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Boy Lüthje, Dan Wu, Wei Zhao

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China's auto industry: regimes of production and industrial policy in the age of electric cars

Boy Lüthje*

Institute for Public Policy,
South China University of Technology,
14/F, Automobile Technology Building,
No. 381, Wushan Road, Tianhe District,
Guangzhou, China
Email: luethje@ipp.org.cn
*Corresponding author

Dan Wu

Freie Universität Berlin,
Hittorfstr.18, 14195 Berlin, Germany
Email: danwu@zedat.fu-berlin.de

Wei Zhao

ESSCA School of Management,
1 rue Joseph Lakanal – BP 40348,
49003 ANGERS CEDEX 01, France
Email: wei.zhao@essca.fr

Abstract: This article discusses China's industrial and labour policy for the automotive industry facing the transition to the era of new energy vehicles. A conceptual framework on the regimes of production is employed to analyse the present transformation of industry structures in production models and labour markets. The growth of private-capitalist regimes of high-performance, low wages, and high profit incentives for workers is identified, which can be described as the 'Foxconnisation' of the industry, and it is at the expense of the corporate-bureaucratic regimes prevalent among the leading Sino-foreign joint ventures. As production networks become vertically disintegrated, some non-traditional industrial players are highlighted in the discussion of some recent developments in the industry during the ongoing COVID-19 pandemic. The profound transformation in the regimes of production brought about social contradictions related to the production process, and new challenges and implications for workplace policies. The empirical study of this article confirms the necessity of trade union strategies inside China from an international perspective in order to ensure social standards and a more sustainable green transformation of the industry.

Keywords: new energy vehicles; regimes of production; industrial policy.

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Biographical notes: Boy Lüthje is a Senior Research Fellow and the Director of the Industrial Policy Research Center at the Institute for Public Policy, South China University of Technology. He was a VW China Endowed Professor at the School of Government, Sun Yat-sen University (Guangdong), China. He also held positions as Senior Research Fellow at the Frankfurt Institute of Social Research and Visiting Scholar at the East-West Center, Honolulu, Hawaii. He obtained his doctorate in sociology from the Johann Wolfgang Goethe-Universität in Frankfurt.

Dan Wu is a PhD candidate at the Otto Suhr Institute of Political Science, Freie Universität Berlin. Before her candidacy, she was a Research Assistant at the East Asian Institute, National University of Singapore.

Zhao Wei is an Associate Professor at the ESSCA School of Management, Senior Fellow at the Institute for Pearl River Delta Reform and Development at Sun Yat-Sen University, and Associate Researcher at the Centre d'économie de l'Université Paris Nord (CEPN). Before academia, he was Marketing Director of a Hong Kong real estate company and Director of Public Affairs with Carrefour in South China. Since 2011, he has conducted empirical research on China's industrial modernisation and innovation policy with the think tank established jointly by the Guangdong Provincial Government and Sun Yat-Sen University. He holds a Master's degree in Sociology from Sun Yat-Sen University and a PhD in Economics from Paris 3 University.

1 Introduction

With the accelerated transition to new energy vehicles (NEV), the automotive sector is undergoing a massive transformation. Historically, this can be compared to the break-up of Fordist and Neo-Fordist production models and the subsequent globalisation of major manufacturing industries in the 1980s and 1990s, electronics in particular. Vertical disintegration and re-integration is at the core of this process. On the one hand, the existing production systems of global carmakers and their hierarchical supplier pyramids (commonly known as the 'Toyota model') may gradually lose their core role in the automotive sector. New sources of production know-how are emerging, which are no longer exclusively controlled by traditional car makers. NEV batteries are a key element in this transformation (Lüthje, 2021; Wang et al., 2022).

Compared to the 1990s the conditions of what we call 'globalisation' have changed considerably. Emerging economies have not only developed as low-cost production bases and 'extended work benches'. Rather, they have accumulated substantial technological and production know-how at various stages and become important players in global innovation. In the NEV and battery sector, China is the global lead market, the major producer and a key innovator. Global supply chain development, therefore, no longer is a top-down process, controlled by the leading brand-name companies in industrialised countries, but multidimensional in the sense of distributed centres of innovation and industrial players leading in different segments. The global carmakers are no longer the undisputed leaders of industrial development in the auto sector.

At the same time, the traditional car industry is eroding as a base of high-paying industrial jobs and trade union power. As production networks become vertically disintegrated and non-traditional players enter at all levels, the partnership between

capital and labour at core carmakers is coming under pressure. Trade unions in the automotive sector are facing the challenge of finding new strategies of organising the emerging new industry segments, most of them located in low-wage regions inside and outside the established countries of car making. The new structure of global supply chains also raises the question of how to monitor the basic social and environmental standards of NEV manufacturing and to secure decent work in global supply chains.

This article will take a closer look at the policy implications of this shift, and raise some strategic questions for trade unions, based on empirical developments in China. The country is certainly not the place to study advanced strategies of trade union organising. However, the changes in the production system are most developed and visible here, and the changes in working models and conditions are comparable to traditional industrialised countries. We will try to understand how the sector-wide restructuring drives a re-composition of production regimes, which is resulting in the growth of private-capitalist regimes of high-performance, low wages, and high profit incentives for workers, at the expense of the corporate-bureaucratic regimes prevalent among the leading Sino-foreign joint ventures. For a systematic understanding of this process, we need a theoretical concept based on relevant academic debates of regimes of production in Chinese manufacturing industries.

