Who earns the gains from automation?

Industrial upgrading, productivity and labor in China

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FRIEDRICH EBERT STIFTUNG

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Content

1. Introduction

This report summarizes the results from a research project conducted by IPP Technology and Industry Research Center in cooperation with the Friedrich-Ebert-Foundation, Shanghai office in 2021. The project reviewed the productivity and employment effects of automation and digitalization of production in key industrial sectors in China. The goal of the project was to take stock of the status and impact of the so-called "Fourth Industrial Revolution", which has been promoted under key government programs such as "Made in China 2025", "Internet Plus" and most recently "Industrial Internet".

Automation of production has been put forward in China under the slogan "robot replaces men". It reflects visions of massive automation and digitalization, which would widely eliminate human labor from production and promote "workerless factories". Internationally, such views have been developed by a large number of experts predicting the "end of work", and by strategies such as "Industry 4.0" promoted by industry and government in Germany. However, the impact of such policies on work, employment and society have not been studied thoroughly, in China as well as internationally.

Against this background, a number of basic questions have to be answered:

- What has been the real impact of automation on productivity, employment and wages in core manufacturing industries in China?
- How do the specific conditions of a large emerging economy shape the development of automation and industrial upgrading?
- How has productivity been influenced by the growth of knowledge-intensive sectors and relocation of manufacturing to low-cost areas inside and outside of China?
- How can the development of productivity and wages be balanced, in order to promote better living conditions for large parts of the working population?
- What kind of policy changes are needed, especially with regard to labor markets, vocational training and the representation of workers?

Our study examines the recent decade from 2010-2019, during which industrial upgrading and automation became a key strategy in China's manufacturing sector. In order to gain a better understanding of the qualitative factors and conditions, the study develops a regional perspective. The focus is on Guangdong province, China's largest manufacturing region, where the researchers have conducted regular studies on the development of production and work in key industrial sectors for many years. The goal of the study is to better understand the conditions for developing a system of dual circulation and common prosperity in China, and to make specific policy recommendations.

2. Productivity, wages and socio-economic progress: China's uneven regime of development

During the recent decade, China's economy has shifted from rapid growth based on cheap labor and resources to a more capital-intensive pathway that relies on investment, infrastructure and the development of science and technology. Overall economic growth is still high, but the growth of productivity has slowed compared to the early years of market-based development in the 1990s and early 2000's.

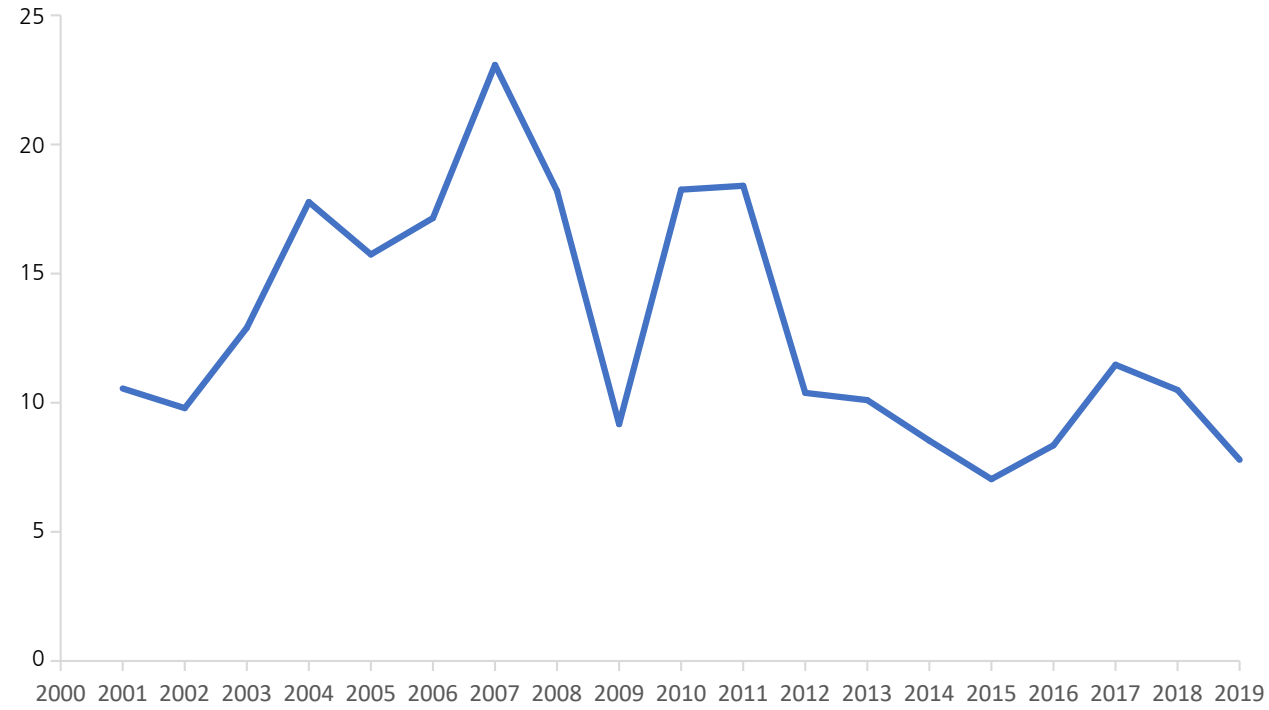
From 2010 to 2019, China's total gross domestic product (GDP) has grown around 10% per year. During previous years, growth rates had even been higher, reflecting the explosive economic development during the early 2000s. In international comparison, China's gross national income (GNI) per capita has also been growing relatively fast. In 2019, it reached US$10,410, which is classified as middle-income status. GNI even was higher than the average level of upper-middle-income countries.

However, the growth of GDP per capita has slowed continuously over the last decade and previous periods. In 2010 and 2011, when China's economy recovered from the global financial and economic crisis 2008/9, GDP per capita grew by almost 18%; similar to the growth rates in the 1990s and early 2000s. Since 2012, growth rates have been significantly lower, between 6,5 and 10,85 per cent. This reflects a longer-term slowdown in productivity development which has become a characteristic feature of China's economic development in recent years.

Most observers agree that slower productivity growth is typical for emerging economies when they reach a more mature stage of development. China's extraordinary economic growth rates in the 1990s and early 2000s were driven by heavy investment in infrastructure (mostly from government and SOE) on the one hand, and large-scale migration of rural workers at low and very

