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'Industrie 4.0': Will German Technology Help China Catch Up with the West?

Road map for tomorrow's industry. Germany is China's preferred partner. Intensified co-operation coupled with great risks.

by Jost Wübbecke and Björn Conrad

MAIN FINDINGS AND CONCLUSIONS

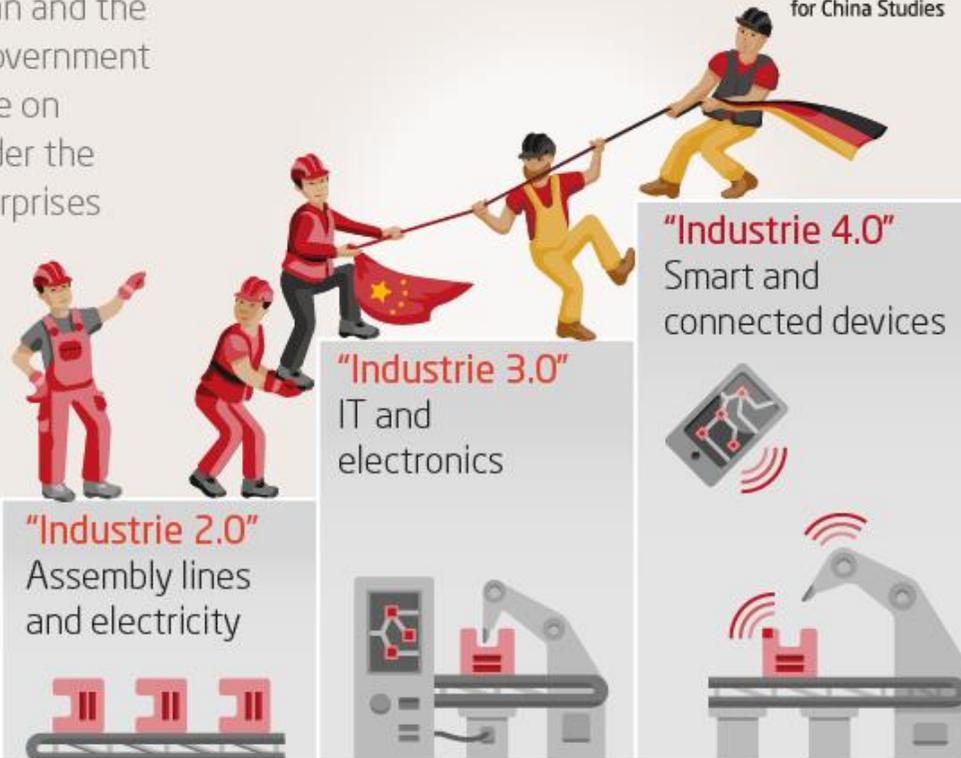
- First we saw the advent of the steam engine, then the assembly line, followed by industrial robots. Now, intelligent manufacturing is heralding the beginning of the fourth industrial revolution. The **rise and fall of enterprises and entire national economies** will hinge on making 'intelligent factories' a reality.
- China is absolutely determined to jump on this bandwagon. There is no time to spare: increases in wages portend the end of the low-wage era. **China wants to utilise digitisation to enhance efficiency and quality and to draw level with leading industrialised nations.**
- Germany is China's preferred partner: the German concept of 'Industrie 4.0' serves as a guideline for the Chinese government. Germany has the advanced technology needed for 'Industrie 4.0'. **Demand from China offers German sellers unique sales opportunities.** The time window is limited, though, as German firms are likely to be edged out as soon as Chinese companies close the technology gap.
- **Germany's co-operation with China will strengthen Chinese competitors.** In general, it will take decades for China to draw up with Germany. However, several large Chinese corporations (Sany, Haier, etc.) will jump forward with the aid of 'Industrie 4.0'. Chinese industry **will quickly become digitised in any event** – if not with German assistance, then with products made by other international competitors.
- The greatest danger to co-operation with China is the loss of sensitive data in China. **State data control and its use as an instrument of protectionist industrial policy are destroying the foundation for working together.** Under such circumstances, exchanging data with Chinese partners and suppliers is virtually unthinkable.
- Data security in China cannot be universally guaranteed. Specific co-operation between Chinese and German companies may offer a way out. Together, the partners would need to find a way for protecting their joint technological advances towards the outside while fairly sharing the associated returns on the inside. **German companies must define clear terms and conditions for these partnerships.**
- German market leaders (SAP, Siemens) should first test the market. They have the capacity to monitor risks more closely than smaller companies. On the other hand, for medium-sized companies experiencing problems in protecting their technology, **the loss of know-how can quickly become a threat to their very survival.**
- Co-operative pilot projects will shed light on the opportunities and limits imposed by in-depth co-operation and reveal starting points for political support. This should serve as the basis for a **co-ordinated strategy pursued by both German politics and industry.**