In the second section of this article, a conceptual framework based on our previous research on industrial relations in China will be presented and related to the traditional structure of the Chinese automotive industry. The third section traces the present transformation in production models and labour markets, illustrated by some recent data on productivity and employment from South China's. In the fourth section, our analysis of changing regimes of production will be examined in more detail with regard to the changing structure of industrial players, highlighted by some recent developments during the ongoing COVID-19 pandemic. Section 5 will discuss new challenges for workplace policies related to the production process of Li-batteries. Section 6 will trace the social contradictions emerging from the transformation and the changing contours of production politics, illustrated by recent developments in the wake of the corona pandemic. In the conclusion, we will discuss some policy recommendations for trade unions inside China and from an international perspective.

2 Production networks and regimes of production in China – a systematic perspective

The regimes of production in the Chinese car industry in the era of reform and opening have been centred on the joint ventures between Chinese state-owned and foreign multinational carmakers, the core enterprises of China's auto industry and the backbone of its phenomenal history of growth and innovation in the recent two decades. However, the Chinese automotive industry has developed multiple production regimes in its different sub-sectors, with different institutional forms and conditions for workers. These differences mirror the segmentations along the supplier pyramids of the contemporary car industry in the Chinese context. In this perspective, the automotive sector mirrors the highly differentiated landscape of production regimes with 'high-wage' and 'low-wage' conditions in China's core manufacturing industries. These differences have been described in many empirical studies of social conditions and social movements in Chinese factories. However, most research on China's industrial relations has not related

systematically to the different practices of labour relations at company and industry level, and the related localities.

Empirical research on this subject can identify generic patterns of labour practices and their institutions, which govern the basic social relations and the reproduction of power relations between capital and labour in specific companies, industries and regions. Our studies on this subject (Lüthje et al., 2013b) are based on the concept of regimes of production (Burawoy, 1985), which has been introduced to and redeveloped for the Chinese context by Lee (2007). Five major regimes of production can be distinguished in Chinese manufacturing (see Table 1):

- The transformation of the state-owned enterprises (SOEs) led to the *state-bureaucratic* regime of production, which is typical in industries such as steel and petrochemicals. The labour relations under this regime are characterised by relatively stable conditions of production, often the result of massive industrial restructuring by privatisation. This regime of production registers core workforces of medium or high skills, and pay systems with relatively low base wages and a high proportion of workplace and personal allowances that often make up more than half of workers' regular personal income. Most companies abide by labour laws and government regulations. Trade unions are relatively stable under this regime. Nonetheless, weak contract-based regulation of wages, working hours and other employment conditions are often observable. Usually, the collective work contracts and side agreements do not specify exact wage rates and job classifications, or such specifications are often kept confidential.
- The regime of production in multinational corporations and joint ventures in China can be called *corporate bureaucratic*. It shares some similarities with the production regime of SOEs. In joint ventures in industries such as automotive or petrochemicals, this regime of production is dominant. The regime is characterised by relatively stable conditions of production and workforces, often distinctively shaped by management and work systems of these multinational corporations. These corporations pay the highest wages and salaries in their regions. Their workforce comprises almost exclusively urban workers. Wage and incentive systems are comparable to Western multinationals. This production regime offers relatively high base wages that consist of 70–80% of regular personal income, regulated working hours and long-term career patterns linking to work experience, skills and education. The high base pay distinguishes the corporate-bureaucratic regime from other production regimes in China. Trade unions enjoy relatively secure positions and are usually coopted into corporation management. Labour relations are stable, but contract-based regulation of wages and working conditions still remains weak. In recent years, we have seen growing numbers of individual labour conflicts, legal disputes with skilled employees with high expectations of payment, working environment and career development.
- The production regime of *corporate high performance* in multinational corporations is shaped particularly by US 'philosophies' of high-performance management. It is comparable in many aspects to traditional multinationals, especially in regard to workforce type, but it displays much stronger performance orientation in workforce selection, work organisation, career patterns and high employment flexibility. Fixed base wages and salaries contribute to less than half of regular incomes and the

proportion of bonuses and performance-based pay is relatively high. Trade unions are either weak or non-existent. There have been labour conflicts due to discontent among highly skilled workers; some led to collective forms of resistance such as strike and public protest via media and internet. The regime of *corporate high performance* typically exists in the US and Western European multinationals in the electronics sector, foreign invested chemical industries, newly established Chinese multinationals in IT industry (such as Huawei), Korean and Taiwanese first-tier corporations (Samsung and TSMC).

- Among the large mass producers of advanced electronics and other industrial products, an extreme type of high-performance management regime emerged, which can be called *flexible mass production*. Modern manufacturing technologies and organisation are associated with the extensive exploitation of low-paid rural migrant workers. Work organisation in regimes of flexible mass production is dominated by massive segmentation and flexibilisation of employment. Workers are housed in factory dormitories. Extremely long working hours, often in violation of existing legal standards, are very common, with very low base wages, usually around local legal minimum wages. There are considerable wage differences between line workers and technicians, managers and engineers. Except employee representations dominated by management that are set up in response to international monitoring efforts by NGOs, trade unions usually have no presence in factories of flexible mass production. The regime of production is typical in US and Taiwanese contract manufacturers and component providers in the electronics industry, as well as some Chinese first-tier manufacturers of consumer goods.
- The production regime of *low-wage classic* represents the bottom end of production regimes in major manufacturing sectors and enterprises equipped with technologically poor factories of low levels of organisation. It reflects traditional divisions of labour between industrialised and developing countries. Its modern manifestations in the production system of global retailers such as Wal-Mart have shaped large segments of Chinese export manufacturing. Workers in this production regime are mostly rural migrants housed in factory dormitories. In contrast to technologically sophisticated flexible mass production, this production regime is based on simple and direct control and methods of exploitation under authoritarian paternalism. Most workers are stuck with base wages around the level of legal minimum and basic economic survival as well as extensive overtime in working hours. The low-wage production regime widely applies piecework systems that induce speed-up of production and often undermines legal minimum wages. Trade unions are mostly absent from such workplaces even though individual and collective labour conflicts are relatively frequent. This production regime is widespread in large and small-scale factories in light industries of garment, shoes, toys and other consumer goods as well as among suppliers of electronics and automotive parts.

