Country Profile Germany

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Präambel:

Wir schreiben im Folgenden in der maskulinen Form, und zwar ausschließlich wegen der einfacheren Lesbarkeit: Wenn beispielsweise von Mitarbeitern die Rede ist, meinen wir selbstredend auch Mitarbeiterinnen.

Empfohlene Zitierweise:

GAUSEMEIER, J.; KLOCKE, F.: Industrie 4.0 – Internationaler Benchmark, Zukunftsoption und Handlungsempfehlungen für die Produktionsforschung. Paderborn, Aachen, 2016

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Summary

Germany is bringing engineering excellence to the digital world: Industrie 4.0 as a visionary holistic concept considers integrating the needs of **technology**, **society**, and **industry**. **Smart manufacturing solutions** are **intended** to increase **collaboration productivity** and **reduce transaction costs** in **design and manufacturing**. Some companies have set up **testbeds** in operative production to observe innovation potentials of Industrie 4.0. However, most companies are **still figuring out business cases** for using Industrie 4.0. As **standards are lacking** in solutions, companies still **fear their investments will not be sustainable**. Large companies and some SMEs are **investing to offer high-end Industrie 4.0 solutions** on the **worldwide market**, especially on **shopfloor technologies**. **Industrie 4.0** has been **pushed by the government** as a concept and is **becoming a global brand**, mostly in Europe and Asia.

Highlights

Technology Overview

Core product functionalities are **engineered**, **manufactured** and mostly **assembled in Germany**. **Core competencies** exist mainly for **hardware solutions of production facilities**. **Differentiation** is done through product **individuality** and **quality**.

Importance of »production«

Production is perceived as a **high-technology field** and is **successfully retained domestically**. »**Made in Germany**« is a **selling point** even in the **domestic markets**. **Payment is high** and **working conditions** in production are on very **high level**. The power between **industry**, **politics** and **unions** is **balanced**.

Training and Qualification

The **dual education system** is a strong advantage by focusing on qualifying **for practical needs of industry**. **Interdisciplinary** experts in the field of **mechanical/ production engineering and management** are valued.

Map

Industrie 4.0 in Germany

Drivers/ Challenges

Drivers

- **Fear of disruptive changes** affecting the core competencies of manu-facturing industry in currently leading markets
- Demand for **personalized** and **individualized** products (lead to realizing lot size one at mass production costs)
- **Increasing global competition** pushes efforts to reinforce attractive-ness and competitiveness of production in Germany

Challenges

- Focus on ➡ safety and continuity in ➡*business models* can **constrain a fast adaption** to upcoming needs for new business models
- **Concerns about data privacy** hinder the appliance of data collection and analysis solutions as well as progresses in the con-sistency of data
- High complexity of products and excel-lence in engineering **hinder the entrance** to growing markets for production systems with lower requirements

Key Stakeholder

- **The Association of German Engineers (VDI)** – »Referenzarchitekturmodell Industrie 4.0 (RAMI4.0)«
- **Major industry associations forming the Plattform Industrie 4.0** – German Engineering Association (VDMA), German Electrical and Electronic Manufactures´ Association (ZVEI), Federal Association for Information Technology, Telecommunications and New Media (BITKOM)
- **National Academy of Science and Engi-neering (Acatech)** – Facilitator of dialog on establishing initial guidelines for Industrie 4.0
- **Federal Ministry of Education and Research (BMBF)**
- **Federal Ministry for Economic Affairs and Energy (BMWi)**
- **Siemens** – Division Digital Factory
- **Bosch** – Internet of Things and Services
- **Festo** – Future Manufacturing
- **Beckhoff** – New Automation Technology based on Smart Factory concepts
- **Wittenstein** – Innovation Factory Industrie 4.0
- **SAP** – Open Integrated Factory Industrie 4.0
- **Fraunhofer Society** – E3 Production
- **RWTH Aachen University** – Cluster of Excellence »Integrative Production Technology for High-Wage Countries«
- **Universität Stuttgart/ Fraunhofer IAO** and local industry partners - Allianz Industrie 4.0
- **It´s OWL** – Regional Cluster for Intelligent Technical Systems

Key Approaches

Industrie 4.0
Landmark program of the German government »Hightech Strategy« carried out by BMBF to promote the digitalization of the manufacturing industry with focus on increasing the efficiency in production systems. Supported by select funds by BMWi (Autonomics for Industrie 4.0).

Smart Service World
Landmark program of the German government »High-tech Strategy« carried out by BMWi to encour-age R&D-activities for smart services across broad industry segments supported by innovative ICT.

