defined period of initial training) to be entered into the register of initial training relationships
- attending of a vocational school (part-time)
- provision of a written certificate after sitting of a final examination
- payment of an appropriate allowance.

Regulatory framework and institutional context

The regulation of vocational training and its institutional context is characterised by a long tradition as well as stability of the institutional framework. The Vocational Education and Training Act (*Berufsbildungsgesetz, BBiG*) entered into force in 1969 and it was amended only once in 2005[4] apart from several minor adjustments. An evaluation of the BBiG in 2015 came to the conclusion that the current regulation has worked well and it offers a reliable and up-to date framework for providing vocational education. The evaluation also stated that the legal framework provides for sufficient flexibility to cope with new challenges (BMBF, 2016c).

Vocational education and training, as defined by the Act, includes vocational training preparation, initial training, further training and retraining. A key concept of the VET system is the term 'training occupation' (*Ausbildungsberuf*), which is defined as a structuring category for the bundling of specific activities, qualifications and skills in the context of a nationwide

[4] The 2005 amendment did not change basic features of the vocational training system but included a number of new elements and principles, for example the acknowledgment of prior qualifications, the possibility to spend training periods abroad, or improve possibilities of transitions from initial to higher training/education. For further details see BMBF, 2005.

acknowledged training programme. Currently, there are more than 300 of such training occupations.

In addition to the key tasks of public VET provisions, the Act also regulates obligations of apprentices and companies providing initial vocational training, regulations on the suitability of training premises and training staff and necessary personal and technical qualifications, examination rules as well as interest representation of apprentices (*Ausbildungsvertretungen*).

Within the federal structure of government, the regulatory and operational competences for vocational education in Germany are shared between the federal government and the 16 *Länder* (federal states) governments. As education policy falls within the legal competence of the federal states, they are also responsible for vocational school education[5]. Thus, there are 16 different legal frameworks of vocational education that are however harmonised by the Standing Conference of Education Ministries (*Kultusministerkonferenz, KMK*).

In contrast to vocational schools, the federal government (represented by the BMBF) is responsible for company-based, on-the job training. Competences and responsibilities at the federal level include the enforcement of the vocational education act (BBiG), overall formulation of vocational policies and the coordination of adjusting occupational profiles and curricula. In relation to the adjustment of occupational profiles and curricula, the whole body of vocational education and training is characterised by close cooperation between the federal government, federal states as well as the social partners.

Further key actors involved in the provision and quality assurance of vocational education and training are employer organisations and chambers, trade unions as well as local public authorities. According to the BBiG, the chambers of industry and commerce, crafts and other trades and professions (for example agriculture or liberal professions such as architects or physicians)[6] are the ‘competent authorities’ providing advice to companies, keeping the register of apprentices (including all apprenticeship contracts, the so-called ‘apprentice roll’), certifying the professional qualification of trainers, conducting exams and fostering dialogue between business and trade unions at local level (in particular through joint committees at local and regional level on various topics and issues linked to initial VET, often linked to the work of the Vocational Education Committees).

Social partnership in the vocational education and training system is highly institutionalised at various levels. At the national level, social partners cooperate in the governing board of the Federal Institute of Vocational Education (*Bundesinstitut für Berufsbildung, BIBB*). At the federal state level, social partners along with the competent federal ministry are part of the Vocational Education Committee (*Berufsbildungsausschuss*). At regional level, they are the key actors in the Vocational Education Committees and examination boards that are established within the Chambers. As stipulated by the legal framework, social partners carry out important responsibilities within the VET system, namely in the context of monitoring, quality assurance and implementing programmes of IVET as well as further training and retraining (for further details see section on ‘key actors involved and their governance role’).

It is important to highlight that the federal government has also delegated the responsibility of elaborating new occupational profiles and respective curricula or adjusting existing ones to the

[5] In 2015, there were 1,550 vocational schools in Germany providing instruction in general and vocational subjects to trainees in the dual system specializing in different occupational fields.

[6] There are around 80 Chambers of Commerce and around 50 Chamber of Crafts.

social partners. These, however, are supported by the expertise provided by the BIBB[7]. The role of the federal government in this context is limited to the legal implementation of occupation-specific VET provisions as federal law.

Some 90% of all dual vocational training courses are implemented at company level as well as in vocational schools, whereby between 60-80% of the training time is spent within the company and 20-40% in vocational schools (BMBF, 2016a). There are, however, some specific forms of dual VET that have evolved in order to accommodate specific needs:

- Industry-wide vocational training centres (*Überbetriebliche Berufsbildungsstätten, ÜBS*): Parts of the on-the job training takes place outside the company where the apprentice is employed because the company is not able to provide all parts of the training. This is often the case in smaller companies. Since 2000, the Germany government has actively supported the transformation of ÜBS into sector or technology-specific 'competence centres'.
- Joint vocational training (*Ausbildungsverbünde, AV*): In order to cover all training contents, on-the job training may also be provided in a 'lead company' (*Leitbetrieb*) as well as in partner companies. Also, this has been introduced to address specific needs of smaller companies as well as to foster cooperation.
- Off-the job vocational training *(Berufsausbildung in außerbetrieblichen Einrichtungen, BaE*): This type of apprenticeship training has been established to support those persons who are not able to find a training company due to social or education/learning disadvantages. Training is provided in VET centres off-the job. However, the objective of these programmes is to place the apprentice as soon as possible into a 'regular' apprenticeship. If this is not possible, the apprenticeship may also be completed at the VET centre.

Financing the apprenticeship system

The apprenticeship system[8] is financed jointly by the private business sector and the German government.

Vocational schools and their teaching and other personnel are financed by public funds, whereby the federal states (*Länder*) contribute to the cost of the supervision of schools, the training of teachers, the definition of teaching plans and the salary of teachers, while the municipalities are responsible for the financing of construction, maintenance and renovation of school buildings according to the BBIG.

The Federal Ministry of Education and Research (BMBF) finances the costs for inter-company vocational training centres and special programmes such as the creation of additional apprenticeship places in the newly-formed German states, student grants, or international exchange schemes. Also cooperation within vocational education, innovation projects, talent programmes and the Federal Institute of Vocational Education (BIBB) is financed by the BMBF.

While direct financial support for companies is not very common in Germany, apprenticeship is supported by specific programmes, for example for VET in SMEs by the Federal Ministry of Economics and Technology (BMWi) or by the Federal Ministry of Labour and Social Affairs (BMAS) for special measures targeting disadvantaged younger people.

[7] The Board of BIBB consists of eight employer representatives, eight trade union representatives, eight federal state representatives and five representatives of the federal government.