"Industrie 4.0" in China

Does Germany strengthen its competitors?



The German and the Chinese government agree to cooperate on "Industrie 4.0" under the leadership of enterprises



1 Connected industry – the fourth industrial revolution will decide the rise and fall of enterprises

In Hall 18 at Sany (三一重工) in Changsha, central China, the factory of the future has already become a reality. China's largest manufacturer of machinery produces asphalt machines and concrete mixers here. The factory is filled to the brim with electronics: the machines are linked together and continuously gather data on the production process. The position of workpieces and supply units can be invoked at any time. Sany uses the information gathered to optimise production. This has brought the company closer to achieving its goal of having a self-organising and constantly self-optimising 'intelligent factory'.

The more flexible and efficient manufacturing brought about by the internet of things represents a fundamental change. The potential for efficiency and productivity entailed by this is so great that it represents the dawn of the fourth industrial revolution. How these new opportunities are used will decide the rise and fall of companies and presumably of entire national economies in the next decade. **If anyone expects to survive in globalised markets, they will have to make the transition to the**

world of intelligent and connected manufacturing.

Governments and companies round the world are therefore working feverishly to implement advanced digitisation of their industries and to use new information and communications technology (ICT) to make them more efficient, productive and flexible. The German government has launched 'Industrie 4.0', a long-term project to keep German industry competitive in the future (see info box).

2 Germany is China's preferred partner for the industry of tomorrow

China is also working at full power on the digitisation and intelligent manufacturing of its own industry. The country's starting point is at a considerably lower technological level, however. Nonetheless, the pressure is enormous as China's days as a low-wage country are numbered. The government is running out of time to restructure the Chinese economy, and industrial digitisation offers a unique opportunity to do so.

Germany is China's preferred partner. The German project referred to as 'Industrie 4.0' fits into China's strategy quite well. Germany offers cutting-edge

technology in this sector. China wants to learn from Germany how to prepare its industry for the future.

Since October 2014, 'Industrie 4.0' has been a prominent part of the German–Chinese Innovation Partnership.¹ Nevertheless, representatives of German industry fear that the co-operation will primarily strengthen Chinese competitors. Is the German–Chinese co-operation within 'Industrie 4.0' a unique opportunity or a drastic mistake?

3 China's industry to date is hardly automated and digitised at all

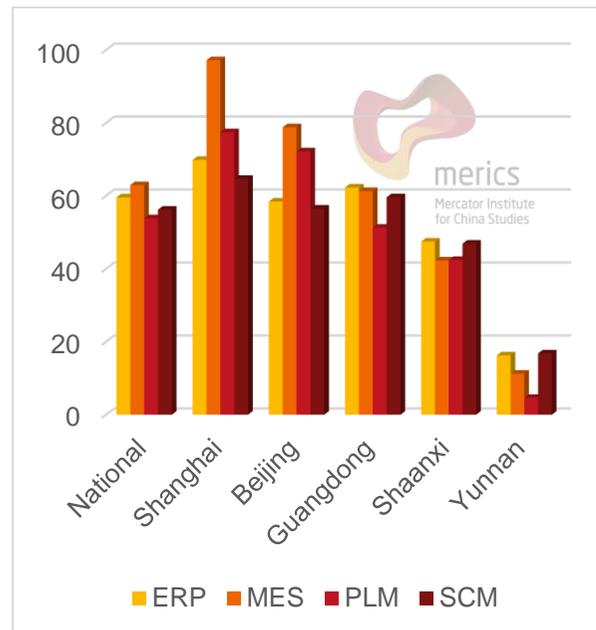
Even in Germany, 'Industrie 4.0' is a vision of the future. However, intelligent manufacturing is clearly even more remote for China's industry – it is currently only in transition from 'Industrie 2.0' to 'Industrie 3.0'; progressive factories such as Sany's Hall 18 are absolute exceptions here. On the whole, Chinese manufacturing is only automated to a limited extent and is hardly digitised at all. Only about 60 per cent of companies use industrial software such as Enterprise Resource Planning (ERP) and Manufacturing Execution systems (MES) (see Figure 1). At present, there are only approximately 14