Plattform Industrie 4.0
Project of BITKOM, VDMA and ZVEI and leading German companies to develop Industrie 4.0 in industrial processes, production and logistics as well as giving strategic guidelines for implementation. By April 2015, the platform is transferred to a shared platform of politics, industry, industry associations, research and unions, led by both BMWi and BMBF, and further repre-sentatives of the stakeholders.

Siemens Digital Factory
Seamless integrated hardware, software and service solutions for manufacturers focusing on flexibility and efficiency in production.

Bosch: Internet of Things and Services
Software platform offering core functionalities of Internet of Things to users, companies, partners of companies and physical devices.

Fraunhofer E^3 Production
Landmark project of Fraunhofer Society aiming at realizing an efficient, emission-neutral and ergno-mic production by a holistic research of ergonomic integration of humans into production processes.

Technology (1/2)

Overview

Differentiation through product individuality and quality. **Increasing productivity** through collaboration of humans and machines is seen as a main objective of ▸*Industrie 4.0*. **High quality standards**, **resource efficiency and automation solutions** rank first in production. Companies, even SMEs, are **strong** in **managing high product complexity** and **variety**. The **degree of domestic value-added** is **extremely high** despite globalized supply chains. Thus, Germany is also a **large market for application of high-end production systems** (e.g. automation solutions). **Core product functionalities** are **engineered**, **manufactured** and mostly **assembled** in Germany. **Focus** is on **hardware solutions rather than on software technologies**. Research on **basic production technologies** and **production management** is **highly valued** as well as working in a production-oriented company. Universities, research institutes and companies cooperate intensively and initiate **application-oriented research** mostly driven by applied research institutes (e.g. Fraunhofer). However, **ICT is not a strength of German suppliers**. ▸*Industrie 4.0* is **economically aimed** at **decreasing the efforts in engineering and production** through **virtualization** and **realizing lot size one at mass production cost**.

Security

➨***Security*** is a »**hygiene factor**« – **production systems** are **expected** to be **safe**. Industrial security is seen as a **big challenge** for **implementing** ▸*Industrie 4.0* in **factories**. Security **concerns prevent** mainly SMEs from **investing** in production facilities that are connected to the internet. Despite these security concerns, especially **SME´s price sensitivity** for more secure systems is **high**. **Emergency management** has **not** been **implemented** by more than half of SMEs. **Public** and **industrial research** activities as well as several efforts in **standardizing** and **regulating the minimum requirements** for industrial security are undertaken but **implementations** are **still rare**. There is a **lack of people qualified** in **industrial security** because **computing departments** of companies are rather **specialized on Office IT** than on **security of production facilities**. **Companies´ views** in industrial security are **reactive** - the **awareness of security risks is driven by incidents**. **Many companies** already had **production failures due to security issues**. However, reporting obligation of invaders is planned for critical infrastructures (»KRITIS«). **Trust** in data security of **German IT security solutions** is high due to its **internationally valued data protection laws**.

Standards, Migration and Interoperability

Standards are seen as a **big challenge,** but **solutions** are developed **nationally. Standardization** is **formalized** and **mostly driven** by **regulations** of **industry associations**. **Many committees** are dealing with standardization in context of ▸*Industrie 4.0*, but **progress is slow**. However, due to Germany’s **industrial strength** and **traditional strong technical standardization processes**, standards in manufacturing are often **adapted by other countries**. Germany released the first **worldwide standardization roadmap** for ▸*Industrie 4.0* (»Deutsche Normungs-Roadmap Industrie 4.0«). In 2015, a ➨***Reference Architecture*** **Industrie 4.0 (RAMI 4.0)** was published to have a conceptual framework of **a step-by-step migration to new production systems**. **Few companies built up smart factories** on **greenfield** to **test innovation potential** (e.g. ▸Wittenstein) as well as **some universities operate testbeds** (e.g. Demonstration Factory of ▸Aachen University). However, due to structure of existing production facilities a **roll-out of scale** will be done by **migration**. **Proprietary standards** are strongly **linked** to the ➨***business model*** of **providers**. **Opening** ➨***interface standards*** is just done where there is **no technical differentiation** or a **specific business potential**. Companies are **hesitant in opening standards consciously to innovate** their proven ➨***business models***.