[8] The following information has been gathered from different sources. However, a comprehensive overview of the German apprenticeship system regarding financing as well as other aspects is provided of the GOVET website of the German Office for International Cooperation in Vocational Education and Training. See https://www.bibb.de/govet/en/54884.php.

The costs of company-based training are paid by the respective companies. These costs include staff costs for the apprentice as well as the training staff within the company, equipment, training facilities and material. It should be noted here that the apprenticeship allowance is set on the basis of specific collective agreements of social partners at sector level and differs from occupation to occupation.

The following overview presents key financial data on the financing of the German system of dual vocational education and training.

Table 3: Financing of the dual system of VET in Germany

Public funds/spending	Private business spending
• €5,900 million total public funds • Thereof €3,200 million for 1,600 vocational schools • €2,700 million for administration, monitoring and support measures	• Employers invest on average €18,000 per apprentice per year (62% of which is for the wage/training allowance) • Total gross investments of private business in the apprenticeship system are estimated at €25,600 million. It is estimated that 76% of the investment is refinanced by productive returns of apprentices during the training period. This means that net costs for employers are around €7,700 million. • 46% of costs of companies spend on apprenticeship is for the wage/training allowance of the apprentice. On average an apprentice received a monthly training allowance of €795.

Source: BIBB 2016a (on private business spending) and further information provided by BIBB (on public funds)

Key actors involved and their governance role

While key actors and their regulatory role within the apprenticeship system have already been described above in the section on regulation, here only key aspects on the governance structure are summarized.[9]

The apprenticeship system is characterised by close and intensive cooperation and shared responsibility of three groups of actors. First, the business community/employers (represented by economic chambers), the social partners (trade union and employer organisations) and the government at central, regional and local level.

Companies employ the apprentices in order to train them. As an employer they are the contracting party for the apprentices and take responsibility for the proper fulfilment of the apprenticeship contract. They are required to engage in-company instructors to provide one or several trainees with the skills and knowledge laid down in the training plan. In addition to the preparation and implementation of the training, they have to exercise the supervisory duty and to monitor accident preventions as well as to assess the apprentice and his or her performance. In-company instructors also have to exchange on issues, requirements and possible problems related to the apprentices

[9] Further information on key actors involved and their governance role are presented at the GOVET website on the German Office for International Cooperation in Vocational Education and Training. See https://www.bibb.de/govet/en/54884.php.

they supervise with training consultants in the Chambers, the teachers at the vocational school, the legal guardians of the apprentice and professional consultants at the employment agency.

As highlighted before, chambers of commerce, industry, trade and skilled crafts play an important role in the apprenticeship system. They gather all apprenticeship contracts within their specific field of business, certify and license companies and in-company tutors for being competent in providing apprenticeship training and provide initial as well as further training for in-company tutors. Also interim and final exams of apprentices are held at the respective chamber. Furthermore, they have further functions such as providing advice for companies as well as apprentices, monitoring apprenticeship training, guidance and information for people interested in apprenticeship training or mediating conflict between apprentices and company owners/trainers. Often, chambers also run their own VET centres providing industry-wide training.

The German apprenticeship system is characterised by a close cooperation between social partners. These are a constituent part of the governance system and responsible for the design of vocational standards based on a consensus principle. Hence, social partners jointly define the requirements for the qualification standard. Reforms of the VET system are either initiated by the social partners or at least have to be accepted by them.

For the occupations in the metal and electrics sectors, *IG Metall* is the trade union and *Gesamtmetall* the employer organization involved. The chemical industry is represented by the Mining, Chemical and Energy Industries Union *IG BCE* and Employers' Federation for the Chemical Industry *BAVC*. The industrial unions IG Metall and IG BCE as well as Gesamtmetall and BAVC are represented in the main committee of the Federal Institute of Vocational Education (BIBB).

There are several dimensions of involvement and responsibilities of social partners in the dual VET system. Five different levels are important to highlight:

- At the national level, social partners are key actors of the development of occupational training standards and curricula (supported by BIBB). They are also the main source of suggestion on needs to revise existing occupations or develop new occupations. Finally, they are involved in the development of quality standards and make recommendations on reforms and VET policy. Social partners along with the government at federal and *Länder* level are also constituent partners of the 'Alliance for initial and further training' (*Allianz für Aus- und Weiterbildung*) that has been established in 2014 to increase the attractiveness of apprenticeship and dual VET pathways.
- The role of social partners is similar at the level of federal states, being involved in all areas of VET policy, making recommendations as regards federal VET orientation, and coordination between VET schools and companies.
- At local level, social partners are responsible for providing advice to companies, monitoring the quality and implementation of apprenticeship training, participating in exams and lobbying for apprenticeships in local politics.
- At sector level, social partners negotiate working conditions and remuneration of apprentices that are concluded in specific collective framework agreements.
- Finally, at the company level, social partners plan and implement the company-level training and contents reflecting company specific needs. In larger companies the works council plays an important role in this context; apprentices elect their own spokesperson or representation body (*Ausbildungsvertretung*).

Against the strong element of self-organisation of the dual VET system, the role of the government is basically one of a facilitator. Apart from the jurisdictive and other regulatory functions described already, the government at federal and *Länder* level plays an important role in monitoring, evaluation and research (in cooperation with BIBB), standard development as well as VET policy development.

The interviewed stakeholders for this study have indicated that more recently the role of the federal government has become more active. This is elaborated further in the section of this report on reform processes and adjustments.

Statistical data and trends

The apprenticeship system is the most attractive pathway of initial vocational education in Germany. On average, every year around 500,000 people or around 65% of the population looking for a VET are entering the dual VET system in nearly 330 recognised occupations. In 2014, about 431,000 companies or 20% of all companies offered apprenticeships, whereby the companies providing places in the dual system has decreased since 2007 (490,000 companies offering training, 24%) (BIBB, 2016b). The loss is almost exclusively attributable to micro-enterprises and the non-participation in the training of small enterprises in new sectors that lack training traditions or report significant problems in finding suitable apprentices. The share of apprentices in the total number of employees is however higher in small and medium sized companies (5.5%) than in large companies (4.6%) (BMBF, 2016a).

In September 2015, there were a total of about 1.59 million apprentices subject to social insurance contributions in Germany according to the Federal Labour Office (*Bundesagentur für Arbeit*). The manufacturing sector accounted for 22%. Most of the about 352,000 apprentices in manufacturing worked in the manufacture of machinery and equipment (19%), followed by manufacture of fabricated metal products (14%) and manufacture of motor vehicles, trailers and semi-trailers (10%). While the total number of apprentices decreased by 12% between 2008 and 2015, the number of those in manufacturing declined only by 9%. Especially the number of apprentices in the manufacturing of food products declined (-37%). In contrast, there was a slight increase in manufacture of machinery and equipment, manufacture of rubber and plastic products and manufacture of electrical equipment (+1%) as well as manufacture of motor vehicles (+2%) and a more marked increase in repair and installation of machinery and equipment (+4%) and manufacture of chemicals (+9%) (Federal Labour Office, 2017).

