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Going Digital, Going Green: Changing Value Chains and Regimes of Accumulation in the Automotive Industry in China: A conceptual framework for understanding the transformation of China's car industry

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Abstract

This paper analyzes the changes in production and innovation networks in the automobile industry in China that have resulted from the transition to new-energy vehicles and digital driving technologies. This transformation is seen as a fundamental break with the present “neo- Fordist” regime of accumulation in the car industry and a rise of new forms of network-based mass production, comparable to the IT industry since the 1990s. The paper traces the complex politics of this transition embedded in different modes of regulation in the Chinese automotive sector, its impact on work and regimes of production, and the perspective of a broad-ranging “Foxconnization” of car manufacturing.

Keywords: China, automobile industry, production and innovation networks, new-energy vehicles, digital-driving technologies

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Introduction

Digitalization and the rapid emergence of new-energy cars and new mobility systems are beginning to drive a massive restructuring of production models and value chains in the global car industry. The underlying changes in the base technologies of driving, propulsion, and control of cars and traffic constitute a cluster of potentially disruptive innovations that the automotive industry has not seen in decades. Continuing structural overcapacity in car production, the frequent breakdown of car traffic, and the related ecological crisis in megacities around the globe—as well as the continuing emission cheating scandals surrounding major auto makers—are driving a broad-ranging process of restructuring that puts into question the existing regime of capital accumulation in the global car industry. In addition, the emerging forms of new and shared mobility undermine the model of private car ownership as the dominant norm of consumption on which the growth of the automotive industry had been based since the days of Henry Ford.

China is at the center of this process. The unprecedented build-up of state-of-the-art car production capacity during the past decade has made China the largest market and production site for cars worldwide. Since the early 2000s, the rapid growth of automobile production and consumption in China has provided a safety valve for structural overcapacity in the global car industry, but it has also presented the country with serious environmental and social problems. More recently, the Chinese government had initiated a set of policies to rapidly develop new-energy cars and new mobility systems (Muniz, Belzowski, and Zhu, 2019). The goal is to leapfrog industrialized countries in technologies, innovation networks and the value chains of future mobility (Wand and Kimble, 2011)

Will the government-driven big leap forward in car technologies and mobility be disruptive to the existing model of “post-Fordist” mass production in the Chinese automotive industry?

This paper proposes a conceptual framework and empirical arguments to help understand the structural changes in Chinese automobile production models, value chains, and innovation strategies. The concepts refer to regulation theory, theories of global production networks, and analysis of China as an emerging variety of capitalism developed in recent years (Lüthje, McNally, and ten Brink 2013). The restructuring of the industrial and innovative basis for Chinese car manufacturing will be examined as a complex transformation of the *regime of accumulation* and its *social norms of production and consumption* (Aglietta 1979). The competitive structure of the Chinese car industry, enshrined in the joint ventures between multinational carmakers and Chinese state-owned enterprises, will be analyzed as a specific mode of regulation, named “refurbished state-capitalism” (McNally 2013). This industry model is now being challenged by the new industrial players in new energy and digital car technologies. Many of them have a background in electronics manufacturing and are heavily supported by China’s Internet and e-commerce

giants. Together, this sector represents a different mode of regulation, which can be called “network capitalist” (for a systematic theoretical analysis see Lüthje forthcoming).

Based on ongoing empirical studies, this paper will trace the major contours and fault lines of the emerging tectonic shifts in the Chinese car industry. The first section will explain the theoretical framework of this analysis related to theories of global production networks and value chains. The second section provides an analysis of the mode of regulation that has governed growth and capital accumulation in the Chinese car industry since the 1990s. The third section draws a taxonomy of disruptive forces emerging from independent carmakers; producers of new-energy vehicles (NEV), digital car technologies, and batteries; suppliers of car components and parts; and electronics contract manufacturers. The fourth section looks at the potential impact of these forces on models of production and work in the emerging sectors as well as the potential impact on existing carmakers. The conclusion will outline major policy challenges.

The “neo-Fordist” car industry under stress: Late revenge of “Wintelism?”