Technology (2/2)

Sustainability

Sustainability is a **strong driver** for **implementing smart production systems** due to expected increased **resource efficiency**. The **awareness** of sustainability aspects in **politics**, **society** and **industry** is **high**. **Environmental regulations** are **strict**. Sustainability **efforts** are also driven by **society demands and public relations**. As Germany has almost no **natural resources**, **recycling in production is a necessity** and **becoming an increasing domestic source of resources**. **Waste management regulations** for **hazardous materials** are particularly **strict** causing companies to look for **innovative solutions to reduce their usage**. **Shifts** in **national energy strategy** will lead to **rising energy costs** in the **mid-term**. Currently, **energy efficiency** is **less of a driver** as **energy for industry is subsidized**. **Public opposition** to potentially environmentally hazardous technologies leads to **uncertainties in energy supply** (e.g. nuclear energy, fracking, high distance power lines).

User friendliness

Use of technology is centered around the human. **Focus on ergonomics** is driven by awareness of **demographic change** for years. Thus, **ergonomic production systems** are **researched** and **applied** on a **high-end level**. Additionally, one focus of the ▸*Industrie 4.0* is on **enhancing work on shop floor** even in **higher age**. User friendly **concepts** for production systems are researched to enable even the **shop floor worker** to make **more and better decisions**. **Expertise** in the field of **industrial robots collaborating with humans** is **very high**. Further, **collaborating industrial robots** are **already used**, especially in the **automotive sector**. Several research institutes are closely cooperating with the main manufacturers and users. Consideration of **usability design concepts for** ➨***application software*** **is weak**. There is a **lack of knowledge** in this interdisciplinary field. The **competence** is rather seen in **competing countries** (e.g. U.S.). The majority of companies **do not use or rarely use smart mobile devices** in production. The awareness of the **importance of industrial design aspects increases**, as seen in a high number of industrial design students.

Collection and Analysis of Field Data

Data is collected extensively in production lines, but just a small fraction is used efficiently. German suppliers have **strong competencies** in **production-specific sensor technology**. **High-end** ➨*sensors* are **researched**, **developed domestically** and **exported**. **Industry** sees enormous **potential** in using sensor technologies as a technological driver for ▸*Industrie 4.0*. **Politics** tries to protect population against excessive data collection.

Material and Information Flow

Germany is global leader in offering ➨***intralogistics*** **solutions**. **Intralogistics** is seen as a **non-value-adding process** which **needs** to be **optimized as much as possible**. Thus, mature systems are **already used in productive operations**. Additionally, several **research projects** work on the development of **new intelligent transport systems**. The **focus is mainly on hardware solutions**. **Competencies** in **industrial IT** is **high**, but there is a **lack of radical innovations**. Germany has **strong suppliers specialized in IT solutions** for **management and business processes** (e.g. SAP) as well as **core competencies in virtualizing manufacturing processes** and entire factories. The **material flow on shop floor level** is a major strength of suppliers and users. **SMEs** want **open interface solutions** for a **single source of truth** and **connection of processes**. However, **closed interfaces** are **still the norm**. Especially **SMEs** are **dependent** on **standard software solutions** while larger companies are developing software solutions for their own requirements. The **lack of** ➨***interface standards*** between different **software solutions** and **machine control systems** and concerns about **data** ➨***security*** constrain implementation.

People

Overview

***Industrie 4.0* focuses on the human rather than on technology.** The majority of **companies** in the production sector are **committed** to **society**. Unions have a **strong influence** in **larger companies**. Many **SMEs** are still **family-owned** with a high awareness of their **responsibility** for their **workers** and the **region** where they are located. The ***Industrie 4.0* strategy** was influenced by unions in an **early stage** and aims at using **smart technology** as an **enabler** to **innovate workplaces in production**. Enabling qualified workers to **make more complex decision**s assisted by smart technologies even on **shop floor level** is focused, as opposed to simplifying tasks to reduce the need for qualified workers in production. Most **shop floor workers** have a **higher qualification than the job requires**. Further qualification besides the job is common especially for young workers. However, **job opportunities are insufficiently available** for **higher qualification level**. Thus, there is a **demand in domestic companies** to **increase qualification requirements even on shop floor level**. **Health** and ***safety* protection** at **workplace** have developed to a »**hygiene factor**« because of **high-level standards**.

Training and Qualification

The **quality of education** is an **advantage**. **Technical-oriented education is highly regarded in society**. **German engineering universities** have a **high international reputation**. The transition from school to work is seamless, due to the **dual education system**. **Universities of Applied Science (FHs)** are focused on **qualifying students for practical needs of industry** while **traditional universities** are doing **basic and applied research** in **cooperation with industry**. **Professional training** of employees is **valued** and often done by company-internal training centers. **International talent** is of growing importance due to a **shortage of engineers** (mainly electrical engineers) especially **affecting SMEs**. **Interdisciplinary** study focuses on **connecting mechanical with electrical engineering or management**. Study courses in **production engineering** and **production management** are **popular** as career opportunities are at high level. **Computer science** is a natural science and taught very theoretically. There is a **lack** of **interdisciplinary-qualified engineers** in the subjects of **mechanical/ production engineering** and **information technology**.