industrial robots per 10,000 factory workers in China, as opposed to 282 in Germany.

Industrie 4.0 – a concept made in Germany

Among experts in Germany, the term 'Industrie 4.0' has become synonymous with the industry of the future. Since the first industrial revolution by steam power ('Industrie 1.0'), manufacturing has undergone continuous further development. At the beginning of the twentieth century, mass production on the assembly line became the standard practice ('Industrie 2.0'). 'Industrie 3.0' began in the 1970s with the advent of robots and programmable logic controllers (PLC). This stage is still defining manufacturing today. The next step of industrial development is characterised by **intelligent and connected machines and workpieces, augmented reality, cloud computing and big data** ('informatisation'). Machines in 'Industrie 4.0' work, make decisions and optimise largely autonomously in collaboration with humans. Production processes become more flexible, transparent and efficient. Customers can feed their own wishes into the production of individualised bulk goods (mass customisation).

Figure 1: Distribution of industrial software (2014, in per cent of companies). PLM = Product Lifecycle Management, SCM = Supply Chain Management. Source: MIIT 2015.



4 With Industrie 4.0, China wants to catch up and take the lead internationally

However, this snapshot must not be allowed to obscure the view into the future: a major turning point in the Chinese economy is at hand. Economic growth is slowing down and wages are increasing. The old model of cheap mass production does not work any more. What China needs in order to have continued economic success is greater efficiency and quality achieved by technological advances. China's plans for its industrial development are long term and ambitious: **the Chinese government envisages making China an 'industrial super power' (工业强国) that can hold its own with the leading industrialised nations.**

From the Chinese perspective, this goal is anything but a remote utopia: according to an unpublished study by the Chinese Academy of Engineering (CAE, 中国工程院), the PRC could be on an equal footing with the USA, Germany and Japan as a progressive industrial producer by 2045.²

Digitisation is the fitting stepping stone for China. By Chinese estimates, Industrie 4.0 could increase China's productivity by 25 to 30 per cent and lower unforeseen production losses by 60 per cent.³

A new production era is already dawning in China: investments in automation and digitisation there are skyrocketing. Investments in IT by the manufacturing industry have doubled since 2005.⁴

Meanwhile, China has become the world's largest market for industrial robots. Most of the world's industrial robots will be in use there as early as 2017.⁵ The sellers' markets for radio chips (Radio Frequency Identification, RFID), sensors and embedded software systems are booming.

While this trend is initially leading China into Industrie 3.0, the first steps towards intelligent linkage have already been taken: Industrie 4.0 experiments have long since begun, especially in large Chinese companies.

5 China's government heavily supports the digitisation of industry

China's government is rushing forward headlong. It is currently pulling out all the stops of industrial policy for rapid industrial modernisation. Support by the state is much more comprehensive than in Germany.

In 2007, the government had already developed a strategy for the digitisation of industry. The Ministry for Industry and Informatisation Technology (MIIT,

工业与信息化部) is pursuing the most important strategy in this area, namely the 'integration of industrialisation and informatisation' (aka the 3i's, 两化融合).⁶ The 3i strategy aims at digitisation technologies in Industrie 3.0 and merely contains the first few steps towards Industrie 4.0.

In addition, the state promotes the digitisation of the industry with elaborate support programmes relating to the Internet of Things (IoT, 物联网), robots, intelligent manufacturing systems (智能制造装备), cloud computing or the transformation and upgrading of industry (工业转型升级).