Graph 1: High, but decreasing economic growth

China's GDP growth in Percent



Source: China Statistical Yearbook

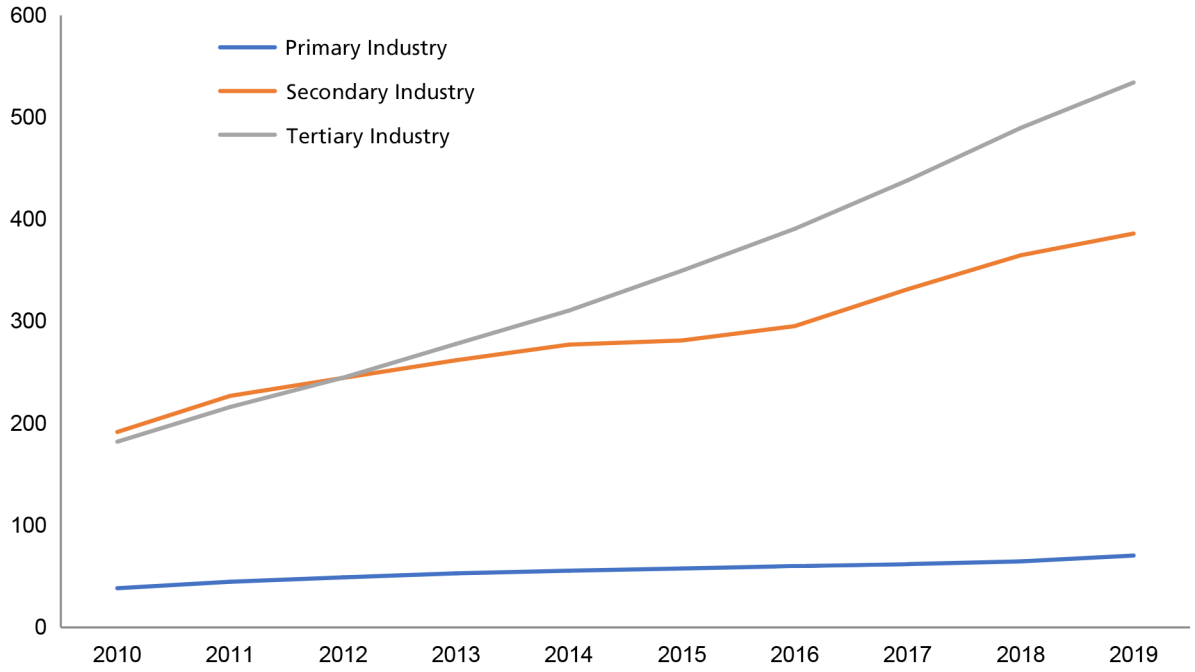
low wages on the other. Since around 2008-9, overall productivity growth slowed, although investment in infrastructure and real estate reached peak levels in the aftermath of the global financial and economic crisis[1].

At the same time, China's service sector began to grow rapidly. In 2012, the proportion of China's tertiary industry exceeded the secondary for the first time and has kept growing fast in recent years. Growth of the tertiary sector was heavily driven by real estate, which according to recent analysis accounts for almost one third of China's GDP[2].

Productivity gains from infrastructure investment only become visible over longer periods, although infrastructure provides key conditions for overall productivity growth. The service sector generally has lower productivity than manufacturing. Continuous heavy investment in real estate in particular has produced a large base of fixed capital with relatively low productivity. Overall productivity growth, therefore, can only be maintained when productivity growth in manufacturing remains significantly higher than in the first and second sectors and the economy as a whole. To achieve this goal, investment in technology, education and human resources is needed, and an overall shift towards consumption from higher wages and incomes at a broad scale.

Graph 2: Service sector outperforms general economic growth

Development of economic sectors in 100 billion yuan



Source: China Statistical Yearbook

1 Brandt, L., Litwack, J., Mileva, E., Wang, L., Zhang, Y., & Zhao, L. (2020). China's Productivity Slowdown and Future Growth Potential.
2 Rogoff, Kenneth, and Yuanchen Yang. 2021. "Has China's Housing Production Peaked?" China and the World Economy 21 (1): 1-31. https://scholar.harvard.edu/files/rogoff/files/nber_27697_peak_china_housing_1.pdf

Table 1: Imbalanced industrialization

	GDP (trillion yuan)	Employment (million persons)	Total wages (trillion yuan)
Tier 1 Cities*	12.41	66.61	3.49
Eastern Cities**	6.06	24.66	1.18
Western Cities***	5.64	37.16	0.97

*Tier 1 Cities include Beijing, Shanghai, Guangzhou and Shenzhen
**Eastern Cities include Suzhou, Hangzhou, Nanjing, and Ningbo
***Western Cities include Chengdu, Chongqing, Xi'an, and Kunming

Source: China Statistical Yearbook, Guangdong Statistical Yearbook, Zhejiang Statistical Yearbook, Jiangsu Statistical Yearbook, Sichuan Statistical Yearbook, Chongqing Statistical Yearbook, Shanxi Statistical Yearbook, and Yunnan Statistical Yearbook.

There is widespread consensus that economic rebalancing towards consumption-driven growth has not really taken place in recent years. The consumption share of China's GDP remains extraordinarily low. It declined from roughly 50% in the 1990s to less than 40% in 2010 and has remained so since[3]. Obviously, this reflects the continuing overweight of fixed capital investment in China's growth, and the persisting inequality in income distribution. Low-wage rural labor continues to be a growth reserve. Stagnating domestic consumption due to sluggish wage development slows down the development of a new growth regime.

In addition, the existing imbalances in industrialization need to be considered. China's Western regions have grown rapidly in recent years, but differences in income and productivity remain high. China's tier-1 cities Beijing, Shanghai, Guangzhou and Shenzhen are all located along the Eastern Coast. Their combined GDP in 2019 was over 12,4 trillion yuan. The four major tier-2 cities in the East (Tianjin, Qingdao, Nanjing, Hangzhou) together have a higher GDP (6,06 trillion) than the four leading cities in the West (Chengdu, Chongqing, Xian and Kunming, 5,64 trillion). Employment, wages and allocation of R&D funds in the eastern cities are also much higher in Western tier-1 and -2 cities.

China's growing service sector does not only contribute to slower rates of productivity growth. It also drives a rapid expansion of lower-paid and -skilled work, especially in urban areas. According to recent studies [4], employment in labor-intensive services (such as restaurants, hotels, or delivery services) grew between 6,5% and 16% annually from 2011 to 2019. During the same time, skill-sensitive employment (such as software development, engineering, or managerial services) grew only between 1% and 10% per year. The expanding service sector absorbs large amounts of low-skilled labor from the countryside as well as industrial workers made redundant by automation. It also reflects the rapid growth of the "platform economy" in key sectors of services and distribution.

3 Pettis, Michael (2022). China's difficult choices as export growth slows, in: Financial Times 5.10.2022
4 Rozelle, S., Xia, Y., Friesen, D., Vanderjack, B., & Cohen, N. (2020). Moving beyond Lewis: Employment and wage trends in China's high-and low-skilled industries and the emergence of an era of polarization. Comparative Economic Studies, 62(4), 555-589.

The current slowdown in Chinas overall productivity as well as GDP growth reflects the tendencies and difficulties in the transition to a new development regime. With the shift of the economic sectors, the share of the service sector in GDP is now larger than the manufacturing sector. In the service sector, low-skilled, low-paid, low-productivity jobs in particular have increased.

Table 2: Rapid expansion of low-paid work

Growth rate of employment in selected sectors of the tertiary industry in percent

	Labor-cost-sensitive Employment*	Skill-sensitive Employment**
2011	15.54	5.47
2012	8.92	4.55
2013	16.51	9.46
2014	11.77	3.90
2015	9.94	2.63
2016	7.78	2.57
2017	8.89	2.21
2018	8.30	1.39
2019	6.50	10.36

*Labor-cost-sensitive Employment: Wholesale and Retail Trades; Transport, Storage and Post; Hotels and Catering Services; Leasing and Business Services; Services to Households, Repair and Other Services; Construction

**Skill-sensitive Employment: Information Transmission, Software and Information Technology; Financial Intermediation; Real Estate; Scientific Research and Technical Services; Education; Health and Social Service; Culture, Sports and Entertainment