The apprenticeship contract termination rate increased between 2009 and 2014 from 22.1% to 24.6%. In 2014, the termination rate in occupations in industry and commerce with 21.5% was below the average (BiBB, 2016a).

As regards supply and demand, between 2009 and 2016 the total supply of apprenticeship places in Germany has decreased by 3% while the supply of company-based apprenticeship places has grown by 2 %. While the total supply increased in western Germany by 0.36%, it declined by 19.4% in eastern Germany (BiBB, 2016b).

As to apprenticeship places demand, it has decreased since 2011 due to a declining number of school leavers among other influencing factors. Between 2009 and 2016 there has been a decline by 8%. The decline in demand in 2016 compared to 2015 by 0.4% took place in western Germany while the number remained stable in eastern Germany where the number of school leavers has increased slightly (BiBB, 2016b).

Table 4 : Development of the German apprenticeship market, 2009 - 2016

In thousands	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2009/2016**
Apprenticeship places supply	581.9	579.8	599.8	585.3	564.2	561.5	563.8	563.8	-3%
• *company-based**	536.1	538.7	569.4	559.4	542.5	541.1	544.9	546.3	+2%

• *extra-company***	45.8	41.0	30.5	25.9	21.7	20.4	18.9	17.6	-62%
Apprenticeship places demand	652.9	640.4	641.8	627.4	613.3	604.6	603.2	600.9	-8%
Unfilled company-based apprenticeships	17.6	19.8	30.4	34.1	34.6	38.3	41.6	43.5	+148%
Share of unfilled supply	*3.3%*	*3.7%*	*5.3%*	*6.1%*	*6.4%*	*7.1%*	*7.6%*	*8.0%*	
Unsuccessful demands	88.6	80.5	72.4	76.1	83.7	81.4	81.0	80.6	-9%
Newly concluded apprenticeship contracts	564.3	560	569.4	551.3	529.5	523.2	522.2	520.3	-8%
• *thereof company-based*	518.5	518.9	538.9	525.4	507.9	502.8	503.3	502.8	-3%

**not (mainly) financed by public funds; ** (mainly) financed by public funds*

Source: BIBB, 2016b

In 2016, for the first time there were more applicants for apprenticeships who were entitled to study at a university than those who had completed Secondary General School (*Hauptschule*). While the female demand for apprenticeship places declined by about 16% against the previous year, the male demand decreased by about 2% (BiBB, 2016b).

The supply-demand ratio has increased since 2013. In 2016, 93.8 apprenticeship places were available for 100 demands throughout Germany. Higher ratios were reached (100 and more) mainly in Southern and Eastern Germany while lower ratios (between 80 and 90) were stated in Northern and Western Germany (BiBB, 2016b).

It becomes more and more difficult for many companies to fill the apprenticeship places they offer. The number of unfilled company-based apprenticeships has grown significantly (+148%) since 2009. However, there are important differences between sectors and occupations as well as regions. Vacancies are more frequent in Eastern and Southern Germany than in Northern and Western Germany. The share of unfilled supply is highest in the craft sector (9.4%), followed by industry and commerce (7.7%) while the lowest share is stated for the public sector (1.1%) (BiBB, 2016b).

Matching problems have become more acute over the years due to regional economic discrepancies and lacking mobility of future apprentices (school leavers interested in an apprenticeship living in an area of low supply and not being able to move to an area with higher supply) as well as market imbalances in terms of choice of occupations (division between occupations being perceived as attractive or not attractive).

From 2009 to 2016, the number of newly concluded apprenticeship contracts decreased by 8% on average. The decrease occurred in industry, commerce, crafts and agriculture. The only increase was registered in liberal professions (+4) and the public sector (+1).

Table 5 : Number of newly concluded apprenticeships contracts per sector in thousands, 2009-2016

Sector	2009	2010	2011	2012	2013	2014	2015	2016	2009/ 2016

Industry and Commerce	333.4	331.0	342.8	332.6	317.3	311.7	308.2	304.3	-9%
Crafts	155.6	155.2	154.5	147.3	142.1	141.2	141.5	141.8	-9%
Public sector	13.7	13.6	12.4	12.0	12.2	12.4	13.3	13.8	+1%
Agriculture	14.6	13.9	13.5	13.3	13.2	13.2	13.6	13.6	-7%
Liberal professions	42.7	42.4	42.6	43.1	42.1	42.1	43.1	44.6	+4%

Source: BIBB, 2016a

With regard to major characteristics of apprentices, official statistics show that in the training year 2015-2016, 56% of the apprentices were aged between 17 and 20 years and 31% between 21 and 25 years. Only 7% were aged over 25 and only 5% under 17 years (Federal Statistical Office, 2016b).

There is a certain gender bias of apprenticeship in Germany: 61% of the new apprenticeship contracts in 2016 were concluded with male and 39% with female apprentices. While the number of apprenticeship contracts with women has steadily decreased since 2009, it increased since 2014 for those concluded with men. One reason is that the trend towards higher educational qualification is more evident for young women than men (BIBB, 2016b). Women are represented in apprenticeship programmes to a lesser extent than men and in addition concentrate on fewer training occupations (mostly commercial and healthcare). Occupations relevant to the (advanced) manufacturing sector are more often occupied by men (for example, electronics technician, industrial technician, IT specialist, mechatronics technician, cutting machine operator, machine and equipment operator are among the 25 training occupations most occupied by men) (BMBF, 2016b).

As mentioned above, concerning secondary school qualifications, a growing share of apprentices hold a higher secondary school degree granting university admission (*Abitur*). However, the largest group of new apprentices had an intermediate secondary school degree (*Realschule*) with 43%. Some 28% had a higher secondary school degree, 26% had a basic secondary school degree (*Hauptschule*) while only 2% had no secondary school degree at all (BiBB, 2015b).

Given the increasing multicultural character of the German society the apprenticeship system is not yet reflecting this. According to a recent survey (BIBB, 2015a) only 27% of all young people with a migration background applying for a company-based dual vocational training were successful in obtaining an apprenticeship contract. In contrast, the respective share of those without a migration background was 43%.

Key challenges

A number of challenges have been highlighted in relation to matching of supply and demand of apprenticeships, quality of training, as well as changes in skills/qualification requirements.