The central government, provinces and cities are all supporting the implementation and expansion of IT by providing several thousand companies with large sums of money. In 2013 and 2014, MIIT supported approx. 720 pilot companies this way. Numerous experiments on a local level have been added (see Figure 2). Chongqing, for example, is supporting the digitisation of automotive suppliers and equipment manufacturers with a fund of 40 million CNY. Qingdao wants to strengthen the international position of Haier and Hisense (海信) by investing in the manufacture of household appliances.

Figure 2: Selected local '3i' funds (专项资金)
(* funds for overall digitisation)⁷

City/Province	Fund scope (in million CNY)
National	100 (only 2013)
Chongqing	40
Nanjing	40
Qingdao	30
Shenyang	100
Henan	80
Ningbo	100*
Zhengzhou	30 (per annum)

Nanchang (Jiangxi province) is building an industrial park for digital and intelligent manufacturing in aerospace technology (南昌航空城两化融合创新产业园) with an investment volume of 80 million CNY.⁸ State sponsorship is comprehensive and covers all branches of industry. However, it focuses primarily on the aerospace industry, shipping, metal finishing, automotive manufacturing, machine manufacturing and the IT industry. Aerospace companies such as the China Aerospace Science and Technology Corporation (中国航天科技集团公司) exert particularly heavy political influence through their chairmanship of the national 3i alliance.

Viewed from the perspective of the central government, co-ordination of the various market participants appears to be difficult. Different committees are responsible for standards in automation and IT, and the individual sectors work independently of one another. But in 2014, MIIT succeeded in bringing 14 state-run associations from different sectors together and creating a voluntary quality management standard for automated and intelligent manufacturing.⁹

To date, only a few alliances of companies have been formed to digitise the industrial sector. The Alliance for Promotion of the 3i Innovation (国家两化融合创新推进联盟) was created at the beginning of 2014 under the leadership of the MIIT. This alliance has hardly appeared since then. Businesses from many sectors are represented in it, but only a few state business associations take part. Another alliance is the Chinese Robot Alliance founded in 2013 (中国机器人产业联盟).

6 China uses 'Industrie 4.0' as the timetable for tomorrow's industry

The German concept of 'Industrie 4.0' (工业 4.0) is a topical subject in China. Ever since 'Industrie 4.0' was featured at the 2013 Hannover Messe trade show, there has hardly been an article or discussion among Chinese experts on digitisation of the industry in which this term has not come up. 'Industrie 4.0' has established itself in China as the conceptual timetable for tomorrow's industry. State-run institutions such as the MIIT and the Chinese Academy for Engineering (CAE, 中国工程院) define the dialogue in this respect. The visit that PRC President and CPC General Secretary Xi Jinping paid Germany in March 2014 and Li Keqiang's notes on the "Internet Plus" strategy in March 2015 gave Industrie 4.0 in China added impetus.¹⁰

To China, Industrie 4.0 is a strategic source of inspiration. The German concept provides China with a vision and a relevant concrete developmental path on which the government can focus its endeavours. Contrary to this, the Chinese 3i strategy focuses primarily on the technologies of Industrie 3.0. To date, China has lacked a strategy that would place intelligent manufacturing of industrial

companies at the centre. Industrie 4.0 should now fill this gap.

The concept of 'Industrie 4.0' is spreading at an opportune moment in China as the Chinese government is just in the process of drafting its industrial strategy for the next ten years. Under the label 'Made in China 2025' (中国制造 2025), China is going to publish a strategy in April this year which will provide a concrete guideline for its industrial race to catch up with industrial developments in the West. 'Industrie 4.0' will foreseeably be the core element (see info box).

And yet 'Industrie 4.0' is more to China than merely a concept; it is also the heading for a comprehensive partnership that China is seeking with Germany. China wants to purchase technologies from German companies that are necessary for the 'upgrade' to stage 4.0 and in which Germany holds the lead: industrial software, manufacturing technology and system integration.

7 Digitising its industry will make China a serious competitor

Germany's co-operation with China is a risky business: if China does in fact succeed in moving forward with digitising its industry, it will become a

'Made in China 2025' (中国制造 2025): China's timetable for the industrial race to catch up

The MIIT began drafting the 'Made in China 2025' strategy early in 2014. The goal is to establish China as an industrial super power. According to the draft, China wants to transition to an industry driven by innovation, efficiency and quality, environmentally friendly manufacturing and service orientation.