Source: China Labor Statistical Yearbook

3. Manufacturing: persistent growth of productivity, but no "fourth industrial revolution"

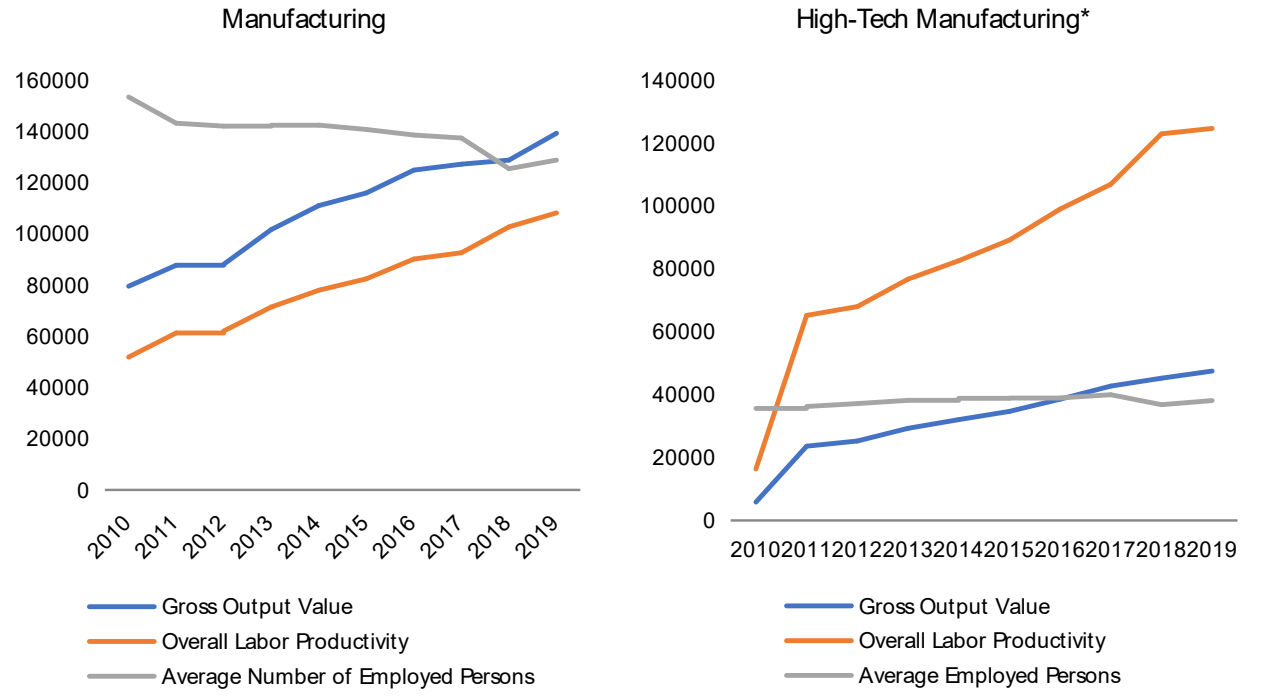
How can these changes in overall economic growth be related to the productivity development in manufacturing, the backbone of China's growth and development over the last three decades? What has been the impact of digitalization and automation of production, brought forward under key industrial policy programs such as "Made in China 2025"? And, how can productivity growth be maintained under conditions of a relatively mature industrial society at middle-income level and beyond?

Generally, the impact of the so-called fourth industrial revolution on work and labor markets has not been studied thoroughly. Many popular studies propose that robots would radically eliminate human labor from industrial production, but have not provided much evidence yet. In China, comprehensive studies of the impact of industrial automation have not been conducted, although the slogan "robot replaces men" has been used widely. Government programs and documents usually do not examine the labor market impact of automation and digitalization[5].

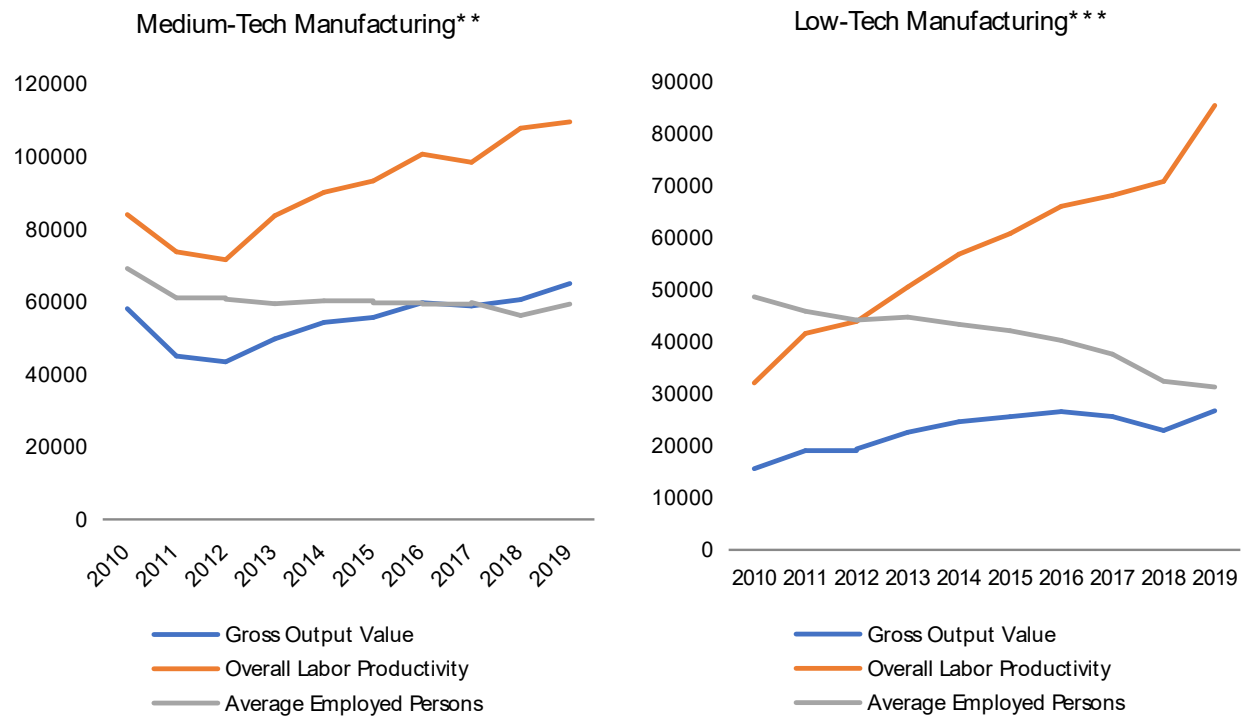
However, official statistical data in China offer plenty of insight into this subject. In this project, we used data from Guangdong, China's largest manufacturing province and a key area for the implementation of advanced manufacturing. We combine quantitative methods with qualitative insights from existing research of changes in work and employment to identify relevant trends.

Graph 3: Uneven development in the manufacturing sector

Gross Output Value in hundred million yuan, Overall Labor Productivity in10 yuan per person and Average Employed persons in 100 persons



5 Butollo and Luethje 2017



*High-tech industries include Aircraft and spacecraft, Pharmaceuticals, Office, accounting and computing machinery, Radio, TV and communications equipment and Medical, precision and optical instruments.
**Medium-tech industries include 10 industries, such as Motor vehicles, trailers and semi-trailers, Electrical machinery and apparatus.
***Low-tech industries include 4 industries, such as Textiles, textile products, leather and footwear, Food products.

Source: Guangdong Statistical Yearbook

According to the Statistical Yearbook of Guangdong province, Gross Industrial Output grew from 8.6 trillion RMB in 2010 to 14.6 trillion in 2019, or 70.3% total and 7.8% average per year. Overall labor productivity measured in revenue per employee was 129,709 RMB in 2010 and 246,953 RMB in 2019. The growth was 90.4% total and 10% average per year.