Current changes in the car industry do not merely represent a new technological paradigm. They constitute a comprehensive rupture in the production models, innovation strategies, and corporate structures that were established with the “Fordist” model of mass production in the 1920s and revised under the so-called lean production revolution of the 1980s and 90s. The new changes can be compared to the transformations of other mass-production industries, in which “post-Fordist” restructuring led to a fundamental reversal of production models and value chains—such as in information technology (IT) and electronics (Borras and Zysman 1997; Lüthje 2001), textiles and garments (Bair 2002), and footwear and furniture (Gereffi and Korzeniewics 1994)—during the 1990s. As in those older cases, the present changes in the car industry imply deep-ranging shifts in the international division of labor and the shape of global production networks.

The automotive industry has often been portrayed as the paradigmatic example of “Fordist” mass production and consumption, governed by strong bargaining relationships between employers and trade unions (Aglietta 1979). In the wake of the economic crisis of the mid 1970s, the industry has been at the center of the restructuring of production models through lean production and modularization (Womack, Jones, and Roos 1990). This restructuring has enabled a refurbished model of car consumption with a greater variety of models, market differentiation and segmentation, and significantly shorter model cycles. The accumulation regime continued to rely on private car ownership as the primary norm of consumption for households, however (Kingsley and Urry 2009). This pushed mass production and thereby capital concentration in the car industry to ever larger dimensions and limited flexible specialization as an alternative pathway of capitalist production and growth (Piore and Sabel 1984).

Related to the basic trends of technological change, four sets of disruptive factors can be traced, which are relatively independent from each other but interrelated (Gao, Hensley, and Zielke 2014, McKinsey 2016). These are:

1. **New energy vehicles (NEV):** Electrification of the car promises a solution to the major environmental problem of car-based mobility, carbon emission. It therefore offers a lifeline of survival for the established growth model of the car industry (Tyfield 2018) but renders much of the know-how and skills of established carmakers obsolete and radically reduces the labor content of car making (by as much as 50 percent according to earlier estimates (HBS 2012)). It also brings in new players from the field of new-energy components, especially car batteries and power-management systems.
2. **Digital driving and control systems:** Digitization of driving brings in the big players of the IT industry, their models of innovation and market control, and their financial power, including venture capital. This development challenges the traditional innovation cycles of the car industry and implies a potential shift of market control from brand-name manufacturers to providers of key components of digital driving systems and their related partners in big data and artificial intelligence (McKinsey 2016).
3. **Mobility networks:** Digital mobility is the main driver breaking up the model of private car ownership as a dominant norm of consumption (McKinsey 2016). It shifts the center of innovation downstream to the networks and applications that enable the shared use of cars, comparable to other mass-production industries with “platform-based” models of innovation, such as mobile telecommunications (Thun and Sturgeon 2017), where the hardware and its brand name are becoming a less important element of competition than software apps and networks. At the same time, car sharing and other mobility networks de facto become public infrastructures (Srnicek 2017) that affect the requirements for the development of the hardware products.
4. **Digital manufacturing:** The car industry, so far, has not been a great promoter of industry 4.0 and other forms of advanced digital manufacturing, mostly because the industry has been highly automated already (Butollo and Lüthje 2017; Pardi, Krwindzinsky, and Lüthje 2019). The disruptive potentials of digital manufacturing lie in the new possibilities for flexible specialization that can combine high-volume manufacturing with unknown degrees of customer-specific design and ordering. Up to now, these potentials have hardly been explored, but they can enable flexible specialization along the supply chains in the manufacturing of green and digital cars that may render the traditional model of mass manufacturing obsolete and undermine the dominance of brand-name firms over the industry (Ali Research 2016; Tu 2017).

Disruptions “from outside” are related to the internal problems of the traditional accumulation regime of the “neo-Fordist” car industry. The industry has been plagued by structural overcapacity since the 1980s,

particularly in the wake of the global financial crisis of 2008–09. China and other emerging economies provided a “safety valve” to maintain global growth in the face of severe disruptions in developed-country markets, helping to postpone substantial restructuring of the dominant accumulation regime (Lüthje and Tian 2015). This was backed by tacit coalitions between global carmakers, trade unions, and mainstream political parties to protect the car industry and related jobs. The delayed restructuring of the recent decade resulted in a massive political crisis, propelled by the emission-cheating scandals of Volkswagen and other global carmakers in 2015/16, often referred to as the “Fukushima of the car industry”.