Implementation of »Production«

Production has a good image. »**Made in Germany**« **is** a **global brand** and ***Industrie 4.0*** is **becoming** a **global brand**. **German production industry** is **high valued** by **society and politics, and has a high-tech reputation. Manufacturing contributed highly to rising prosperity** in the last decades. The **majority of jobs** are directly or indirectly **dependent** on the **production industry**. **Working in production** is regarded **positively** in society due to **high payment** and **good working conditions**. Despite the strong influence of unions on industry and working conditions, **power** between **industry** and **politics** is **balanced**. **Unions** are **actively participating** in the development of the ***Industrie 4.0* approach**. **Managing boards** of production-oriented companies are dominated **by engineers**. Even **SMEs** in the **production sector** are **global market leaders in technological niches**. **Exceptional quality awareness** and the high level competence in machinery and plant engineering increases willingness to pay more for German products.

»Pioneering Spirit«

The loyalty of employees towards their employer is high. **Employees** have a **strong identification** with their **work** and the **products** their company is producing. Many **employees** stay a **long time** in the **same company** and **avoid job changes**. Being **risk-averse** and **fear of financial insecurity** are **predominant**. **People prefer** to be **employed** at a **secure workplace** rather than to be self-employed and take financial risks. Positive aspects like turning own ideas into reality or self-determination are recognized and valued. But due to the **low acceptance of failure**, especially as an entrepreneur, the **fear to fail** is a main **barrier to found a company**. Employees are **motivated intrinsically** and are **goal-oriented** rather than process-oriented. However, **management is often consumed by day-to-day business** and, thus, **losing big-picture awareness**. **Acceptance** of **developing technologies** is **low** until **technologies are mature**. Thus, technologies are developed to full **maturity** before being **introduced to the market**. **Functionality** and **performance** are **more important than simplicity for acceptance of technology**.

Organization

Overview

Family-owned SMEs take a long term vision on innovation. The **broad basis of SMEs** pursues to become **and remain lead-suppliers in highly specialized niche markets**. **Companies focus** on their **strategies** and **markets**, but **keep broad portfolio** of **competencies** and **technologies** to address them. Companies have a **great confidence in the legal system** and protection of **intellectual property on a national basis**. Companies, even SMEs, **protect their products and processes with patents** as this way of protection is seen to be **fast** and **cost-efficient**. **Automotive, machinery and plant engineering** are the sectors with the **highest number of patents**. The patent system is considered a **driver for innovation activities** of SMEs.

Business Model

Incremental innovations are **predominant** rather than disruptive changes. German companies focus on ▪ ***safety* and continuity** of their business models, **constraining fast implementation**. Business models are made **too complex** and thus **less successful**. Besides that, **risk-averse business cultures** lead to rare **investments in new business models**. Companies traditionally prefer **technology push strategies** rather than market pull strategies. **Technologies** are often developed first before thinking about how to **create value for customers**. ▪ *Business model innovation* and service innovation are seen as **major weaknesses**. However, companies realize that in context of ▸*Industrie 4.0* radically new ▪ *business models* are paramount, even for B2B sectors (e.g. suppliers of production facilities). But **service innovation** has still **less reputation** than technology innovation.

Corporate Culture and Flexibility

German companies are still **structured hierarchically**. This especially applies to the broad basis of automotive OEMs. The mindset of **companies' management** is often **visionary** and **innovative**. However, there is a **lack of innovation culture** on **operational level**. As the market is strongly characterized by automotive industry, the **innovation cycles are mid-term to long-term** while **comparable countries** with focus on **consumer electronics** adopted a **higher innovation speed**. **Less experiences** in **development of IT solutions** which have shorter innovation and product lifecycles are a restraint for companies to supply smart manufacturing solutions. **Flexible work hours** and **large vacation periods** lead to a **good work-life balance**. However, especially young **employees demand** more **involvement** in the **design** of **working time models**.

Internationality

Skill- and competence-intensive parts of the value chain are done nationally. When **German companies shift** their **production into** the **sales market**, **competencies**, **production concepts**, and **important manufacturing steps often remain** within the **responsibilities of the German headquarter**. **R&D activities** are mostly **done domestically**. **Strength of German suppliers** based on the **processing of procured materials** and **electrical components** to **complete** ▸***Industrie 4.0* solutions**. The vast **majority** of **machinery and automation technology produced in Germany** is **exported**. English skills are required and companies set **English as corporate language**. However, even large companies are **still not able to consistently document processes in English unified for global production plants**.