With regard to the supply and demand of apprenticeship, an important challenge is the matching of supply and demand which differs significantly across sectors as well as regions:

- despite demographic changes there is an increasing number of unplaced applicants that are not able to find an apprenticeship place (13% or more than 80,000 in 2016) (BIBB, 2016a);
- apprenticeship supply and business demands are not matching. There are occupations in sectors such as hotels and restaurants or cleaning as well as in the craft sector where companies have significant problems to find applicants (in September 2016 companies reported more than 40,000 vacant places, i.e. 8% of the total supply) while in occupational

areas such as media, IT or in the commercial business the number of applicants is much larger than apprenticeships offered by companies (BIBB, 2016b);

- increased matching problems also result from the steady decrease in the number of companies providing apprenticeships (20% in 2014 compared to 24% in 2009) – in particular smaller companies are less likely to offer dual VET opportunities (BIBB, 2016a);
- interviewed stakeholders (representing BIBB and the IG BCE trade union) have highlighted that attractive and dynamic business areas such as IT, media or software companies are characterised by corporate cultures that are unfamiliar with apprenticeship traditions and practices.
- interviewed stakeholders (representing the employer organisation Gesamtmetall and the Ministry of Labour) have stressed the increased need to strengthen the links between initial and further training, particularly in relation to new technologies, advanced manufacturing techniques, computerization and IT. Also the boundary between initial training and continuous learning/skills development is becoming obsolete and there is a need for providing new forms of knowledge acquisition, transitions into apprenticeship and career paths after completing initial VET.
- challenges have also emerged in relation to changes in skills and qualifications requirements at the workplace. Globalisation (for example, requirements of language skills and inter-cultural competences) and technological changes such as digitization of services and production processes have led to increasing skill demands at the workplace. At the same time, the need for improving life-long learning opportunities has also increased – both for workers and older applicants as well as teaching and tutoring personnel. This creates further challenges in terms of curricula adjustments, pathways of dual VET practices open for older applicants (including through the acknowledgement of informally acquired competences) as well as VET quality assurance.

In this context, all interviewed stakeholders have highlighted a number of new and emerging challenges adding to the existing matching problems:

- IT-skills and their application is becoming prominent across all occupations
- in production-related occupations there are new demands for transversal competences and skills (IT, process management skills, monitoring and control skills) as well as new basic skills such as English language knowledge, ability to work in teams, problem solving competences
- in order to continuously update own qualifications and skills, workers are expected to have a certain degree of so called ‘trainability’, that is, the willingness to engage in continuous learning and further training.

Finally, from the perspective of VET policy as well as from the broader perspective of social cohesion and economic competitiveness, the government is facing additional challenges, such as:

- projected future nationwide skilled labour shortages
- demographic change leading to decrease in number of young people in the labour market
- countering trend of young people increasingly choosing university over dual VET
- strong regional disparities with regard to dual VET training demand and supply
- need for greater participation of people with a migrant background as well as other disadvantaged groups into the VET system, offering them access to gainful employment and thus contributing to social cohesion.

Apprenticeship policy and practice in the manufacturing sector

Apprenticeship in the manufacturing sector

In 2015, there were about 147,000 newly concluded apprenticeship contracts and 433,000 existing apprentices in dual apprenticeships in occupations in manufacturing (BIBB, 2015b).

Also in comparison to academic pathways, apprenticeships are highly relevant in manufacturing. Of those persons employed with a professional qualification in manufacturing, 71% had completed an apprenticeship in 2015, 14% had a certificate from a trade or technical school. Eight percent had graduated from a higher technical college and only 6% had a university degree (Statistisches Bundesamt, 2016).

Apprenticeships are of major importance for VET in the manufacturing sector. In 2012, 58.6 % of all persons employed in manufacturing had completed an apprenticeship (Statistisches Bundesamt, 2015) and the share declined slightly to 57% in 2015 (Statistisches Bundesamt, 2016).

Within the manufacturing sector, the technical occupations in machine-building and automotive were those where most of the new apprenticeship contracts were concluded and where most of the existing apprentices were employed, followed by occupations in mechatronics, energy electronics and electrical engineering and occupations in metal-making and -working and in metal construction (for further details see Table 6).

Table 6: Newly concluded apprenticeship contracts and apprentices in manufacturing occupations, 2015

Occupations in	Newly concluded apprenticeship contracts	Apprentices
Machine-building and automotive industry	43,902	136,143
Mechatronics, energy electronics and electrical engineering	33,963	108,708
Metal-making and -working, and in metal construction	23,532	75,939
Food-production and -processing	16,956	38,877
Plastic-making and -processing, and wood-working and -processing	13,869	32,820
Technical research and development, construction, and production planning and scheduling	6,201	18,201
Paper-making and -processing, printing, and in technical media design	5,601	14,619
Textile- and leather-making and -processing	1,884	4,560
Production and processing of raw materials, glass- and ceramic-making and -processing	1,158	3,234

Source: BiBB, Tabelle: Duale Ausbildungsberufe (BBiG/HwO) 1 gruppiert nach KldB 2010 mit ausgewählten Indikatoren zur dualen Berufsausbildung, Deutschland 2015

So far, there has been only one occupational profile that has been established as a new occupation in direct response to new requirements of advanced manufacturing technologies and processes. In 2008, the occupation of the 'production technologist' (*Produktionstechnologe*) was established following a strong request from business organisations such as the professional organisation in the machine and tool making sector, VDMA and individual companies in the automation sector.

However, so far, only quite few new apprenticeship contracts are concluded by companies (table 7). According to the interviewed stakeholders (namely BIBB, Gesamtmetall and IG BCE) this may be particularly due to difficulties in understanding its innovative character (being an occupation that is perhaps 'ahead of time') and the lack of know-how in vocational schools as well as qualified training personnel within companies. It may be also the case that both companies and potential applicants/trainees have difficulties to understand the complexity of the occupation. As a result, they tend to choose more established occupations such as mechatronics or electronic technician for automation technology.

Table 7: New apprenticeships in manufacturing-related occupational groups and individual occupations, 2008 - 2015

	2008	2009	2010	2011	2012	2013	2014	2015
Occupational groups*								
- Metal-related occupations	56,202	46,045	43,265	49,042	49,638	46,771	46,690	46,731
- Industrial electronics	11,845	10,791	10,458	11,651	11,879	11,526	11,216	11,272
- Technical IT occupations***	11,822	10,467	10,530	11,674	12,033	12,066	12,323	12,477
Specific occupations**								
Industrial mechanic	52,830	52,248	50,619	48,768	47,472	47,439	47,394	46,428
Mechatronics fitter	26,235	26,388	26,031	25,707	25,698	26,193	26,490	26,364
Electronics technician for automation technology	6,063	6,042	6,057	6,066	6,102	6,381	6,480	6,534
Production technologist (since 2008)	24	54	96	132	159	159	147	123

*Sources: * Gesamtmetall; ** BIBB Database DAZUBI*

**** Information Technology Specialist; Information Technology and Telecommunications System Electronics Technician*

Strengths and weaknesses of the system

Within manufacturing, apprenticeship training is regarded by all relevant interviewed stakeholders as a key aspect of the sectors competitiveness as well as its capacity to adjust and innovate. Thus, apprenticeship training in manufacturing is attractive for companies. Between 2013 and 2015 the share of enterprises training apprentices was 32.9% in manufacturing and therefore above the average of 20.9% considering all sectors.