Table 1 Taxonomy of regimes of production

Type	*Production model*	*Work/HR*	*Labour relations*
State-bureaucratic	Integrated Medium to high technology Brand name	Stable after restructuring, but increasing workforce segmentation Urban workers High wages Low base, allowances	Stable TU, party, government relations Collective contract Weak collective bargaining Few labour conflicts Worker's mobilisation on traditional 'socialist issues'
Corporate bureaucratic	Integrated High technology Strong brand Market control	Stable employment Urban workers, skilled High wages, benefits High base pay Career incentives	TU, cooperative Mostly collective contract Weak collective bargaining Labour conflict few collective, often individual
Corporate high performance	Integrated High technology Strong brand High flexibility	Flexible employment Urban workers High wages, benefits Low base, high variable and OT	Weak or no TU Employee involvement Often no collective contract No collective bargaining Occasional labour conflicts
Flexible mass production	Integrated Medium to high technology No brand name High flexibility	Flexible employment Rural workers Neo Taylorism Low wages, benefits Very long working hours	Mostly non-union No collective contracts Occasional labour conflicts, sometimes militant Violations of legal standards
Low wage classic	Low integration Low tech No or weak brand High flexibility	Flexible employment Rural workers Low wages, benefit Personalised control Very long working hours	Mostly non-union No collective contracts Frequent violations of legal standards

Source: Lüthje et al. (2013b)

As has been said, the Chinese car industry comprises all five of these production regimes along its supply chains and at different layers of its production systems. Until the mid 1990s, the state-bureaucratic regime was dominant, since carmakers in China historically were fully state-owned enterprises. In the course of privatisation and restructuring in the

1990s, joint ventures became the leading forces in the industry, and the newly developed combinations of Chinese and foreign management practices produced a variety of corporate-bureaucratic regimes, which rapidly dominated the industry. Today, 'pure' state-bureaucratic regimes can only be found among major state-owned truck makers and some subsidiaries of core carmakers.

On the other hand, the regimes of production of China's independent carmakers, such as Geely, and of the major players in the NEV industry (such as BYD) are essentially based on private-capitalist 'high-performance' regimes of all kinds. Flexible mass production is the standard regime in most sectors of car electronics manufacturing, whereas classical low-wage regimes still dominate large sectors of low-end suppliers, both in traditional car manufacturing and in electronics (Lüthje and Tian, 2015).

3 Transformation of production and shifting labour markets

As we have explained in a series of recent publications (Lüthje, 2021, 2022; Wang et al., 2022), the restructuring of the value chains of car manufacturing can be described as a complex process of vertical de- and re-integration, accompanied by new forms of centralisation of capital. What a few years ago appeared to be a somewhat distant projection of an emerging industrial landscape, rapidly took shape in the wake of the COVID-19 pandemic. The pandemic acted as a catalyst that accelerated the existing trends and shifts in the automotive sector. Primarily, the crisis accelerated the decline of sales and revenues among incumbent carmakers. The big joint ventures did not only suffer from the country-wide lockdowns in early 2020 and subsequently in Shanghai and other key regions of China in the spring of 2022; sales and production volumes never reached pre-pandemic levels. At the same time, a new brand of specialised NEV makers led by Tesla, BYD, NIO, Xpeng took the lead in selling new and pricey NEV, whereas incumbent car makers with their recently created NEV models trailed hopelessly (Volkswagen and General Motors in particular) (Automotive News China, 2022b)

Following our earlier analysis, five groups of industrial actors are driving this transformation:

- Sino-foreign joint ventures of traditional car makers
- NEV and battery makers
- contract manufacturers
- car suppliers
- communication equipment makers and internet firms.

The battery sector is of key significance. China caught the opportunities of impeding disruptive transformation and gained a leading position as a first mover in NEV battery making. This development was based on a large sector of battery suppliers for consumer electronics, computers and mobile phones. China now has a complete Li-ion battery value chain for NEV, from upstream materials production to midstream manufacturing of cells, modules, BMS, and packaging, as well as downstream applications in mobility and various other fields, such as grid storage, lighting, solar energy, and movable storage. Within the automotive sector, Chinese battery producers are becoming important players

as providers of core components, reaching out into other battery technologies such as fuel cells (Wang et al., 2022).

The changes in value chains are transforming work and employment in the car industry. In industrialised countries, the transition to NEV is seen as a major threat to jobs in the existing car industry. Potential job reductions by global car makers indicated that substantially fewer workers would be needed for NEV manufacturing. It also means that the traditional mechanical skills of car workers and engineers will be devalued (HBS, 2012; Pardi et al., 2020). The impact from changing value chains and relocation has not been sufficiently studied. As the electronics industry has demonstrated, technological revolutions and business models in the 1990s initiated a massive transformation of manufacturing. As a result, most traditional computer and telecommunications production was either closed down or sold to contract manufacturers and relocated to emerging economies (Lüthje et al., 2013a).