In the manufacturing sector[6], gross industrial output grew from 7.95 trillion RMB in 2010 to 13.92 trillion in 2019 (75.1% total and 8.3% annual average), overall labor productivity rose from 518,378 to 1,081,363 yuan per person (108.6% total and 12.1% annual average). The average number of employed persons fell from 15.3 to 12,9 million during the same period (-15.7% total and -1.7% annually). The reduction in employment was particularly strong between 2016 and 2018, a result of a massive automation drive in some industries during that time (explanation see below).

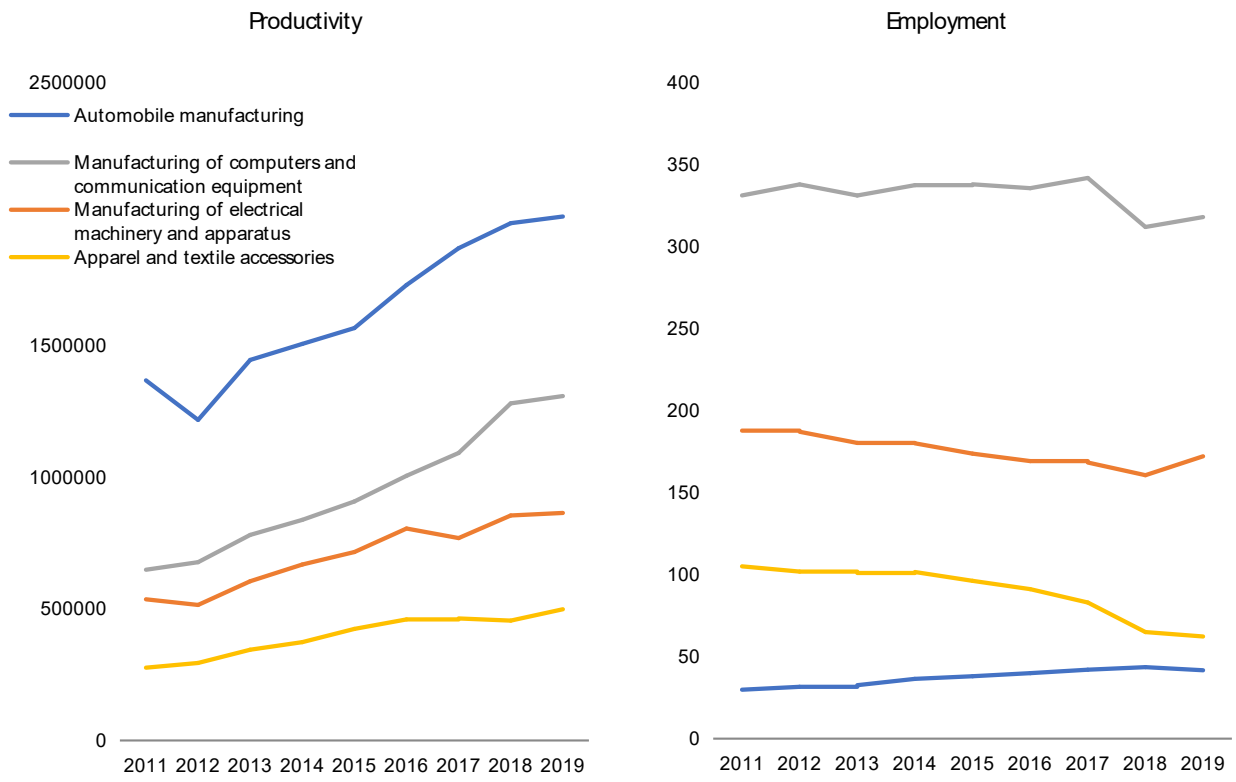
6 31 industries, excluding mining and production of gas, water and electricity

The growth of productivity, however, was highly uneven between sectors[7]. Strong gains occurred in high-tech manufacturing[8]. Productivity grew by about 100% between 2011 and 2019, whereas employment remained roughly equal (increased by 7%). In medium-tech manufacturing[9], productivity grew slower, around 30.4% during the same period, employment was reduced by about 14.2%. The highest growth, however, was achieved in low-tech manufacturing[10], where output per person roughly doubled (105,4%) and employment was reduced by almost 1/3 (decreased by 35.6%).

It appears that productivity growth was highest among the most technology-intensive sectors on the one hand and labor-intensive low-technology industries on the other. The middle ground of industries with average technology intensity saw much slower change, both in terms of productivity development and employment reductions. Obviously, automation and digitalization were employed in different ways with diverse effects in various industrial sectors.

Graph 6: Productivity growth highest in technology-intensive and labor-intensive industries,

Labor Productivity in 1 yuan per person and Average Employed persons in 10.000 persons.



Source: Guangdong Statistical Yearbook

7 We are considering the figures from 2011-19. The year 2010 was still affected by the massive downturn in the wake of the financial crisis 2008-09, output was extraordinarily low in most industries.

8 According to 《OECD Classification of manufacturing industries》, high-tech industries include Aircraft and spacecraft, Phar-maceuticals, Office, accounting and computing machinery, Radio, TV and communications equipment and Medical, precision and optical instruments.

9 According to 《OECD Classification of manufacturing industries》, medium-tech industries include 10 industries, such as Motor vehicles, trailers and semi-trailers, Electrical machinery and apparatus, and so on.

10 According to 《OECD Classification of manufacturing industries》, low-tech industries include 4 industries, such as Textiles, textile products, leather and footwear, Food products and so on.

Productivity development at industry level confirms this observation.

- Automobile manufacturing (rated as medium-tech manufacturing) has by far the highest productivity measured in output per workers. But productivity growth was only moderate, around 45.5% between 2011 and 2019[11], and employment grew slightly during that period. These figures reflect the fact that in Guangdong several new large car factories with very high automation were opened and existing facilities were upgraded during that time (e.g. FAW-VW Nanhai).
- Manufacturing of computers and communication equipment (IT) (considered as high-tech) has the second highest productivity, but significantly lower than automobile manufacturing. However, overall labor productivity grew much faster, more than 101.7% between 2011 and 2019, whereas employment remained largely stable. Traditionally, IT manufacturing included a high proportion of manual assembly, but the sector saw massive automation during the last decade (particularly in labor-intensive assembly shops at the lower end of supply chains, see below). With more than 3 million employees the IT industry remains the largest industrial sector in Guangdong.
- Manufacturing of electrical machinery and apparatus (which includes household equipment as the largest subsector, rated medium-tech) has productivity levels slightly lower than IT. Productivity growth was around 61.2% between 2011 and 2019, and employment fell by around 8.3%. The main driver of rationalization was large-scale automation in big factories and the introduction of handling robots among lower-end suppliers, especially in the field of stainless-steel processing.
- Apparel and textile accessories manufacturing, the most labor-intensive among Guangdong's low-tech mass production industries, has per capita output well below the metal-related sectors above. The industry has also seen productivity increases of around 80.3% during the recent decade and significant reductions in employment of around 40.7%. Automation has only been employed in some sectors of clothing manufacturing, but productivity was pushed by the use of e-commerce and internet platforms as sales and logistics channels. The total output of the garment industry in China and Guangdong diminished, partly driven by relocations to lower-cost countries in South and South East Asia.

Very different upgrading strategies can be seen. However, the low-tech segment, where a large part of the productivity gains did not lead to the expansion of production but to the release of workers, is rather the exception. In the medium and high-tech segments, the number of employees has changed only slightly. The empty factory is therefore not yet foreseeable.