In the wake of these developments, conditions can be compared to the traditional IT and electronics industry on the eve of the personal computer (PC) and Internet “revolutions” in the late 1980s. The incumbent global champions—vertically integrated computer, chip, and telecommunications equipment makers such as IBM, Siemens, and Fujitsu—were challenged by newcomers such as Microsoft, Intel, and Cisco. These companies not only pioneered sweepingly disruptive technologies, but they brought in a whole new model of innovation and industry organization that became known as “Wintelism” (Borras and Zysman 1997). The new model was based on vertical disintegration and specialization, industry-wide modularization of core components under “open-but-owned” standards, and the separation of product innovation from manufacturing. As brand-name control transitioned from final assemblers to component suppliers, the “assembly-oriented model of innovation and market control” (Borras and Zysman 1997) in traditional mass-production industries, such as electronics, cars, textiles, and garments, was fundamentally challenged. Manufacturing was shifted to a new brand of vertically integrated contract manufacturers such as Flextronics and Foxconn that created massive manufacturing sites in Mexico, Eastern Europe, South East Asia, and China (Sturgeon 1997; Lüthje 2001).

At the time, the question was raised whether vertical disintegration and contract manufacturing could become a model for car assembly or components manufacturing as well. But there remained consensus that the dominant model of vertical integration in the car industry, i.e., modular supplier pyramids dominated by final assemblers and their production architectures, would basically stay intact (Juergens and Sablowski 2004; Lüthje, McNally, and ten Brink 2013). Seen from this perspective, the current restructuring of the car industry may appear as some kind of late revenge of Wintelism over the Toyota model. IT and Internet giants, as well as some NEV carmakers and car suppliers, are driving new forms of organization that mark a break with the refurbished Fordism of global carmakers. Similar to the “PC revolution,” and perhaps even more so, restructuring is driven by massive financing of innovation and pushes the logic “of vertical fragmentation and centralization” (Ernst and O’Connor 1992) into the car industry.

Triple alliances and refurbished state capitalism: Accumulation and regulation in the Chinese car industry

Whether and how the forces of vertical disintegration and contract manufacturing can transform the structure of the car industry has to be assessed in the context of the changing patterns of global restructuring and the historically new role of large emerging economies within the international division of labor. The driving forces are much more complex than just government subsidies or ambitious industrial policy goals (Chen and Midler 2016). The green-digital transformation of the car industry is evolving within a distinctive dynamic of vertical specialization and re-integration. It is embedded in the regimes of accumulation and modes of regulation shaped by national conditions in the key regions of the global car market, now including China and other emerging economies. The regime of accumulation and the complex politics in China are essential factors shaping the current process of restructuring. Global production networks function in and are shaped by different national contexts, depending on the national state and its strength or weakness in controlling economic and social power relations in the relevant fields (for a fuller discussion, see Lüthje et al. 2013).

China's automobile industry, now the largest in the world, has seen a double transformation during the past two decades. The 1990s were dominated by the massive restructuring of the major state-owned automobile firms of the Mao period on the one hand, and the emergence of first-generation joint ventures between local state-owned holding companies (such as Shanghai Automotive) and foreign carmakers such as Volkswagen on the other. The car market was relatively undeveloped during that period (Thun 2006). Since around 2000, a huge influx of foreign investment introduced a new series of joint ventures and a major modernization of production under various models of lean manufacturing. This surge of investment in advanced technologies and manufacturing systems has created a production base comparable with that of industrialized countries, including a growing array of design and development activities (Lüthje and Tian 2015).

The norms of production and consumption in China's automotive sector today mirror the globally dominant model of flexible mass production of standardized car models in large varieties. It is based on modular, company-specific platforms, promoted by the major producers, on the side of production, and on private car ownership among large sectors of the population on the side of consumption. Different from the newly emerging automotive industries elsewhere in East Asia (South Korea in particular) and in Latin America in the 1990s, the Chinese auto industry has not followed an export-oriented development model. Rather, Chinese joint ventures have mainly served the domestic market. The key policy goal was to transfer state-of-the-art technology and manufacturing know-how to Chinese carmakers (Lüthje and Tian 2015).