In China, there are no comparable concerns and discussions about work and employment, since NEV production promises substantial growth opportunities and a global competitive edge for Chinese carmakers, battery manufacturers and other players along the industrial chains. But still, labour experts have a critical eye on the shift of job growth into lower-paying industry segments, especially electronics manufacturing.

In quantitative terms, the employment effects of both the transition to NEV and of automation and digitalisation in the Chinese car industry are difficult to measure. Obviously, the shift of NEV production networks into the electronics sector, as well as the relatively low level of automation in the assembly of NEV and their components (with the exception of batteries) can be seen as a trend towards higher labour intensity in automotive manufacturing. This may offset some of the job losses in the car industry resulting from the less complex manufacturing processes in NEV production. On the other hand, digitalisation and automation will continue to progress rapidly in electronics manufacturing and in NEV production networks. Therefore, job reductions through automation are to be expected as a long-term trend for NEV manufacturing, especially in its more labour-intensive segments.

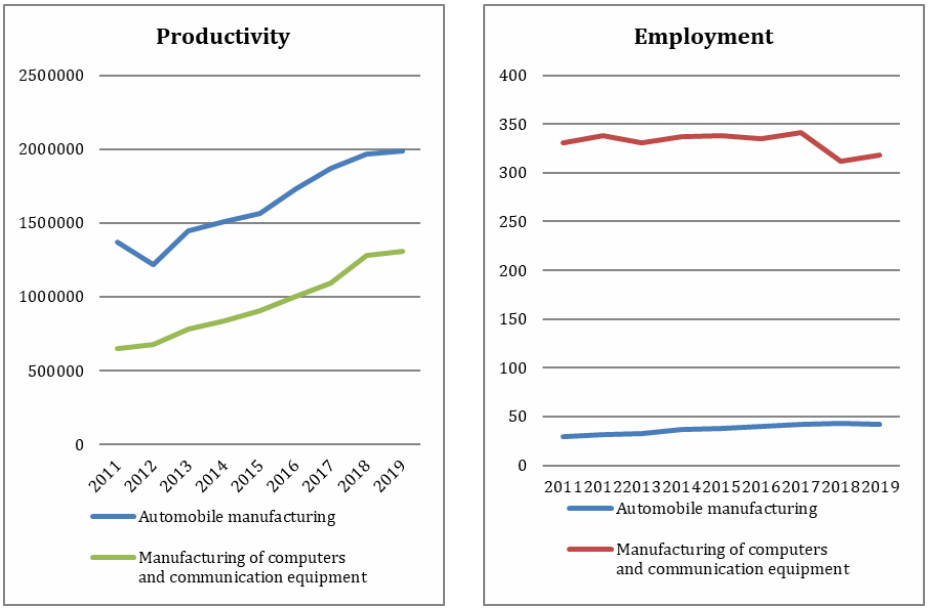
These tendencies can be assessed through a comparison of productivity and employment data of automotive and electronics manufacturing in China. Recent data from Guangdong province, China's largest manufacturing region and a core location for the global electronics industry as well as for the production of NEV and traditional cars, shows divergent trends for both sectors.

- *Automobile manufacturing* has very high productivity measured in output per worker. But productivity growth in recent years was only moderate (by Chinese standards), around 45.5%, between 2011 and 2019, whereas employment grew slightly during that period. These figures reflect the fact that the main car factories in the region, namely of the joint ventures of Toyota and Honda (with Guangzhou Automotive) and Volkswagen (with FAW), have only been established between 2007 and 2012 as greenfield facilities with high degrees of automation.
- *Manufacturing of computers and communication equipment (IT)* has also high productivity per worker, but significantly lower than automobile manufacturing. However, labour productivity in electronics 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, and the sector saw

massive automation during the last decade (particularly in labour-intensive assembly shops at the lower end of supply chains).

With more than 3 million employees the IT industry remains the largest industrial sector in Guangdong, whereas employment in the automotive industry is much lower (under 500,000 including car suppliers). Therefore, the potential for automation-related job losses is much higher in electronics manufacturing than in the highly automated car industry. However, NEV production will certainly add new products and production lines to the electronics industry. But whether this will compensate for job reductions through automation remains to be seen.

Figure 1 Productivity and employment in automobile and electronics manufacturing in Guangdong Province 2011–2019 (see online version for colours)



Source: Guangdong Statistical Yearbook. The data have been generated from a recent study with FES Shanghai (FES and IPP, 2022; Copyright IPP)

4 Sectoral transformation in regimes of production

The rapid emergence of new industrial players and networks in the NEV sector implies a break in the existing competitive structure and production models in the Chinese car industry. New lines of competition are between the incumbent joint ventures with relatively upscale wages and working conditions, and their competitors from independent car makers and the IT industry. The latter mainly depends on low-wage manufacturing workforces that consist of high proportions of rural migrant workers. The sectoral transformation of China's car industry traced in previous sections also denotes a complex restructuring and recombination of the existing regimes of production (Lüthje et al., 2013b) along the lines of the five groups mentioned above.