At the core of this quadruple transition lies the change to a smart and connected economy ('Industrie 4.0'). At the start of the planning process, the government envisaged defining a strategy by 2020. Inspired by the German high-tech strategy, however, it decided on a longer-term strategy running until 2025.

competitor to Germany that is not to be taken lightly in the field of high-quality industrial products. **German flagship sectors such as mechanical and electrical engineering and ultimately even the automotive sector will then feel the pressure.**

The fact is that, on the whole, in spite of all its endeavours, it will take decades for China's industry to reach the level that German industry has now attained. Small and medium-sized Chinese compa-

nies are far removed from progressive manufacturing capability. Roughly half of these companies have never invested in automation and information technologies such as robots before.¹¹ Even vital industries such as the automotive sector are far removed from the international level of efficiency and productivity.

This should not lead German companies to become overconfident, though, as China does not need widespread digitisation to create serious competition; a few 'national champions' on the international markets will suffice. And these are developing at this very moment: **major corporations such as the machine manufacturer Sany or the electrical appliance manufacturer Haier (海尔) are experiencing rapid growth. In the 'Industrie 4.0' area, these enterprises are already following closely at the heels of German companies.** Telecommunications equipment supplier ZTE (中兴) increased its production capacity for smartphones in Xi'an by 40 per cent by automating and digitising its production, at the same time lowering personnel costs by half. Zeng Xuezhong, Chairman of the Board of ZTE Devices, recently stated: 'We are going to surpass Apple with [...] Industry 4.0; ZTE is very confident about that.'¹²

These are the companies that those in the West should keep an eye on. Irrespective of the rest of the industry in China, these 'champions' are set to make far more rapid technological progress and will close the gap to German companies in terms of efficiency, quality and flexibility.

8 Unique but temporary market opportunities for German sellers

Last October, China and Germany declared their co-operation in the field of 'Industrie 4.0' to be a key component of the German–Chinese innovation partnership. Major users of 'Industrie 4.0' technology such as the German automotive sector and medium-sized machine manufacturers are sceptical, however – and rightly so. China does not mince words about its goals: it intends to get Germany to show it how to make its industry competitive on a global basis. German technology will promote China's race to catch up with Western industrial development and will thus support a powerful future competitor.

But in any event, China's industry will quickly become digitised, if not with German assistance, then with the products of international competitors. Large companies such as ABB,

Cisco, IBM and General Electric are prepared and willing to supply China with the required technology. China's businesses will become more efficient and manufacture products of higher quality. German industry will have to come to terms with this. The time frame for profits is limited: Chinese companies will eventually close the technology gaps. For the time being, Chinese firms such as Yonyou (用友), a maker of industrial software, are not competitive. However, this will change over the next ten years. China's industrial policy strategies will take hold as soon as Chinese companies become competitive. **The Chinese government is effectively protecting domestic companies from foreign competition, especially in the IT sector.**

If German companies hesitate too long, they will miss the great market opportunities of 'Industrie 4.0' in China. Siemens and SAP – the German market leaders – are therefore working towards rapid involvement in China. The markets for German industrial software, cloud computing, sensors, robotics and radio chips are still enormous. At the moment, China is limping behind in all these areas, technologically speaking, and is being forced to fall back upon foreign products (see Figure 3). Due to growing demand, Kuka, a manufacturer of robots based in Augsburg, Germany, opened a new plant

in Shanghai in 2013 to secure a better position on the local market.

Figure 3: Chinese technological level in key technologies for 'Industrie 4.0'¹³

Technology	Technology-gap			Chinese companies (examples)
	Small	Medium	Large	
Sensors			●	Zhonghang Diance
Industrial software		●		Yonyou, Shenzhen
Robotics			●	Shenyang Xinsong
RFID		●		Yuanwanggu
Cloud			●	Alibaba

9 Data misuse is destroying the basis for commercial co-operation

Strengthening one's own competition is not a sound argument against co-operation. A far more serious problem is posed by the loss of sensitive data, which can go hand in hand with 'Industrie 4.0'. Intelligent manufacturing means passing on large

volumes of data. Business and value-added processes become far more transparent. Data on manufacturing processes that are subject to protection of intellectual property are stored and processed on cloud servers. Internal corporate data are transmitted to Chinese suppliers and partners. This, however, opens the doors to data espionage at the same time.