In spite of this strong domestic-market orientation, the rapid growth of the auto industry in China is not a replay of the success story of the industry in the West during the golden days of Fordism. Mass car ownership remains restricted to urban middle classes with incomes above the level of most manufacturing and agricultural workers. The growth of the industry cannot rely on rising income levels of large sectors of the working population. Rather, it is heavily dependent on extensive investment in infrastructure, subsidized fuel prices, and accelerated urbanization. The auto industry thereby reflects the general accumulation model of China's emergent capitalism, which favors fixed-capital investment over the growth of mass incomes and consumption (Eurasia Group 2011; Lüthje, McNally, and ten Brink 2013; Hung 2016).

The production networks of the car industry in China mirror the lean production model with relatively slim core factories for car assembly and global-local pyramids of first-tier system suppliers and second- and third-tier parts manufacturers (Zhang 2015). The automobile industry's supply pyramid is embedded in a highly segmented structure growing out of the sector's trajectory of capitalist transformation. The top layers of production networks—assembly of cars and some strategic components (engines in particular)—are controlled by joint ventures. The middle and lower tiers of the supply pyramid are mostly owned by private local, foreign, and overseas-Chinese investors, usually with little access to high-level government resources. Multinational first-tier car suppliers have expanded rapidly in China, including sizeable research and development operations. However, the overall picture remains dominated by heavy cost competition and labor-intensive production processes with relatively limited industrial upgrading (Lüthje and Tian 2015).

Against this background, the accumulation regime of China's automobile industry is split into a capital-intensive "high end," dominated by Chinese state-owned enterprises (SOE) and their multinational partners, and a "low end" in which multiple strategies of accumulation prevail. The automotive industry represents a predominantly *state-capitalist mode of regulation* at the core, formed by the joint ventures of Chinese state-owned carmakers with multinational brands and top-tier global car suppliers from North America, Europe, and East Asia. Each Chinese SOE has joint ventures with several global auto companies. Often, competing brands are involved in joint ventures with the same SOE. Shanghai Automotive, for instance, partners with both Volkswagen and General Motors. Among the six biggest Chinese carmakers, three are majority owned by the central government (FAW, Dongfeng, and Chang'An), and three are majority owned by the local governments of big cities (Shanghai, Beijing, and Guangzhou Automotive Groups).

The big six have ample access to the economic and political resources of local and national governments. They are integrated into national strategies to enable technology transfer and develop domestic car brands. The government is also heavily involved in the regulation of structural overcapacities and over-accumulation, epitomized by the massive financial subsidies to car buyers that kept the industry afloat during the 2008–09 financial crisis (Lüthje and Tian 2015). Compared to other state-capitalist sectors

of the Chinese economy, where joint ventures play a more limited role and pure SOEs prevail (e.g., in petrochemicals or steel), the automotive market is much more competitive and subject to global pressures on profits and capacity utilization.

There remains a fairly large number of smaller enterprises owned by local governments, especially producers of vans and light trucks, which have resisted competitive consolidation under major SOEs or joint ventures. At the same time, some smaller carmakers under private or “hybrid” ownership, such as Geely, Chery, or BYD, have emerged that have been able to challenge the large SOEs in some important markets. The smaller indigenous Chinese carmakers that are not part of joint ventures are either owned by local governments of cities or townships (e.g., Chery) or by private investors, often with some involvement from local governments. These companies have developed extensive production networks at local and regional levels, and they receive support from interventionist local governments to build supplier networks, infrastructure, and technological resources. This type of regulation can be called *network-capitalist* (Lüthje forthcoming).

Compared to the relatively coherent state-capitalist core of car making, the ownership structure of China’s automotive supply sector remains scattered. Among first-tier suppliers, global firms—either with foreign direct investment or in joint ventures with Chinese SOEs—are dominant. At the lower tiers of the supply chain, privately owned and hybrid companies of all sizes can be found along with overseas-Chinese enterprises from Taiwan or Hong Kong (Lüthje, Luo, and Zhang 2013). Generally, there is strong integration at the first tier, but disintegration among second- and third-tier suppliers. At the second- and third-tier levels, there are many collective-owned enterprises based in townships or villages. These are mostly allied with local township or village governments that provide cheap land, workers’ dormitories, and “flexible interpretations” of laws and regulations. This mode of regulation can be called *market-despotic* (Lüthje forthcoming).