In the *joint ventures* of leading brand-name carmakers, China's globalised model of state-capitalist regulation is aligned with the regime of production that combines the practices of transnational automakers with the party-based management systems of their Chinese partners, resulting in a parallel structure of Western and East Asian corporate lean management mixed with state-bureaucratic practices on the shop floor (Lüthje and Tian, 2015). Currently, the core joint venture factories suffer from increased cost competition and slow market growth. Workforce reductions and plant closures have been observed in China's major centres of car manufacturing.

Most carmakers have already started to incorporate the manufacturing of electric and hybrid vehicles into their existing production systems. This segment of NEV manufacturing remains under the corporate-bureaucratic production regimes of the joint ventures, but there are new flexibility requirements for factory organisation and workers. Pressures at core carmakers increasingly made their workers dissatisfied about the wage level, benefits and employment prospects, especially for temporary workers. In one case, a major labour conflict with temporary workers over principles of equal pay for equal work occurred at FAW-VW in Changchun.

Independent carmakers, *NEV and battery producers:* most of these companies rely on vertically integrated production with high flexibility. The wages of their workforces are substantially lower than in the joint ventures. The rule of thumb for salary among industry experts at the top joint ventures is about 9 US-dollars as a standard hourly wage compared to 4–4.50 dollars at independent carmakers such as Geely and BYD. The lower wage scale is especially common among companies with a background of electronics manufacturing, for example, BYD and most battery makers.

This regime of production represents labour relations of *corporate high-performance*, which is adapted from Korean, Taiwanese and US models. Wages and employment conditions are fairly decent albeit the system is highly incentive-based. Skilled employees can achieve considerable extra income and promotions, but work organisation is based on relatively low base wages and salaries, usually less than half of a regular monthly income. Production workers, many of them migrants, are forced to work overtime to achieve a barely surviving income (Lüthje et al., 2013a). Even though the production systems of these companies are very flexible, they rely on a core of relatively experienced skilled or semi-skilled workers. One of the leading firms of this kind maintains its operations in two large industrial parks in South China, one with 20,000–30,000 workers and the other with over 70,000 (2017/2018 field research and interview data; IPRD, 2018).

Electronics contract manufacturers are notorious for their unpleasant working conditions and low wages in China. These very large factories, many with 100,000 or more workers, represent a regime of flexible mass production closely associated with the unique characteristics of China's internal labour migration system (Lüthje et al., 2013a). The production regime is based on large-scale employment of rural migrant workers in coastal provinces or big-city inland locations. Base wages are usually at the local legal minimum level and migrant workers have to endure massive overtime work, often beyond legal limits. Such work is extremely segmented and deskilled, designed to accommodate mass recruitment and lay-offs according to market conditions. Workers are mostly housed in dormitories, some with harsh living conditions. Due to the increasing role of EMS contract manufacturers in NEV and digital car production, such working

conditions are expected to penetrate supply chains, manifesting the 'Foxconnisation' of car manufacturing.

China's large sector of car industry suppliers demonstrates diverse regimes of production, reflecting the segmented structure of the industry and their positions in the supply chain. First-tier multinational car suppliers have the high-performance type of production regimes, while the type of production regime in joint ventures of Chinese state-owned carmakers is state-bureaucratic (Lüthje et al., 2013b). The wages in China's car supply industry are generally much lower than the wages in core joint ventures, such as first-tier multinationals Bosch and Denso. The lower end of suppliers in Chinese car industry is typically traditional low-wage industries, comparable to the flexible-mass-production regime in the IT industry or to the 'classical' low-wage regime of labour-intensive small and medium enterprises.

Our studies on the car industry suppliers in South China indicated that the shift to NEV manufacturing and automation has not yet caused major restructuring among car suppliers in the middle and lower tiers, since most car manufacturers in the region still concentrate on traditional car technologies (Yang et al., 2019). Automation, however, does have a potentially heavy impact at the low end of the supply chain. Recent studies of metal-related manufacturing industries in Guangdong province found that relatively simple forms of automation (mostly with Chinese-branded low-cost robots) can lead to massive replacement of manual labour. Such automation often affects the most experienced workers in physically challenging labour processes such as machining of metal or polishing of stainless parts (Huang and Sharif, 2017; FES and IPP, 2022).

China's *communication and internet industry* is rapidly expanding its role as provider of digital driving and car communications systems, of software and platforms and mobility services, and with its own car models (such as Xiaomi and Huawei). This sector has completely developed under private-capitalist forms of enterprise organisation. The leading companies, such as Ali Baba, Baidu and Huawei, have corporate high-performance regimes of production with elevated salaries and very high bonuses or premiums from employee stock ownership. However, they require very long working hours, a system that in China has become notorious under the name 9-9-6 (work from 9 am to 9 pm, six days a week). Notably, most companies do not have their own production, they mostly rely on contract manufacturers. Therefore, the dominant labour regime in communications hardware manufacturing is flexible mass production at major contract manufacturers. The relationship with the contract manufacturing sector is particularly intimate, since some major NEV producers like BYD also maintain large operations for mobile phone making in electronics manufacturing services.

5 New challenges at the shop floor: work processes in Li-battery manufacturing

The work process in Li-battery manufacturing has not been studied systematically yet. It is very different from the manufacturing of traditional lead-acid batteries, which had been notorious for severe toxic health hazards for workers, especially in developing countries including China. The manufacturing of Li batteries is highly automated in most core processes, and includes printed circuit board and mechanical assembly as known from the electronics industry. In the absence of systematic studies, we provide a first description of

manufacturing processes along the industrial chain from factories in the Pearl-River Greater Bay Area (GBA) that we visited between 2017 and 2019.