11 There is no automobile manufacturing category in 2010 statistics, so in this part we calculate from 2011

4. Automation and Digitalization: industry trends

The uneven trends of productivity development in China's manufacturing industries reflect the nature of industrial upgrading in an economy that had relied on low wages of large numbers of rural migrant workers since the initial stages of market-based reform and opening. Obviously, the heritage of the low-wage model is still strong, in spite of China's ambitious overtures to become a globally leading manufacturing power. The highly uneven value chains in key manufacturing sectors leave ample space to make profit from exploiting low-wage labor and loopholes in the system of labor regulations, rather than investing in improved manufacturing technologies and human resources.

A closer look at three major sectors of metal-related mass production industries in Guangdong–automotive, IT and household appliances – can help to understand the realities behind the statistical trends analysed above. It reveals highly diverse trends of automation, employment and skill development. The different scenarios reflect different types of value chains and ownership, roles of lead firms, but also traditions and cultures of individual enterprises in the respective industries.

4.1 Car manufacturing

Automotive manufacturing is highly capital intensive, but split along the industry's hierarchical supply chains, known as the Toyota model. The lead firms are represented in Guangdong by the joint ventures of Guangzhou-Toyota, Guangzhou-Honda, Dongfeng-Nissan and FAW-Volkswagen. They have highly automated production systems that reflect the strategies and practices of global car makers. The main factories have only been established in Guangdong since about 2005 as greenfield plants with state-of-the-art production technologies and organization. Automation stood at a very high level at the beginning and, therefore, progressed only at a relatively slow pace in the course of the last decade[12].

Car makers have highly developed internal training systems that combine the traditions of Chinese state-owned enterprises with the practices of the respective multinational partners. Frontline workers are recruited from local labor markets in the province through an extensive assessment system with very high requirements. Workers are recruited with only little regard to their skills or grades from vocational schools. Vocational training is organized "on the job" and in company training centers. Workers can acquire a wide range of certificates for jobs and tasks, and achieve skilled-worker status through experience and accumulation of qualifications. Workers undergo annual assessments and are classified in the wage system according to their individual achievements. Workers in core car joint ventures are generally among the highest paid industrial workers in the region, but their number remains comparatively small[13].

On the other hand, most segments of the car supply industry are less technology intensive and rely on relatively low wages with large numbers of migrant workers. First-tier car suppliers are concentrated in large industrial parks near the core factories, lower-tier suppliers are mostly small- and medium-sized firms in semi-rural "industrial villages" in Foshan, Huizhou and other second-tier cities in the region. Among top-end car suppliers (who assemble complex products such as gear boxes, dashboards or seats), automation has progressed steadily in recent years. Labor-intensive production was rationalized through the introduction of standard automation equipment for mechanical assembly, metal cutting and welding, handling robots – but mostly not through comprehensive digitalization and robotization. At the lower ends of metal parts manufacturing as well as in most areas of car electronics assembly, labor-intensive models of production at low wages persist.

Car suppliers are mostly private-owned and do not provide long-term employment and extensive training and career systems comparable to car industry joint ventures. Workers are recruited from regular labor markets, many of them migrants from rural provinces. Most training is on the job provided by external training institutes of all kinds. Workers also take training from commercial providers or online platforms at their own initiative and cost. Wage systems at car suppliers are not linked to formal skills and qualifications acquired by workers and, therefore, do not offer incentives for

12 Pardi, Krzywdzinski Luethje 2021
13 2019-21 field research interviews by authors.

long-term career development. A study commissioned by FES in 2019 found that automation did not only replace workers, but it also increased the number of tasks and skills to be performed by the remaining workers. However, in most cases the diversified skill requirements were not rewarded through higher wages, a typical sign for the absence or weakness of collective standards of wages and job classifications.[14]

4.2 Information technology

The manufacturing of information technology hardware (computers, smartphones, communications equipment etc.) represents the largest industry in Guangdong and the backbone of the region's role as a global center of high-tech production. As opposed to the car industry, global brands separated from production dominate the value chains, manufacturing is performed by large-scale contract manufacturers and their suppliers. These contract manufacturers, lead by Foxconn from Taiwan, form the backbone of electronics manufacturing in the region, accompanied by a number of indigenous companies of this kind such as Luxshare or BYD, and scores of smaller suppliers. In addition, a large sector of independent manufacturers for low- to medium-end electronics products exists in Guangdong, many of them companies from Hong Kong or Taiwan, as well as a number of large Chinese brand-name manufacturers such as TCL, Konka or Skyworth.

Manufacturing of IT products relies almost entirely on migrant workers from rural areas, most of them from other provinces. Employment is highly flexible, base wages are low, and workers have to work extensive overtime. Companies offer only basic job training and local governments do not provide vocational training for migrants. Most workers live in factory dormitories, some of them very large. This regime of flexible mass production has not changed much in the course of the last decades. In some respect, automation has been introduced to remedy the shortcomings of this regime in terms of production quality and to maintain social stability.
IT manufacturing has been a focus for the introduction of robots and digital automation in recent years. Most prominently, Foxconn promised to introduce one million robots in its factories related to Made-in-China 2025. However, automation has progressed much more gradual at most contract manufacturers. These companies already had a relatively high level of automation connected with the digital supply chain management of their global brand-name customers when the industry was established since the late 1990s[15] Among the Chinese brand-name mass manufacturers, digitalization had a much bigger impact. Since about 2015 these companies moved from labor-intensive manufacturing to large-scale introduction of automated standard-equipment for assembly and of computerized factory management (known as MES-systems). Thereby, domestic mass manufacturers caught up with the global standards represented by contract manufacturers like Foxconn or Flextronics. But job losses were considerable in this sector.[16]

The most severe impact of automation occurred among small- and medium-sized suppliers of electronic and mechanical components for IT products. Production of these companies had been mostly manual, after 2015 some segments massively introduced robots and automated equipment. Automation was heavily subsidized under local government programs, following the goal "robot replaces men" propagated by the Guangdong provincial government in 2015. Electronics component firms were among the main recipients.[17]

Detailed studies by a member of this research team on a group of component suppliers for mobile phones have shown that automation resulted in significant reductions of low-skilled workers and massive increases of output. At the same time, the companies experienced problems to recover the cost for their automation equipment, as the prices for mobile phones kept declining and competition among parts suppliers intensified. In addition, companies faced growing difficulties to find the technical workers to program and maintain automated assembly lines. Most companies did not provide retraining for replaced workers or try to improve their vocational training systems and to provide wage

14 Yang and Luo 2019
15 Huertgen, Luethje, Pawlicki and Sproll 2013
16 Luethje and Butollo 2017
17 Huang, Yu, and Naubahar Sharif (2017): From Labour Dividend to Robot Dividend: Technological Change and Workers' Power in South China. Agrarian South: Journal of Political Economy. 6-1, 53-78. DOI: 10.1177/2277976017721284 http://ags.sagepub.com

incentives for skill improvement. The few who did had a relatively upscale position in the supply chains. But such efforts remained scattered throughout the industry and did not receive support from the local government or other government programs related to Made in China 2025. In these and related cases the lack of a core workforce of broadly skilled production and technical workers becomes particularly visible.