This quasi-monopolistic structure was relatively efficient in guiding the massive restructuring of the Chinese car industry in the late 1990s and its great leap forward into state-of-the-art production technologies and networks. The cost of restructuring in the wake of the industry’s marketization during the late 1990s could to a significant extent be shifted to car buyers, tax payers, and in some cases foreign joint venture partners (Thun 2006). State-capitalist regulation has also been critical to support the massive geographic expansion since the financial crisis of 2008–09. Last but not least, the existing mode of regulation has been instrumental in the globalization of Chinese state-owned carmakers as investors and shareholders in multinational car companies (such as Beijing Automotive in Daimler and Dongfeng in PSA). Chinese SOEs have emerged as a new type of multinational player, without brand name but with deep pockets—an unprecedented phenomenon in the global car industry. All these factors have essentially strengthened the state-capitalist mode of regulation in the wake of the 2008–9 crisis.

Given the challenges of economic rebalancing and changes in the global car industry, however, serious doubts have been voiced about the efficiency of this framework. The state-capitalist mode of regulation not only curbs competition and encourages oligopolistic pricing behavior (Yang 2014), but it also limits innovation. The major players put substantial resources into the adaptation of foreign car models to the Chinese market but show little interest in sharing core innovations in components, car concepts, or new technologies. This points to systemic contradictions between the overall goals of government policies, the profit-making strategies of individual companies, and the interests of the state as a shareholder (Liu, Lüthje, and Pawlicki 2007).

Most problematic, however, is the fact that this structure is reproducing the bi-furcated regime of accumulation with high profits at the top and massive pressure on suppliers, especially those at the bottom of supply chains. It leads to continuing heterogeneity of supplier networks, impedes the development of a technologically viable component industry, and limits the scope for industrial policies at the local and regional level to develop innovation and production networks for digital car technologies and new-energy vehicles (Lüthje and Tian 2015).

Disruptive forces: The challenge of network capitalism

The disruptive forces reshaping the global car industry in China manifest themselves within the segmented regulation of the automotive sector and within China's emergent variety of capitalism in general (McNally 2013). The entry of rapidly growing new players potentially undermines and reshapes the present model of state-capitalist regulation since it brings in innovative firms from the "unconsolidated," non-state-capitalist sector of the car industry (independent car and NEV makers as well as component producers), from the IT industry, and from global and Chinese car suppliers. Significantly, the Chinese government increasingly relies on such new industrial actors, taking account of the success stories within the country's IT and other industries that followed trajectories different from the joint-venture model.

Here, again, the IT sector provides the key reference for the changes in accumulation regimes and for the fundamental shifts in China's innovation system in recent decades. The successful development of Chinese IT brand-name firms, such as Huawei, Lenovo, and ZTE, into national and global lead firms was achieved in the absence of or in competition with joint-venture strategies. In the telecommunications industry, joint ventures of SOEs with global players such as Ericsson, AT&T, and Siemens were designed in the 1990s to trade technology transfer for market access. The Chinese partner firms reaped substantial profits from making and selling foreign-branded telecom equipment in rapidly growing urban markets, but they failed to develop brand-name products and services for the huge markets in rural areas. This was left to newcomer firms such as Huawei that combined expertise in undeveloped markets with rapid adaptation of

leading-edge technologies from the evolving Internet equipment industry in Silicon Valley (Pawlicki 2015; Thun and Sturgeon 2017).

The push by the Chinese government to expand the NEV sector by imposing production quotas for fully electric vehicles (10 percent in 2018, 12 percent in 2020) has already produced a significant change in investment, while carmakers suffer from sluggish sales and mounting overcapacity. In 2017, growth of light-vehicle sales slowed to 1.4 percent from nearly 15 percent a year earlier after the government phased out parts of the tax cuts enacted in 2015 to bolster slowing sales of smaller and medium-sized vehicles (*Automotive News China*, January 12, 2018). In 2018, the Chinese market for passenger cars contracted for the first time in recent history. In the first half of 2019, sales of passenger cars fell by 14 percent (*Financial Times*, July 10, 2019). The massive build-up of capacity by the joint ventures that has dominated the scene since 2008–9 has come to a halt just as construction of most joint-venture assembly plants permitted in recent years is nearing completion. Factories are reporting idle capacities. In some cases, such as Beijing-Hyundai, plant closures are imminent (*Automotive News China*, March 8, 2019).