However, at the same time its share of enterprises with unfilled apprentice positions was also above average (43.2% against 42%) (BIBB, 2016a). While apprenticeships in the metal working, automotive and chemical industry are known by and very attractive for apprentices also due to the relatively high remuneration, the newly designed occupation of production technologist still is not known and is judged to be too complex in its design by some.

According to all interviewed stakeholders this also results from the flexibility of the apprenticeship system which is regarded as a clear strength of the German apprenticeship system. Occupational standards are regulated in an open manner, focussing on basic requirements and leave space for adaptions at company level as well regarding regional/local specificities. Companies already use the flexibility of the apprenticeship regulations to adapt curricula.

But the training departments often lack the know-how for training on high-tech machines. Also, companies state that they are not sufficiently supported by the chambers of crafts, commerce and industry in the adaption and update of contents (as reported by interviewees representing Gesamtmetall and IG BCE).

The general quality of apprenticeships programmes in manufacturing is considered to be high due to a strong tradition and long experience, a well built-up infrastructure as well as the close relation between processes at the workplace and learning at vocational schools. According to a survey carried out by the Federal Institute of Vocational Education (BIBB) between 2006 and 2009 among 1,400 companies, companies providing apprenticeship training reported that framework conditions such as equipment, motivation and aptitude of the instructors, didactics and methodology were meeting their quality requirements. By contrast, results published in 2010 pointed to some limitations in relation to coordination or joint actions of the two places of learning, cooperation with other companies and support by the chambers of crafts, commerce and industry (BIBB, 2010). More than 75% of the apprentices stated that the quality criteria for a good apprenticeship[10] were met to a large or a very large extent. The quality of apprenticeship within companies was generally assessed to be better than that in vocational schools. With regard to different occupations within manufacturing, the ratings of quality by apprentices differed quite significantly. Whereas the industrial mechanic apprenticeship was amongst the top rated as regards the quality, apprentices in the mechatronics fitting occupation were much less satisfied with the quality of their apprenticeship (BIBB, 2010).

However, comparisons between sectors have shown that in general the satisfaction of apprentices with their apprenticeship in the manufacturing sector is higher than in other sectors, for example 88% as compared to 73% in the services sector and only 65% in the commercial sector (Ernst, 2016).

As highlighted before, a key strength of the German system of apprenticeship occupations according to all interviewed stakeholders, is the definition of occupational profile and training programmes that leave a certain scope and freedom for actors at the company level to adjust the curricula to their own needs and requirements (*Gestaltungsoffen*). This scope also exists with regard to technologies in the sense that occupational apprenticeship programmes are designed as far as possible in a technology-neutral manner (*Technikoffen*).

According to the stakeholders, this specificity of occupational profiles clearly is a major strength when it comes to implementing adjustments within specific occupations (rather than inventing new occupations from scratch) in response to new needs. However, as highlighted by the interviewed stakeholder representing the Ministry of Education and Research, adjustment processes that are more substantive than adjustment of existing occupations are much more difficult to implement. These are for example the introduction of new occupations or changes in the cooperation of companies and schools, establishing stronger links between initial and further

[10] The study is based on quite a large number of quality characteristics that belong to several quality aspects in four groups of *input- and process related quality* (framework conditions, conception/coordination, didactics/method and cooperation of learning places and companies). Also output-related quality has been assessed with regard to company-specific, occupation-related, labour-market related, as well as society and individual outputs.

vocational education and training. Here, the specific procedural requirements and the role of different actors tend to slow down adjustment processes. This challenge according to all interviewed stakeholders has become quite evident particularly with regard to fostering the transition to Industrie 4.0 and Work 4.0. As will be shown in the section below on reform processes and adjustments, a number of changes and initiatives have been initiated both by the government as well as the social partners to cope with this challenge.

Regarding weaknesses of the system, at the vocational schools, there is a lack of teachers especially in natural science and technical subjects that are highly relevant to advanced manufacturing as well as adequate instruction methods in the training of teachers (Ernst, 2016). Another weakness relates to the financing of VET schools. Financial resources in economically better off federal states are greater than in regions that are characterised by fiscal strains and restricted budgets. As to school modernisation as well as innovation (for example the creation of competence centres in specific sectors or professional fields) the resources between sectors as well as regions differ significantly.

A further weakness of apprenticeship training in the manufacturing sector relates to the limited number of instructors and tutors in companies. The number of instructors has decreased between 2009 and 2015 by about 4% in total (Federal Statistical Office, 2011 and 2016a). The decrease was less pronounced in the industry and commerce sector (-0.3%). Full-time instructors as defined in the Ordinance on Trainer Aptitude (AEVO) today are a minority in German companies (BIBB, 2012). In addition, in the context of industry 4.0 there is a need for 'instructors 4.0'. However, according to the interviewed stakeholders these do not always have the required knowledge of advanced manufacturing technologies and they lack related pedagogical skills.

Furthermore, according to the stakeholder interviews, there are limited possibilities of progressing to higher apprenticeship and related career pathways within the VET system. This has resulted in a competition between the VET system and manufacturing-oriented bachelor courses in the tertiary education system (see detailed description in the following section).

Key requirements arising from technological and other changes in manufacturing

From a company's perspective, the existing apprenticeship system is generally flexible enough to adapt the content of the apprenticeships and occupations to changing requirements in advanced manufacturing. Most companies today do not train in different or new training occupations, but they rather change the content of apprenticeship programmes through more frequent use of state-of-the-art information and communication technology (ICT) but also personal, social and problem-solving competencies.

As stated in the interviews for this study, despite these tendencies of companies to adapt contents to their needs, contents like production process knowledge and the ability to solve problems still are not always as important at the beginning of apprenticeships as they should be. Manufacturing companies often have not enough trained employees in the field of IT knowledge. Hence, an additional qualification for IT to be included in the curricula would be useful. In general, supplementary contents for curricula are very valuable as not all companies are at the same stage of development of advanced manufacturing and have the possibility to choose whether they see a need to teach these qualifications or not.