4.3 Home appliances

The home appliance industry has also been one of the focus points of robot introduction and automation. The production of this industry is highly diverse, ranging from larger-size equipment like air conditioners to standard consumer products such as refrigerators or washing machines and a large spectrum of small items like toasters, rice cookers of coffee makers. The scale and scope of manufacturing enterprises, therefore, is highly diverse[18]. The industry is led by vertically integrated global corporations such as Midea, Gree or Galanz; it includes a large number of small and medium-sized manufacturers (with their own brand name or OEM) and a huge sector of supply firms, especially in sheet metal processing. The industry is heavily clustered in some industrial townships, namely in the cities of Foshan and Zhuhai. The leading companies figured prominently in Made in China 2025 and have developed extensive research and production of robots and other advanced production equipment. Midea made global headlines in 2016 when it took over German robot maker Kuka. Household appliances is also a key field for the development of the industrial internet. Some industry leaders are among the main providers of national industrial internet platforms in China, several industry clusters in Guangdong are involved in regional platform projects for small and medium enterprises.

Home appliance making has emerged as a highly labor-intensive industry from its beginnings in the 1980s, both among bigger and smaller enterprises. Similar to electronics, the majority of production workers are migrant workers who live in dormitories in factories and industrial parks. Production work is mostly low- or semi-skilled assembly work. Some occupations, such as sheet metal polishing, require considerable experience. Wages are generally low and turnover among workers is high. Bigger companies pay wages above industry average and offer some benefits and vocational training with limited career opportunities and incentives. Automation in the industry started relatively late. The 2008/09 financial and economic crisis was a main driver, when the industry was hit by a major downturn in domestic and international demand.[19] The industry is a key field for industrial upgrading, and representative for the problems to achieve social upgrading. After 2015, sheet metal and stainless steel processing were among the main fields for robot deployment. Driven by generous subsidies from local governments, companies purchased robots and other automation equipment. Similar to the examples above, profit expectations were very high and mostly achieved through the elimination of human labor. Robots especially replaced the more experienced workers in sheet metal polishing, who where among the highest paid in the industry. However, in most cases companies did not try to retrain such workers, but had to hire technical specialists and engineers for programming and maintenance. Training of operators was neglected or provided by local equipment providers. For some robot makers, worker training services became a highly profitable business (ibid.).

The larger companies tried to cope with this problem through their own training systems. It appears, however, that these companies pursue different styles of automation and skill development, especially for the training of skilled workers. Detailed studies by a member of this research group show company-specific strategies, which can be characterized as "skill-replacing technical change" on the one hand, and "skill-developing" on the other.

In the first case, large-scale elimination of manual labor through automation is the dominant goal – both for saving cost and improvement of manufacturing quality. In its air conditioning business, for instance, the company reduced the number of manufacturing workers from 50.000 in 2011 to 16.000 in 2018. Automation of assembly lines was heavily supported by standard robots that perform most of the welding and

18 Luethje 2022
19 Butollo and Luethje 2017

handling of heavy parts. In addition, production logistics was comprehensively automated and digitalized. Work for the remaining assembly workers workers was highly highly deskilled. The company usually does not offer retraining and skill upgrading for replaced assembly workers. Maintenance and programming is exclusively performed by the company's engineering department or external firms.

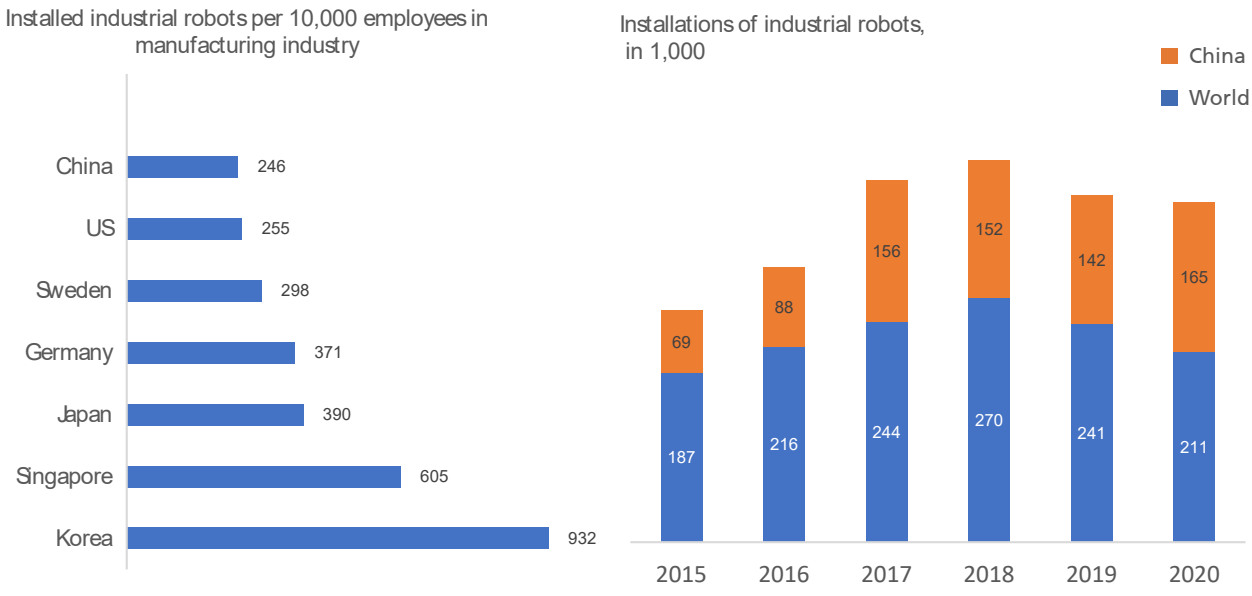
In the second case, similar changes in the production process occurred, and the company also envisages highly automated "lights-out" factories with minimal assembly workforces. However, the company has been pursuing the practice of recruiting skilled workers from the ranks through extensive training on the job, and in related vocational schools. The company maintains an extensive system of job grading, in which skill and pay are related to the specific tasks. Similar to state-owned enterprises, front-line workers can advance from unskilled assembly work to jobs with higher technical skills and achieve the status of a comprehensively skilled worker (gongjiang). At the workplace, older and experienced workers act as peers for younger and less-skilled ones. The company extensively promotes skill competitions and has a large number of successful graduates from public vocational programs. This system has also been employed to mitigate the impact of automation in recent years, and to train assembly workers to supervise complex automated equipment.

5. Low wages and poor vocational training slow down productivity

The above figures make clear that automation and digitalization in a key manufacturing region like Guangdong have taken a different route than predicted by many protagonists of the digital revolution. Productivity has developed rapidly, and in many areas fewer workers are needed to produce more. But workers have not been eradicated from factories, and many industries still maintain large segments of labor-intensive manufacturing, especially at the middle and lower levels of supply chains. As it seems, automation has not changed the hierarchies in most production networks, rather than reiterated them[20].

The impact of robots in manufacturing has been lower than usually assumed. In fact, China has become the largest market in the world for industrial robots. But the number of robots installed per 10,000 employees is still behind developed industrial nations, like Germany or Japan, and the global leaders in this field, Singapore and South Korea. Robot installation saw rapid growth in China between 2013 and 2017, but started to decline after 2017[21]. Obviously, the robot wave had also been driven by government subsidies under the program Made in China 2025, especially from local governments in manufacturing cities in Guangdong and other provinces.

Graph 7: Large investment in industrial robots, but still behind industrial nations



Source: International Federation of Robotics (IFR)

20 For a systematic discussion see the contributions "China's New Development Strategies. Upgrading from Above and Below in Global Value Chains' edited by Gary Gereffi, Penny Bamber and Karina Fernandez-Stark. Palgrave Macmillan 2022.

21 According to data from World Robotics 2020, published by the International Federation of Robotics.

Rather than being eliminated, the human factor continues to play a key role in industrial upgrading. What about the changes in this field? According to expertise and data from the provincial trade union, the following tendencies can be observed in Guangdong.