Business Environment

Overview

Application of smart manufacturing technologies in factories is still rare. Governmental support and joint projects of research organizations and industry **push the development** of smart manufacturing technologies. **Pilot approaches** both from **industry** and **academia** are operating and developed but **target** »**low-hanging fruit**«. **Some SMEs** are **strongly involved** in these **pilots**. However, outside of landmark projects **SMEs rarely apply** ▸***Industrie 4.0* solutions** while large companies **more frequently** im-plement smart manufacturing solutions in their factories. Many companies have **difficulties** to **interpret** ▸*Industrie 4.0* in context of **their business**. ▸*Industrie 4.0* is a **very broad field** of possible **applications** and **technologies**. Companies have no information basis to see specific **benefits** which **restrain** espe-cially **SMEs** from **investments** in relevant technologies. Thus, **best practices** and **specific business** cases are demanded. Domestic suppliers see the **improvement of production effi-ciency** as a main objective, but **suitable IT solutions** and **capable** ➨***business models*** are **missing** in order to implement the ▸*Industrie 4.0* concept holistically.**of patents**. The patent system is considered a **driver for innovation activities** of SMEs.

Political Will and Restrictions

German government has **accepted** the ▸***Industrie 4.0* concept** as its own and **massively pushes the concept internationally**. ▸***Industrie 4.0* has become a global brand**. Overall **aim** is to **strengthen** the **competitive position** of production industry by **increasing collaboration productivity** of companies through **smart technologies**. Industry associations (▸*BITKOM,* ▸*VDMA,*▸*ZVEI)* established a committee with the involvement of most relevant German companies, the ▸*Plattform Industrie 4.0*, to work out speci-fic actions for applying the ▸*Industrie 4.0* approach to industry. **Results** are just **lacking** except from **general recommendations for actions**. ▸***Industrie* 4.0 is seen as a national challenge**. **Assignment of responsibilities** between the **Ministry of Economics** (▸**BMWi)** and the **Ministry of Research and Education** (▸**BMBF**) are not clearly defined. **Companies** demand **actionable recommendations** and are currently **unable to derive business cases for the specific application of** ▸***Industrie 4.0***. ▸*BMBF* and ▸*BMWi* are funding ongoing **research projects** (e.g. on tools management, productions device net-working, localizing objects in production). **Projects** are **tendered to open calls on specific target**. Re-search programs **persist government changes**. The **process between calls for proposals and ap-proval** is seen as being **too slow**.

Access to Capital

Consortial research and contract research is very common. **Technology transfer to industry** is considered as **very successful**. **Universities, applied research-oriented institutes** (e.g. Fraunhofer Society), and **companies** are closely cooperating. The research budget provided by the government **is strongly focused on application-oriented projects**. **Basic research has been disregarded** in the past. The **ratio of public investments** in **production-related research to GDP** is one of the **highest globally**. **Few industrial R&D expenditures, in select strategic areas**, are supported by **public fund-ing**. However, **EU funding for SME innovations aims to change this**. The availability of ➨***venture capital* (*VC*)** from non-institutional market participants is **low**. **VC** is mainly available for **less capital-intensive segments** (e.g. IT, E-Commerce). **Lack of capital** is a **main obstacle for innovation** espe-cially for **SMEs and start-ups**. **Infrastructure** of **public-owned banks** to provide **loans** with attractive conditions exists especially for **SMEs**.

Access to Markets

Companies **sell** and **procure products world-wide**. **Production** is **mainly domestic and outsourced** on **strategic reasons** rather than on cost issues**. Procurement markets** are chosen globally based on **quality and reliability** of **products**. However, mostly **regional suppliers are available**, specialized on the quality needs of larger companies. **Regional clusters** are very well **built up to increase** the **value added** of **participating companies**. Many **SMEs** are »**hidden champions**« and sell to technological **market niches globally** rather than just supplying domestic OEMs. Thus, companies are **dependent** on **exporting** products because the domestic market is not big enough. **Public facilities in all important selling markets** provide support to German companies (e.g. German Chamber of Foreign Trade, AHKs). **Joint ventures** are only taken into consideration if the **market access is not possible otherwise**. The **market share** of German products in **emerging countries** is **rapidly decreasing**. **Emerging countries** have **increased ability** to provide **own mid-end products** competing with German products. **Access to Asian markets is difficult** for German suppliers because business often depends on local distributors. In contrast, **access to the European market is very good**.