In general, Li-battery manufacturing is highly automated and usually does not require large factory workforces as in traditional car or electronics production. According to figures published by the companies, China's largest battery maker, CATL, had a total workforce of roughly 20,000 in 2020, distributed over nine factories (including the newly established one in Erfurt, Germany) and R&D facilities, mostly located at its headquarter in Ningde, Fujian province. The workforces of other battery makers appear to be much smaller.

Some of the leading battery makers concentrate their production in large industrial campuses that include up- and downstream production processes like cell or electronics assembly, or the manufacturing of electric vehicles or electronics products. BYD has the core of its production in three large campuses in Shenzhen and Huizhou, each of which with several ten thousand employees. Battery factories are located within these industrial parks, which also include R&D facilities, logistics and large dormitories and apartment buildings for workers.

Similarly, the battery manufacturing joint venture of CATL and Guangzhou Automotive Corporation (GAC) is located in GAC's large new energy car industrial park in the Panyu District of Guangzhou City. The presumably largest battery factory in the Pearl-River Greater Bay Area (GBA) is located in Huizhou and has been developed as an integrated industrial park in a rural green-field location. The workforce consists overwhelmingly of migrant workers housed in dormitories.

Along the production and industry segments identified above, the following profile of the work process can be drawn (this does not include refining, production of basic materials, and recycling, since we did not have the opportunity to visit relevant facilities).

- *Production of electrodes (anodes and cathodes)* is an industrial manufacturing process that includes metallisation, metal forming and die-casting. It is performed in small-to-medium sized factories with smelter ovens and similar equipment. It includes heavy physical work with high impact from noise, fumes and high temperatures.

- *Production of battery cells*, the core process, is highly automated and occurs in large cleanroom-like facilities. It involves the preparation and processing of micro-thin copper foils, from which the battery cells are made, several stages of metallisation and galvanisation, and the final rolling of the material into small cylindric battery cells. The quality, calibration and maintenance of the equipment are crucial for the production process, which must maintain highly uniform quality of millions of battery cells. Most of the equipment is from first-tier providers from Japan and South Korea. Due to the highly automated character of the process, the workforce inside the cleanrooms is very small, mostly skilled or semi-skilled equipment operators and maintenance workers. Outside of the cleanrooms, most work is in logistics and warehousing.

- *Packaging and assembly of batteries* occurs in facilities of different sizes according to production volumes and product characteristics. Cells are inserted into metal casings and frames, usually by medium-skilled assembly workers with some experience. In larger facilities this is done on assembly lines with some automation, smaller facilities mostly use hand assembly. In cooperation projects between

carmakers and large battery providers, parts of the battery assembly may also be located in or near car plants.

- *Electronics assembly (battery management systems)* consists of the generic work processes of electronics manufacturing, i.e., assembly of printed circuit boards (usually with program-controlled SMT and soldering equipment), hand assembly of certain non-standardised parts and enclosures, and final testing. According to volumes and product characteristics, this work is performed in facilities of different size, some of them integrated in electronics factories with varieties of other products.
- *Production of battery frames and casings* occurs in specialised factories of different size and involves standard processes of metal manufacturing such as cutting, drilling, welding etc. Production is becoming more and more automated, leading companies in the GBA use imported high-precision equipment and robots to improve production quality and save labour costs.
- *Final assembly and configuration for car frames* mostly occurs at the facilities of the carmakers that use externally produced battery cells. The work organisation differs according to the products and the production models of the various carmakers. As has been explained above, the division of labour between carmakers and battery providers is still relatively unstable. The largest car factory in South China, a Sino-European joint venture, has built a battery assembly plant on its factory campus. This plant configures the batteries for the multinational's traditional car platform and models. This process is relatively labour intensive, because platforms for combustion-engine vehicles are not suited to receive large Li-battery assemblies. With the transition to a specific platform for electric vehicles, standardisation and modularisation, this process is expected to require potentially fewer workers. The testing of the batteries includes extensive safety checks. Workers have to acquire special training and certification, which the company provides through its highly developed internal vocational training system.

In general, the work process in Li-ion battery manufacturing is relatively differentiated in its various stages and segments, but its basic characteristics are similar to industrial production known from the metal and electronics sectors. Much of the existing knowledge on practices of decent work, workforce training and occupational safety and health can be applied to this field. For the core process of battery cell manufacturing, there exist no viable studies on the chemical and toxic risks for workers. The existing Chinese and international literature on health hazards in battery manufacturing mostly deals with traditional lead-acid batteries.

According to our observations, working conditions and workforce in the battery industry resembles those of other manufacturing industries, such as electronics or automotive supply. The majority of workers are low to medium-skilled. They are paid according to the general local standard wages in electronics factories in the GBA (around 5,000–6,000 RMB per month for lower-skilled and 6,000–8,000 medium to higher-skilled assembly workers and equipment operators). There are relatively few skilled maintenance workers, since maintenance and calibration of equipment is mostly performed by engineers with college degrees.

As in the GBA in general, most workers including the higher-skilled ones and engineers have a migrant background from rural areas of Guangdong or other provinces. Production workers are housed in dormitories, either on company premises or in rental

facilities in industrial areas. Higher skilled workers live in apartments provided by the companies or in private housing areas. Under the existing rules and regulations, migrant workers have no long-term residency in the cities of employment and have only limited access to social services, schools and government subsidies for housing, etc. Therefore, the turnover among the local industrial workforce remains high, also among higher-skilled employees.