- Manufacturing wages have not kept up with productivity development. In the six core sectors of metal and electronics manufacturing[22] the gross output value increased 3.3 times between 2011 and 2019, and labor productivity by nearly four times. The average salary of employees grew between 2.5 and 3.0 times in the respective industries.
- Manufacturing wages lag behind the service sector. Between 2011 and 2019, the average wage of any manufacturing industry has never been among the top average wages in the province. Manufacturing wages are significantly lower than in high-paying service industries, such as finance, internet, insurance, law, education etc.
- Significant changes have taken place in the structure of the workforce. In most mid- and high-tech industries, new workers today come from colleges and technical colleges. Automation has eliminated many unskilled jobs, but the average age of workers has risen, from below 30 to older than 30 years.
- Automation has eliminated many simple jobs, but production workers have to perform more and diverse tasks. "Multi-skilling" has become widespread, and employees are encouraged to continuously improve quality and learn more skills. A survey by the provincial trade union found that 83% of employees are willing to participate in learning and training on the job.
- Factory jobs are becoming more and more unattractive. In major cities like Guangzhou, Shenzhen or Foshan, more than 70% of secondary vocational graduates changed their jobs within the first year. Middle and higher vocational graduates often prefer to work in service jobs like courier or food delivery, mostly because of a less monotonous working environment.
- Vocational training capacities for skilled industrial workers are lacking. According to figures from a major technician college in Foshan presented to the National People's Congress, demand for skilled workers has exceeded supply by 1,5 times on average in recent years. For senior technicians, technicians and senior workers the figures are 2.72, 2.31 and 2.13 times respectively.

In this light, the major obstacle in advancing industrial productivity is not in the promotion of advanced automation equipment and digital technologies, but in the lack of skilled industrial workers and of working conditions and wages that make skilled employees stay. This is particularly true for medium- and high-tech manufacturing, where most automation has occurred in recent years. Such industries are still making the transition from labor-intensive to more automated production, and the skills needed are in the basic knowledge of mechanics, materials and electronics, as well as in organization, team management and communication. As experience from industrialized countries shows, a solid basic vocational education based on systematic theoretical and practical learning provides the best groundwork for lifelong learning and multiple skilling at the workplace.

22 Manufacturing of automobiles, metal machinery and equipment, general machinery and equipment, special equipment, computer/communications/electronics, instrumentation.

6. Common prosperity: the key role of collective bargaining

From the foregoing analysis and research, we can conclude that sharing the gains in productivity and a fair distribution of income will not be achieved automatically in the process of industrial development. Companies seek the return on investment from automation and digitalization, but fail to simultaneously improve wages, employment conditions and basic training. Falling behind on upgrading of work affects the sustainable development of enterprises and industries and will limit transformation and upgrading to "quick-and-simple" strategies under short-term profit expectations. Manufacturing technology will be stuck at mid-level stages of development, but never reach comprehensive digitalization as under industry 4.0.

The Chinese government respects the autonomy of enterprises for internal distribution and does not interfere with the autonomy of enterprise operations. However, China needs institutions and standards that ensure the just and sustainable distribution of the gains from innovation and automation. Several policies to tackle this problem have been put forward. However, they need to be developed in comprehensive and scientific ways.

For example, the Ministry of Human Resources and Social Security has issued the "Skilled Talent Salary Distribution Guidelines", which offer a systematic catalogue of recommendations. However, the document only represents "guidelines", which are not legally mandatory for companies, workers and government bodies. With such a formulation, it is difficult for most companies to synchronize employee income with corporate profits. We believe that the development of a viable system of collective bargaining is a feasible and operable method under the conditions of China's advancing industrial development.

In industrialized countries collective bargaining has served as a distributive mechanism for productivity gains for many decades. Trade unions base their wage demands on the development of productivity. Usually, wage proposals and bargaining contracts are calculated on the basis of the annual increase of cost of living (CPI)+annual gains in productivity+redistribution of income, according to the economic situation of companies and country in general.

In China, collective bargaining has become an important norm in the labor law system. It is an institutional carrier for the independent coordination of relations between labor and management in Chinese enterprises, including the internal distribution policies at company level. The establishment of a collective negotiation system is an important manifestation of the operation of an enterprise in accordance with the law. Various labor laws and regulations provide the framework for the establishment of a collective negotiation system at enterprise level and its implementation.

Many enterprises in Guangdong Province have established collective bargaining systems, some of them can be regarded as models for further development. For example, in the wake of the Nanhai Honda work stoppage in May 2010, a group of auto parts companies represented by Nanhai Honda successfully resolved a series of labor-management conflicts through collective consultation. Trade unions at all levels in the province have also joined hands with representative organizations of the enterprise, such as the Federation of Industry and Commerce, and the Federation of Entrepreneurs to promote the establishment and development of the collective consultation system.

China's persistent policies for innovation-driven development and common prosperity provide space for the advancement and development of the collective consultation system. According to many relevant government documents, it is necessary to promote industrial workers to achieve higher productivity and better pay, and to synchronize income growth with economic growth. In order to correctly evaluate industrial workers' skill achievements and to ensure distribution according to their contributions, the wage allocation system must be changed substantially. Under market conditions, this cannot be prescribed by the government, but policies and regulations are needed to set standards and to establish collective consultation as core institution for developing and implementing skill and wage standards.

Practice has proven that collective negotiation can improve and reform the corporate wage system. Independent labor-management consultations can specify the wage distribution that workers with high skill levels and large contributions to the development of the enterprise will be allocated preferentially. Learning inside and outside the workplace will be better rewarded, lower-skilled workers have the incentive to participate in training and to develop long-term career perspectives. Under the relevant guidelines in Guangdong, these measures do not require direct intervention by the government, they only need to be approved by a majority vote by the enterprise employee representative assembly, the Workers' Congress.

According to the Guangdong Federation of Trade Unions, at the end of 2019, there were 73,400 enterprises in the province that signed comprehensive collective contracts, covering 9,3 million employees (about 13% of all employees of registered enterprises in Guangdong). These contracts typically include wage increases, labor safety and health, and protection of rights of female employees through collective negotiation. Additionally, 54,300 enterprises have signed special collective wage contracts (which only determine wage increases), covering 6.73 million employees. Such an establishment rate and coverage rate are not satisfactory, and greater efforts are urgently needed.

7. Policy recommendations

As can be concluded from the above analysis, collective bargaining can be an important measure as part of broader local and national policies of industrial upgrading, and to integrate technological with social upgrading in the field of human resource policies. Automation can only achieve sustainable productivity development on the long-term, when its gains are distributed just and efficiently. However, sustainable and shared economic growth must be situated in the context of a broader reform of China's socio-economic economic growth model, serving the goal of common prosperity. Major guideposts have been outlined in the relevant documents by the Chinese government and the 14th five-year plan, and intensified research and further exchange has to be conducted on these topics.