Companies within Germany are already becoming nervous at the intertwining of data streams. In China, the **increased data surveillance by the state and its use as an instrument of protectionist industrial policy is destroying the basis for co-operation.**

Data security in China cannot be universally guaranteed. Market leaders such as SAP and Siemens can largely contain these risks by relying on existing and proven co-operative ventures with Chinese partners. They are in a better position than smaller businesses to ward off the threat of a loss of technology. Under the current conditions prevalent in China, however, medium-sized companies have difficulty providing the extremely demanding protection of practical knowledge and technology that is required in 'Industrie 4.0' co-operation, both technologically and legally. A loss of technology can

rapidly become a threat to their very survival for companies just like these.

10 Strategies and options for action

Germany needs a double strategy: on the one hand, German sellers must act quickly to take advantage of sales opportunities, while on the other hand, medium-sized companies in particular need to proceed with caution to minimise risks.

One solution would be a 'pioneering' function of German market leaders, who – with political support – would set up initial pilot projects for co-operation with Chinese partners. For these specific co-operations at company level the German side would have to **define clear conditions: partners need to find ways for jointly protecting their technological advances towards the outside while fairly sharing the associated returns on the inside.** The German companies have quite a strong bargaining position in this case. The Chinese government wants this partnership with Germany at all costs and will pass this requirement on to Chinese business partners.

Medium-sized German companies could initially move in the wake of the large ones, assess the experience gathered in the first pilot projects and

weigh their individual chances against the risks on this basis. German policy can also draw upon the experience from the pilot projects to tighten specific policy-supporting measures.

On this basis, a co-ordinated political and economic German strategy could be created for the co-operation with China within the framework of 'Industrie 4.0'. Associations and German companies can work together to develop clear and practicable criteria based on their experience for technological co-operation on a corporate level and, if necessary, **exclude highly developed futuristic technologies from use in China.**

To this end, however, it would be necessary to improve co-ordination among the participants inside Germany. Up to now, both the companies and the associations (BITKOM, ZVEI and VDMA) have been preoccupied primarily with their own position on 'Industrie 4.0'. The common platform of 'Industrie 4.0' has hardly yielded any results up to now. Associations, companies and the Federal Ministry of Economics should use the approaching re-organisation of the platform to define a common procedure for co-operation with China, for instance through pilot projects involving co-operation.

Closed ranks would be advantageous for setting standards as well. China has already shown intense interest in the first German 'Standardisation road map for "Industrie 4.0"'. The industrial sectors in Germany should agree on standards quickly and jointly, even if they are not fully mature yet. **These standards could then be incorporated into the German-Chinese co-operation and potentially spread in China.** In this case, the Deutsche Institut für Normung (German Institute for Standardisation) and the Verband der Elektrotechnik, Elektronik und Informationstechnik (Association of Electrical Engineering, Electronics and IT) should seek an exchange with the National Council for Standardisation of China and the Chinese Technical Committee for Standardisation in Automated Systems and Integration (全国自动化系统与集成标准化技术委员会).

This approach – undertaking pilot projects involving bi-national co-operation – could at least partially solve the dilemma surrounding 'Industrie 4.0'. German industry would establish itself quickly as a partner of China and thus secure profits on the growing Chinese market. At the same time, the political and economic risks would be controllable for the most part.

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¹ During the third German–Chinese government consultations in October 2014, the two governments concluded the Innovation Partnership. Under the catchphrase ‘Shaping innovation together’, they agreed to intensify their work together in research and development, e.g. in the sectors involving water, urbanisation and optical electronics (<http://www.bundesregierung.de/Content/DE/Pressemitteilungen/BPA/2014/10/2014-10-10-aktionsrahmen-dt-chin-konsultationen.html>).

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¹¹ <http://www2.deloitte.com/cn/zh/pages/manufacturing/articles/transforming-from-world-factory-to-smart-manufacturing.html>

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