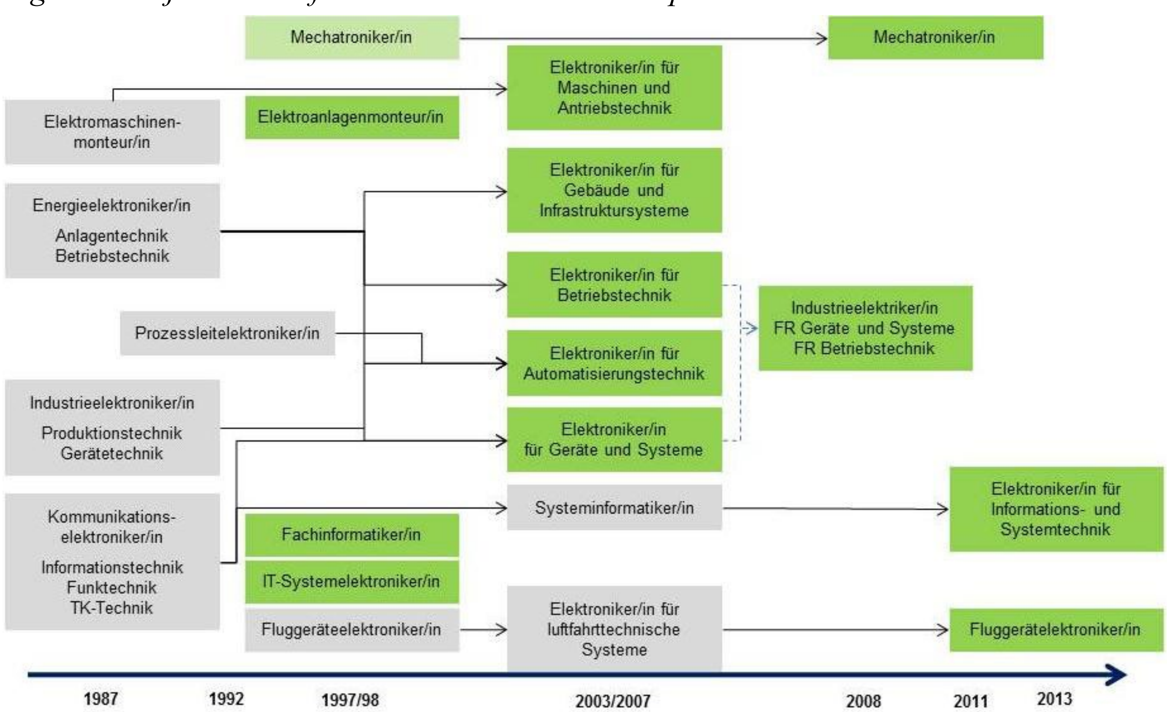
So far, advanced manufacturing, technologies and techniques determined occupational fields such as mechanics, electrical engineering, mechatronics, automation technology and operational technology. In the longer term, there might be a need to adjust the basic profile cut of future professions and create new profiles such as the occupation technician for system maintenance (*Systeminstandhalter*) (BIBB, 2014b).

Nonetheless, developments in advanced manufacturing will not take place at the same speed in every company, sector and even region. It is therefore likely that there will also be a juxtaposition of traditional and process-related professional profiles in the longer term (Zinke, 2014).

Regarding the adaptation of the content of apprenticeships, the Federal Institute for Vocational Education and Training (BIBB), together with the social partners regularly updates apprenticeship regulations on behalf of the Federal Government. Since 2008 a total of about 100 apprenticeship regulations have been updated. Among others, the topic of control technology has been introduced in many training courses in recent years.

Technological change and change in work organization has influenced the adaption of the training occupations. For example, in 2014, the auto body and vehicle construction mechanic was updated, reflecting significant changes in the automobile production technology and processes. In 2011, the new profile for the packaging materials technologist has been established for similar reasons in the packaging production. Already in 2010, the contents of the paper technologist have been modernized taking into account the growing importance of maintenance and measuring and regulation technology. In the field of industrial electronics, occupational profiles have been adjusted in 2003 and new occupational profiles have been defined in 2007. These are mechatronics, industrial electrician, electrician for information and system technology, aircraft electrician). Figure 1 provides an overview of reorganised and new occupations in the field of industrial electronics between 1997 and 2013. However, given the strong impact of digitalisation, these four occupations are being re-evaluated in-depth (BIBB, 2014b).

Figure 1: Adjustments of industrial electronics occupations



Source: BIBB 2014b: Berufsfeldanalyse zu industriellen Elektroberufen als Voruntersuchung zur Bildung einer möglichen Berufsgruppe. Abschlussbericht, Bonn

Note: Existing occupations are highlighted green

As highlighted in the section on strengths and weaknesses, apart from continuous adjustment processes that has always characterised the adjustment of occupational profiles and curricula, the transition towards advanced manufacturing and process-related as well as organisational changes related to the broader concept of *Industrie 4.0* has also led to more substantive needs for adjustments, including formal procedures of modernising apprenticeship occupational profiles.

With regard to the modernisation of apprenticeship occupational profiles, in 2016 the social partners and professional organisations in the metalworking and electronics sector (IG Metall, Gesamtmetall, VDMA and ZVEI) agreed to initiate a comprehensive evaluation process of all relevant occupational profiles and more recently on the basis of a 'lean' or 'agile procedure' (Gesamtmetall, IG Metall, VDMA, ZVEI, 2017). According to this initiative, adjustment of initial training and qualification in the light of advanced manufacturing and industry 4.0 should rather take the form of 'agile' adaptation rather than establishing totally new occupational profiles. However, this initiative also acknowledges the need to integrate new transversal basic skills across all occupations in the metalworking and electronics sector (such as online communication skills, data analysis, data transfer, online search, online learning skills) and knowledge into all metalworking occupational profiles as well as the need to integrate optional additional specific qualifications (such as system integration, process integration and additive fabrication/printing in metalworking occupations and digital networking, programming and IT security in electronic occupations). The social partners also stressed strongly the need to strengthen the link between initial vocational education and training and further training.

Also the recent initiative of the German Federal Government *Berufsbildung 4.0* to foster a more comprehensive modernisation of the VET system and a transition towards 'VET 4.0' in response to technology-driven changes and digitalisation reflects this need for more substantive adjustment processes (see following section).

The government initiatives to foster VET 4.0 also acknowledge the need to create more career pathways within the VET system and establish more possibilities to progress to higher apprenticeships in order to meet new qualification requirements resulting from technological changes. So far, the increasing demands of companies for higher qualified personnel have resulted in a strong expansion of the 'dual study programmes' (*Duales Studium*) within the tertiary education system.