Given the rapidly emerging technologies and manufacturing know how, the definition and enforcement of comprehensive and systematic safety standards can be considered a key challenge of production politics both at the shop-floor and at industry and global levels. According to a recent analysis by Siemens and the German TUV on fire-safety standards for Li-battery manufacturing, there are no industry-wide standards or accepted best practices for most generic processes. Most elements of the production process are still immature and developing quickly, and the companies closely protect their manufacturing know how. This is particularly true for China, since it has the most diverse manufacturing base, and production and technologies are developing particularly rapid. Therefore, comprehensive models and strategies of risk management would be needed to standardise basic elements of occupational safety and health. Such an effort would need to be global in scope and would have to include a broad spectrum of stakeholders (2022 field interviews).

6 Industrial policies and working conditions

The transformation of production networks is creating increasing pressure on the established regimes or production in the Chinese car industry and leads to direct competition between the production practices and social standards of established and new car and component makers. Obviously, there is a need for an integrated institutional framework that connects topics of labour rights, collective bargaining and workers education with public and workplace safety standards, as well as with broader industrial policy goals. Given the scattered multi-level nature of China's industrial and labour policies, unified implementation of advanced environmental, safety and work standards appear difficult.

Industrial policies have an important influence on the general development of conditions of production and work in NEV manufacturing, and they potentially can support standardisation of working conditions. In recent years, China has substantially changed and tightened its subsidy policy. There is a shift away from the early policies of setting production quota for NEV, supported by generous government subsidies for NEV buyers, towards quality-oriented goals. Even in the wake of the pandemic, the government did not return to previous subsidies. At the core of present industrial policies are improved regulations for product and environmental safety and ambitious efforts for the recycling of used Li-ion batteries. The tightened subsidy policies itself have an upgrading effect on quality and environmental standards. However, health and safety supervision and environmental regulations on lithium-ion batteries remain relatively loose and policy implementation shows large deviations among localities.

'Top-level design' of policies occurred only recently. In July 2021, China's major economic policy decision-making body, the National Development and Reform Commission published a comprehensive document, which for the first time highlights the

importance of NEV battery recycling in a national development plan (NDRC, 2021). The establishment of standardised recycling outlets through NEV manufacturing or battery recycling enterprises is the key goal. This policy has been supported by several directives of the Ministry of Industry and Information Technology (MIIT) between 2018 and 2021 on industrial standards for Li-ion battery production and recycling (MIIT, 2018, 2021).

Obviously, these policies tend to raise the standards of production at factory level and have an important influence to generalise high-level safety and environmental standards. However, China has no dedicated policies on production safety and occupational health in battery manufacturing. The general legal and regulatory framework for labour standards has been established under the country's relevant labour laws, namely the Labor Law, the Production Safety Law, and the Occupational Disease Prevention Law. The standards in these laws apply to all types of workers, including contract workers in informal employment. The production, import and use of equipment or material that may cause occupational hazards are banned by law. However, there are hardly any laws or regulations specific to NEV manufacturing, and the increasing competition between different industry players with diverging regimes of production will increase the difficulties to implement centrally developed health and safety standards at the level of firms and regions.

The differences in the functioning of these production regimes and their interaction with the state at various levels became visible during the economic turmoil created by the COVID-19 pandemic[1]. As state-controlled enterprises, the big joint ventures in the traditional car industry closely followed the rules of national and local governments on lockdowns and public health control. In major car industry centres such as Changchun, Shanghai, Wuhan or Guangzhou production was closed during lockdown periods in the beginning of 2020 and in the spring of 2022 (Shanghai and Changchun). Procedures were closely coordinated with local authorities and shutdowns of major car factories were reported in the media as benchmark practices in the respective regions. In 2022, major joint ventures in Shanghai and Changchun practiced 'closed-loop' production, during which workers had to live in makeshift housing in canteens or sports complexes inside the factory area. During shutdowns, workers received their basic wages, but lost overtime and bonus payments. Under the corporate-bureaucratic regime of production companies aimed at workforce retention, although the Chinese system does not provide any direct income subsidies for workers during disruptions of production (such as the German system of 'Kurzarbeit'). Since the base wage in most auto joint ventures contributes 2/3 or more of workers' real monthly wage, most workers still received a basic income during the pandemic. In the wake of lock downs, production could be restarted relatively quickly, since the workforce was retained – obviously a competitive advantage of relatively stable employment relations under the corporate bureaucratic regime.

Private-owned NEV makers pressed much harder for continuation of production during lock-downs. The most prominent example was the Tesla factory in Shanghai, which was among the first to receive special permission from the local government to reopen production during the complete lockdown of the city in May 2022. This was reported as a model case of Shanghai's efforts to keep production of important multinationals running. However, the factory was not well equipped for this endeavour, most workers had to sleep in production areas. They only received a bonus of about $50 per week and had to work 10-hour shifts on six days per week, which is illegal under Chinese labour laws (Caixin, 2022; Financial Times, 2022b). In contrast, BYD was much more successful in retaining constantly high production volumes during the second phase

of the pandemic in 2022. The company relied on its network of large production facilities in central and western provinces, namely its industrial park in Changsha, the capital of Hunan province. Most of these areas did not experience extended lockdowns in 2022, and their supplier networks outside of major car manufacturing centres kept working. In these locations, as well as at its headquarters in Shenzhen, BYD received generous support from local governments for closed-loop production, favoured by the fact that most front-line workers live in dormitories on factory premises (Financial Times, 2022c). Obviously, this resulted in questionable practices inside the factories. In Changsha, citizens living near the factory protested against increased toxic emissions from BYD facilities in the first half of 2022. Chinese social media also reported about suicides among three workers in factory dormitories. However, the information was taken down very soon and could not be verified (Financial Times, 2022a).