From the point of view of our analysis several key points have to be emphasized that have not sufficiently been addressed under present government policies:

- Automation alone is not the key to industrial upgrading. Recent upgrading policies have been biased on technological change, but neglected the social dimensions of organization of production, enterprise management and human resource development. The slogan "robot replaces men" reflected this bias, it should not be further promoted as a political objective. As can be concluded from our data and from current studies of manufacturing industries, most productivity gains have not been achieved by robots and advanced digitalization, but by incremental and evolutionary improvements in manufacturing processes across most industries. This lesson should be disseminated and studied further in order to promote indigenous innovation in manufacturing, based on the existing resources in technology, management and workers.
- Against this background, the German concept of Industry 4.0 should no longer be regarded as the lead-model for intelligent manufacturing in China. Most of the automation concepts under Industry 4.0 and the related equipment are suitable for highly automated factories with long-standing traditions of high-quality work and craftsmanship, but not for developing economies. Investment costs are way too high for most Chinese companies, especially SME. China should therefore accelerate the development of indigenous concepts of intelligent manufacturing, based on the existing strength of industrial clustering, supply-chain management and logistics in key manufacturing provinces such as Guangdong.
- Under the conditions of increasing protectionism and aggressive confrontations on trade, intellectual property, and core technologies in the global arena, implementation of advanced manufacturing, AI and 5G technologies should focus on developing sustainable industrial ecosystems with skilled workers and consistent innovation at the interface between product innovation and manufacturing. The initial focus of Made in China 2025 on developing comprehensive networks of innovation and production in key emerging industries should be re-emphasized, rather than shelved.
- Productivity development has been highly uneven between and within industries. As we have explained, this reflects the hierarchical and uneven nature of value chains in many Chinese industries, including the most successful ones like IT or automotive manufacturing. In our view, the key problem of China's industrial upgrading is the integration of advanced and highly innovative segments in high-tech industries with the large number of traditional enterprises. Our research shows that manufacturing will not disappear in the age of digitalization, but it will be substantially reshaped. However, in many hi-tech industries, such as IT and advanced telecommunications, innovation in product and infrastructure technologies remains disconnected from manufacturing innovation. Chinese lead-firms are using large-scale networks of contract manufacturers with mostly low-cost workforces, but they lack hands-on knowledge in manufacturing, necessary for process innovation and rapid introduction of new technologies into quality production. Industrial policies should promote re-integration of manufacturing into lead firms as well as autonomous innovation and brand-name capabilities among subcontractors.
- Industrial policies should promote diversified quality production and flexible specialization among enterprises and industries. Local governments in manufacturing provinces such as Guangdong should promote innovation from below, increased cooperation and shared innovation between enterprises, as well as the integration of low-tech traditional enterprises

in advanced production systems. This would lead to "flexible specialization", which means open production networks based on highly innovative SME with skilled workforces at regional level. It is comparable to successful industrial districts in Europe and the U.S., and can serve as a lead model for China to overcome the limits of mid-level industrial development.

- Such kind of network-building from below offers an alternative to traditional industrial policies focused on nurturing "national champions" on the one hand, and monopolistic "platform capitalism" on the other. China's strength in advanced communications technologies and logistics networks offers many opportunities to integrate automation, digitalization and the knowledge of traditional manufacturing in-dustries. Such policies can leverage the advantages of China's highly advanced communications infrastructure (5G) with cloud computing and internet-based manufacturing platforms suitable to the needs of small and medium enterprises ("industrial internet"). However, such policies need adequate regulation of network infrastructures and platforms. China's efforts to control and regulate monopolistic and socially undesirable practices of large internet platforms must also be directed to the field of new manufacturing infrastructure and platforms.
- Intensified development of skilled workforces and innovative spirit of rank-and-file workers are key to advanced manufacturing. However, Made in China 2025 and the related projects at provincial and local level have not provided integrated strategies of digitalization of production and supply chains on the one side and up-skilling of workforces on the other. China is now promoting "skilled-worker spirit", but successful and sustainable development of skilled workforces require long-term strategies to reform the system of vocational training, integrate company-based and school-based learning, and reform company wage and career systems in order to provide incentives for life-long learning.
- Vocational training plays a key role in this context. Apart from investment in new schools, learning equipment and teacher training, institutional reform is necessary. Key is improved cooperation between vocational schools and industry, in order to achieve "dual learning" in the class room and at the shop-floor. Vocational training systems in Europe may offer many models. However, China must actively develop its own indigenous system. To generalize the principle of common prosperity, the standardization of skill development is of highest importance.
- Collective bargaining on wages and working conditions can make a substantial contribution to standardize labor markets and skill development at high-quality level. As has been explained above collective bargaining can particularly help to harmonize wage systems across key industrial sectors, raise base wages and reduce overtime work to achieve sustainable income, and determine wages according to job skill levels and job classifications.

References

Brandt, L., Litwack, J., Mileva, E., Wang, L., Zhang, Y., & Zhao, L. (2020). China's Pro-ductivity Slowdown and Future Growth Potential. Washington, D.C./World Bank https://openknowledge.worldbank.org/handle/10986/33993

Butollo, Florian, and Boy Luethje. (2017). " 'Made in China 2025': Intelligent manufacturing and work." In K. Briken, S. Chillas, M. Krzywdzinski, & A. Marks (eds.), The new digital workplace. How new technologies revolutionise work (pp. 42–61). London: Palgrave McMillan.

Huang, Yu, and Naubahar Sharif (2017): From Labour Dividend to Robot Dividend: Technological Change and Workers' Power in South China. Agrarian South: Journal of Political Economy. 6-1, 53-78. DOI: 10.1177/2277976017721284 http://ags.sagepub.com

Gereffi, Gary, Penny Bamber and Karina Fernandez-Stark (editors) (2022): China's New Development Strategies. Upgrading from Above and Below in Global Value Chains'. Singapore: Palgrave Macmillan 2022.

Luethje, Boy, S. Huertgen, P. Pawlicki and M. Sproll. (2013). From Silicon Valley to Shenzhen. Global Production and Work in the IT Industry. Lanham e.a.: Roman and Littlefield.

Klein, Matthew C., and Michael Pettis (2020). Trade Wars are Class Wars. How Rising Inequality Distorts the Global Economy. New Haven&London: Yale, pp. 117 ff.

Luethje, Boy (2022), Foxconnization of Car Manufacturing? Production Networks and Regimes of Production in the Electric Vehicle Industry in China. In: Teipen, Christina e.a. (eds.): Economic and Social Upgrading in Global Value Chains. London e.a.: Palgrave MacMillan. 2022.

Lüthje, Boy and Florian Butollo (2017): 'Why the Foxconn Model Doesn't Die. Production Networks and Labour Relations in the IT Industry in South China'. Globalizations, 2017 Vol. 14, No. 2, 216–231, http://dx.doi.org/10.1080/14747731.2016.1203132

Pardi, Tommaso, Martin Krzywdzinski, and Boy Luethje. (2020). Digital manufacturing revolutions as political projects and hypes: evidences from the auto sector, ILO Working Paper 3 (Geneva, ILO). www.ilo.org/global/publications/working-papers

Pettis, Michael (2022). China's difficult choices as export growth slows, in: Financial Times 5.10.2022

Rogoff, Kenneth, and Yuanchen Yang. 2021. "Has China's Housing Production Peaked?" China and the World Economy 21 (1): 1-31. https://scholar.harvard.edu/files/rogoff/files/nber_27697_peak_china_housing_1.pdf

Rozelle, S., Xia, Y., Friesen, D., Vanderjack, B., & Cohen, N. (2020). Moving beyond Lewis: Employment and wage trends in China's high-and low-skilled industries and the emergence of an era of polarization. Comparative Economic Studies, 62(4), 555-589.

Yang Tao, Luo Siqi and Boy Luethje. (2019). "Machine Replacing Man? Upgrading and Transformation of Car Suppliers in the Pearl-River Delta 2010-2017." Friedrich-Ebert Stiftung Discussion Paper. FES Office China. Authors: Yang Tao and Luo Siqi. Principal Investigator: Boy Luethje. 27pp. August, www.FES-China.org

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