Dual academic programmes combine vocational training and degree programmes, whereas the trainee is employed by the company financing the study course and obtains both practical knowledge within the company and an academic degree (bachelor or master, EQF level 6). Dual academic programmes are expanding in terms of number of programmes as well as number of students participating in such programmes (Hippach-Schneider and Schneider, 2016). In February 2017, there were almost 1,600 dual study courses for initial vocational training registered with the dual study platform *AusbildungPlus* provided by the Federal Institute of Vocational Education (*BIBB*). These courses are mainly offered by technical colleges (*Fachhochschulen*). The majority of such programmes were offered in economics and engineering sciences and IT (BIBB, 2014a).

However, according to stakeholders interviewed in the context of this research, the role of dual study courses in the manufacturing sector should not be overestimated. Though there are no detailed figures on the number of dual students in the manufacturing sector available, the total number[11] as compared to the number of apprentices in the sector is very modest. According to Gesamtmetall, there are also indicators that the dual study market in the manufacturing sector will not expand much further in the future, as during the last 2-3 years the number of courses and dual students was rather stable.

[11] Interviewed Gesamtmetall representative gave an estimation of 40,000-50,000 in total.

While dual study programmes play an important role in the provision of initial vocational training, they are not to be considered as 'higher apprenticeships' as there are no national regulations, not necessarily an involvement of social partners nor quality control. These criteria, however, apply to advanced further training such as the industry master (*Industriemeister*) or process manager electrical engineering (*Prozessmanager Elektrotechnik*) that are offered for those having completed, for example, the final exam of the training occupations as industrial electrician, electronics technician for automation technology and mechatronics after one year of relevant occupational practice. For the new occupation of production technologist (*Produktionstechnologe*) that was established in 2008 the advanced further training 'process manager production technology' (*Prozessmanger Produktionstechnologie*) was created.

According to the stakeholder interviews, there is a need to develop new forms of learning and a greater offer in continuing education and on-the-job training. Learning should not stop after the apprenticeship. Lifelong learning is already considered in apprenticeship regulations, but greater emphasis should be put on this requirement. As career pathways open for those having completed an apprenticeship are not always well known, the social partners of the chemical industry - IG BCE and BVAC – have initiated the Job and Career Compass for the chemical industry informing about development and funding opportunities.

Advanced manufacturing: mapping reform processes and adjustments

Apart from previous reforms and adjustments of the apprenticeship system in the context of the broader and general reforms of the VET system (for example the 2005 amendment of the VET Act), there are currently a number of reform processes and government-led initiatives to adjust the apprenticeship system with a view to making it fit for the future and catering for the needs of advanced manufacturing and Industrie 4.0.

As highlighted in the interview with a BMBF representative, modernisation initiatives relate to the three key dimensions of the apprenticeship system:

- **the individual dimension of apprenticeship**: learning processes, methods and environments;
- **the regulatory dimension**: occupational profiles and programmes containing requirements regarding basic and general skills provision across different occupations, occupation-specific skills as well as space for company specific skills acquisitions and offers for further qualifications;
- **the systemic dimension**: integration of different occupational fields, horizontal links, hybrid qualifications as well as educational paths into the apprenticeship system as well from initial to higher apprenticeship and beyond.

Approaches and initiatives to adjust existing practices in order to better cope with key challenges in the context of advanced manufacturing have been developed in all three dimensions. A number of relevant initiatives were highlighted by the five experts and stakeholders interviewed in the context of this research.

With regard to the individual and regulatory dimension of apprenticeship, the Federal Ministry for Education and Research (BMBF) has highlighted in particular the new initiative *Berufsbildung 4.0* launched in summer 2016 that is implemented in cooperation with BIBB.

The initiative includes company based in-depth research conducted by BIBB in cooperation with Volkswagen on new occupational profiles in the automotive industry (operative maintenance 4.0) and the screening of selected occupations and further qualification practices (across all sectors) with regard to adjustment needs and requirements as arising from advanced manufacturing technologies and digitalisation (BIBB, 2016c; 2016d).

A further focus of the initiative is to improve the digital competences of apprentices and teaching/training personnel. This is done by supporting digital forms of education, the use of digital media, Web 2.0 and mobile technologies in training and education, training educational staff and strengthening the resources of VET schools.[12] Fostering the establishment of industry-specific competence centres (ÜBS) is another major objective of the initiative.

The broader aims of these activities are to develop orientations for reforms and action (for example, the detection of skills needs and establishment of an early warning system, support of competence centres, development of innovative, digitally supported education, communication and information solutions or concepts to strengthen media literacy), provide guidance for industry representatives, social partners and policy makers on how to anticipate skills and elaborate mechanisms for a better anticipation and monitoring of skills needs at occupation and sector level. These results should feed into the tripartite social dialogue on the further development of the VET system.

According to the interviewed BMBF representative, the *Berufsbildung 4.0* initiative also indicates a stronger role of the federal government (as well as BIBB) in adjusting and modernising the apprenticeship system. In the past the role of the government focussed more on the (legal) implementation of changes that were agreed between key stakeholders of the VET system (companies, employer and union organisations) or providing research intelligence (through BIBB). The 4.0 initiative as well as other activities (such as the JOBSTARTER plus programme[13]) imply a more pro-active role.

Also social partners have initiated their own joined activities in order to adjust the apprenticeship system to new requirements resulting from technological change and advanced technologies. As described above already, the social partners in the metalworking and electronics industries have developed proposals for the adjustment of relevant occupational profiles, apprenticeship programmes and further qualification modules in the metalworking and electronics sector.

In 2014, in the chemical sector, the education council (*Bildungsrat*) and the sectoral social partners - IG BCE and BAVC - presented a position paper for the strengthening of vocational schools and their cooperation with the companies partly in response to the rapid technological change (IGBCE and BAVC, 2014). In 2016, IG BCE started the initiative *work@industry4.0* also dealing with education and training[14].

Finally, current adjustment processes of apprenticeship in the manufacturing sector are also driven by individual companies. Especially larger companies have developed own activities to improve apprenticeship training and adjust in-company training to new requirements.

ABB, one of the global leaders in robotics and automation technologies, has established specific training courses for the provision of skills and further qualifications at its ABB training centre in

[12] In the context of this initiative, the Ministry of the Economy and Energy (BMWI) has established an investment support programme to strengthen digitalisation both as a learning subject and as a learning medium in the dual apprenticeship system. To this end, investments in the infrastructure of vocational schools are planned in order to provide equipment designed to impart digital knowledge adapted to the needs of company practice within the initiative ”1,000 vocational schools 4.0“ (1.000 Berufsschulen 4.0) (BMWi, 2016b).