The social and health risks of the regime of flexible mass production became visible in a major labour conflict at Tesla supplier Quanta during the lockdown in Shanghai in the spring of 2022. The world's second largest contract manufacturer from Taiwan has an industrial park with 40,000 workers, most of them housed in dormitories. Besides a very large production of notebook computers for Apple, the factory manufactures substantial volumes of electronics systems for Tesla. Quanta set up closed-loop production on 18 April with about 5% of workers, or 2,000 employees, with plans to triple that soon. All employees had to stay in the factory dormitories during the entire the lockdown of Shanghai. After more than 60 days of lockdown, the employees decided to break through police lines, so they could go buy food. The COVID virus had spread inside the dormitories and workers were desperate to get out of the factory. Chinese social media showed massive confrontations between factory guards and workers (Automotive News China, 2022a).

7 Conclusions: challenges for labour

In the broader context of the restructuring of the Chinese car industry, the work regimes in the emerging NEV and components sector can be considered as an important element of what has been described as the 'Foxconnisation' of car manufacturing. Most of the new industrial players have adopted indigenous Chinese regimes of high-performance production or flexible mass production. Employment in these companies represents lower to middle standards of work and pay in China. Only in NEV assembly and configuration facilities that are connected to core carmakers and their joint ventures working conditions and pay are at the level of established first-tier companies. Official trade unions have an established presence at state-owned carmakers and their joint ventures, but they do not play a strong role in setting the standards of wages and working hours. Collective contracts and bargaining procedures only exist at company level, there are no industry-wide labour contracts or wage standards.

However, decent work in manufacturing is a key issue to make the new-energy vehicle industry sustainable and to ensure social standards in the green transformation of the automotive sector and the global economy. In developed industrial countries as well as in China, trade unions are key actors in this field and should develop their activities based on systematic analysis of supply chains and industry structures. Industrial unions should develop *industry-wide perspectives* of securing labour, environmental and safety

standards. As the development in China shows, NEV production is emerging as a diversified industrial sector with different types of firms and specialisation and with a high degree of local clustering. Such an environment provides the conditions for industry-wide organising, collective bargaining, and industrial policies.

However, union strategies for the automotive sector must go beyond securing the traditional interests of core carmakers and their workers. Unions must rather define new strategic goals that include workers in the battery industry and along the global supply chain of mining, refining and materials production as well as the strategically important recycling sector. Industrial unions should promote industrial policies that support diversity within the battery sector, rather than engaging in a global technology race based on the creation of mega factories with large amounts of government subsidies. The current policies in Europe and the USA to catch up with battery cell producers from China, Japan and Korea support such a technology race in the name of 'supply chain security'. The experiences from local industry clusters in China offer strategic perspectives of diversified development that may also be conducive to the conditions of industrialised countries. Such industrial policies can also help to counterbalance an emerging oligopoly of global battery makers in conjunction with large carmakers.

Industrial unions should support open markets together with strong *multilateral social and environmental standards*. Given the global structure of supply chains and the position of China and other emerging economies in production and innovation, 'decoupling' and protection of national or regional markets is not possible and not practical for workers and trade unions. This is also true for the mining and materials sector, which needs viable global standards and enforcement within multilateral institutions and agreements. Transnational agreements on trade, investment, and technology should include such standards, international trade unions should actively engage in relevant projects. The investment agreement currently under negotiation between the EU and China, for example, should not only contain protections for investors, but also for workers and communities.

The representation of workers and trade unions in the Chinese NEV industry apparently is weak. However, in global perspective this situation seems to represent the norm, rather than an exception. *Organising* the fast-growing NEV battery industry, obviously, has to be a top priority for industrial unions. As known, Chinese trade unions do not engage in such activities and labour relations are mostly dominated by the state. But industrial unions could promote the organisation of employees of newly built battery factories of major producers from China and South Korea in North America and Europe. Recent experiences from companies with Chinese ownership in Europe show that many Chinese multinationals accept local labour laws and standards, including works councils and trade unions.

Industrial unions should seek *cooperation with Chinese trade unions* and experts from government, companies and relevant organisations. The joint ventures of international carmakers can provide an important platform, some of which have developed regular communication between trade unions at company level. The facilities of Chinese battery makers in Europe could create similar channels in the future. Given the scarcity of information on key questions of industrial, environmental and social development of battery manufacturing, we need further studies of production models, supply chains and labour processes. Industrial unions should initiate *health and safety studies* on core processes of battery manufacturing and establish communication with Chinese trade unions and experts on questions of working conditions and work safety.

Supply-chain monitoring and due diligence by stakeholders at multinational carmakers can play an important role to raise awareness and promote communication. In China, this would require communication with and through the joint ventures of the respective companies. Importantly, comprehensive risk assessment cannot be achieved by legal standards and regulations alone. It must be based on bottom-up participation of workers and there must be some institutional arrangements between capital, labour and environmental stakeholders to coordinate and supervise workplace standards.

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Notes

1 The following is based on direct interviews with company and local government representatives during the respective periods in 2020 and 2022, and on reports from companies and trade media.