[13] With the JOBSTARTERplus program, the BMBF is funding several innovative projects that link vocational educational and training to the requirements of digitalization and advanced manufacturing. Since 2006, 436 projects have been funded including developing and testing interdisciplinary additional qualifications for apprentices in metal and plastic occupations or of a specialist in digital production processes, a competence cluster for education and training in the automotive industry in Eastern Germany.

[14] Further information on the initiative is available on the web site at http://www.work-industry40.de/

Heidelberg. These courses are implemented in a cooperative way involving apprentices and dual students from 18 partner companies and technical universities (*Fachhochschulen*) in different occupational fields, including mechatronics, electronics, industrial mechanics, manufacturing mechanics, tool mechanics and commercial apprentices.

Another example is the so-called 'learning factory' established by Festo, a manufacturer and service provider for the automation technology. This is run by apprentices as an integral part of production where learning stations for metal cutting, assemblage, cross-cutting issues and processes and media centre are closely linked to the actual manufacturing.

A further prominent example is the education department of Siemens AG, a leading company in modernising and adjusting training contents as well as methods to adapt them to the needs arising from digitalisation and advanced manufacturing techniques such as robotics or additive manufacturing (Kunz 2015, BMWi, 2017).

With around 10,000 apprentices and dual students (of whom around 7,000 are directly employed by Siemens and around 3,000 employed by external companies) Siemens Professional Education (SPE) is one of the largest training providers in Germany. Training and education provided by SPE covers 30 different apprenticeship occupations and 40 different dual academic programmes, in fields such as electronics, information technology, mechanical engineering, mechatronics and business administration. The various educational programmes offered by SPE are organised in a modular way and consist of modules as well as smaller sequences and single projects.

Commentary and conclusions

The German apprenticeship system is facing a number of challenges that stem from broader social as well as technology-driven changes. At the same time, the system seems to be quite well prepared to cope with change and deal with such challenges. The change of occupation profiles has become more frequent and makes an early impact assessment as well as a continuing development of apprenticeship regulations necessary. In Germany, there is a response to the requirements in the context of advance manufacturing, but the system itself does not have to change.

The German apprenticeship system has important strengths due to its long tradition, experience, and consensus-based involvement of social partners as well as well-developed infrastructure. There is a high commitment on the part of all stakeholders allowing for apprenticeship programmes to reflect the needs of all parties involved. The design of apprenticehsip and apprenticeship regulations are updated on a regular basis.

Apprenticeship regulations cannot be however adapted as rapidly as technological change takes place and standardised centralised examination mechanisms to obtain the certificate limit the extent of individual adaptations. Yet, for the industrial metal and electrical occupations, a ‘variant model’ applies. As part of the final examination, the training company has the choice between a standardised national examination task and an operational task reflecting specific tasks in the company. Both test the professional process competence on a comparable level. Also, the provision for the introduction of additional qualifications in the regulations gives companies the possibility to train their apprentices to their needs.

While there is a need for change in the structure of apprenticeships that is evolutionary in nature and can be dealt within the existing system, the experts and stakeholders interviewed in the context of this research see a need for more substantial change in continuous training. A chance lies in the further connection and cooperation between apprenticeships and further education and continuous leanrning. According to stakeholders, the seperation between initial and further vocational education and training has become increasingly obsolete.

One interesting trend in this context has been the rapid increase in the number of dual academic courses. According to the interviewed stakeholders, this reflects the increasing need for highly qualified personnel in the manufacturing as well as other sectors. However, the stakeholders also highlighted that dual academic courses are not a part of the VET or even the apprenticeship system and thus they do not reflect the tripartite principles of governance and practice. While stakeholdes acknowledge the positive aspect of dual academic courses as a complementary element of the VET system, they also stressed that there is a need to develop further pathways such as higher apprenticeships that lead to EQF level 5-7 degree within the VET system.

Many of these challenges have been recently addressed by new initiatives whereby the responsible Federal Ministries as well as the Federal Institute for VET play an important role. Also the social partners as well as individual companies have developed their own initiatives in response to requirements and challenges of the VET system arising from technological change, digitalisation and Industrie 4.0.

The general structure and involvement of stakeholders have a positive influence on apprenticeships in Germany and create a chance to design a viable apprenticeship system. In relation to such a system of dual ‘VET 4.0’, this study and in particular the interviews with stakeholders revealed a strong consensus of all actors as regard to key requirements and needs for action as well as a strong degree of confidence as to the ability of mastering the transition.

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Annex 1: Glossary

Abbreviation	Original term	English translation/explication
AV	Ausbildungsverbünde	Joint Vocational training
BaE	Berufsausbildung in außerbetrieblichen Einrichtungen	Off-the-job vocational training
BAVC	Bundsarbeitgeberverband Chemie e.V.	Federal Employers Organisation Chemical Industries
BDI	Bundesverband der deutschen Industrie e.V.	Federation of German Industries
BIBB	Bundesinstitut für Berufsbildung	Federal Institute for Vocational Education and Training
BBiG	Berufsbildungsgesetz	Vocational Education and Training Act
BITCOM	Bundesverband Informationswirtschaft, Telekommunikation und neue Medien	German Association for Information Technology, Telecommunications and New Media
BMAS	Bundesministerium für Arbeit und Soziales	Federal Ministry of Labour and Social Affairs
BMBF	Bundesministerium für Bildung und Forschung	Federal Ministry of Education and Research
BMWi	Bundesministerium für Wirtschaft und Energie	Federal Ministry for Economic Affairs and Energy
Cedefop	Centre européen pour le développement de la formation professionnelle	European Centre for the Development of Vocational Training
ICT		Information and Communication Technology
IG BCE	Industriegewerkschaft Bergbau, Chemie, Energie	Trade Union for the Mining, Chemical and Energy industries
IG Metall	Industriegewerkschaft Metall	German Metalworkers' Union
KMK	Kultusministerkonferenz	Standing Conference of Ministries of Culture
VDMA	Verband Deutscher Maschinen- und Anlagenbau e.V.	Professional organisation in the machine and tool making sector
VET		Vocational education and training
LFS		Labour force survey
ÜBS	Überbetriebliche Berufsbildungsstätten	Industry-wide vocational training centres
ZVEI	Zentralverband Elektrotechnik und Elektronikindustrie	Association of the Electrical Engineering and Electronics Industry

Annex 2: List of consulted national stakeholders and experts

Type of organisation	Name of organisation	Position
Ministry responsible for VET	BMBF	Head of Department Vocational Education and Training
Employer organisation	Gesamtmetall	Head of VET Department
Trade union organisation	IG BCE	VET expert
VET expert /research institute	BIBB	VET expert on effects of digitalisation
VET expert /research institute	BIBB	Apprenticeship expert / comparative analysis