New production capacities are mostly being added by independent carmakers and NEV producers. Geely in particular has opened three plants in the past two years, bringing production capacity to 1.7 million cars per year. In 2017 alone, 14 NEV startups in China were granted production licenses, and most of these companies have started building factories (*Automotive News China*, January 12, 2018). According to the China Association of Automobile Manufacturers, annual capacity for the production of pure and plug-in-hybrid electric cars will hit 2 million in 2019, and a large number of additional NEV startups are expected to start production by 2022 (*Automotive News China*, May 31, 2019).

The emerging landscape of new indigenous players in the Chinese car industry can be grouped by technology clusters, business models, and their relationship to the world market. They are:

1. **Independent car and NEV makers with a background in the auto industry, such as Geely, Cheery, JAC, and BYD:** These companies represent the “unconsolidated” segment of the traditional car industry, with some recent success in capturing low- to mid-end markets on the basis of innovative design, creative imitation, and low production costs. Some key companies have strong exposure to global markets, such as Geely with its acquisition of Volvo, London Taxi, and Lotus, and BYD with its financial ties to Warren Buffet and its NEV joint venture with Daimler (named Denza). With a diverse product portfolio of small and medium-sized cars as well as buses and utility vehicles, BYD has sold more electric vehicles than any competitor worldwide (*Financial Times*, October 24, 2017). Geely has embarked on a highly ambitious strategy to convert its Volvo brand completely to NEV, starting with the joint internal development of components and the use of a low-cost production system that the company created (*Financial Times*, October 15, 2017). Most of the independent car and NEV makers

have their own factories and are vertically integrated within Chinese-style conglomerates (jituan). They run extensive local production networks, designed to leverage cost advantages for local players (Balcer et al. 2014).

2. **Digital car and NEV start-ups backed by Internet giants, global venture capital, and Chinese business tycoons, such as NextEV/NIO, LeEco/Faraday, and Baoneng:** Most of these companies focus on the development of high-end vehicles, similar and in competition to market leader Tesla. They have received considerable publicity. Most are highly speculative. In the light of some spectacular bankruptcies, their market and financial success still needs to be tested (Financial Times, June 6, 2017). In contrast with Tesla, these companies focus on design and development and use contract manufacturers to assemble cars. NIO, for example, has chosen independent carmaker JAC as a contract manufacturer for its ES8 electric SUV, whereas Taiwanese electronics contract manufacturer Wistron supplies electronic control components and modules (*Digitimes*, January 8, 2018). Tesla announced in 2018 that it will build its own integrated plant in Shanghai with a planned capacity of 500,000 cars per year (*Automotive News China*, October 7, 2018).
3. **Integrated new-energy and battery producers:** Here, Chinese companies clearly have the strongest position in the world market (Fraunhofer 2016). BYD is a battery maker by tradition, originally a supplier of Li-batteries for computers and smartphones to Foxconn and other large electronics manufacturers. In 2017, the company was classified as the biggest producer of Li-batteries in the world, leveraging vertical-integration effects from various end markets such as cars, buses, IT, and solar and energy management systems (Sanderson, Hancock, and Lewis 2017). The second lead firm is CATL, a hitherto unknown battery maker from Ningde, a rural city in Fujian province, where China's president Xi Jinping once served as local party secretary. The company is expanding its production, with plans to reach a capacity of 50 gigawatt-hours by 2020, which would make it the world's largest producer. As part of a major globalization effort, CATL announced the construction of a factory in Erfurt, Germany, with an initial capacity of 14 gigawatt-hours per year to supply BMW, Volkswagen, and other major European carmakers with Li-battery cells. This plant is meant to be CATL's biggest manufacturing facility world wide (Dongfang IC 2019). In addition, China's major electronics-producing areas, the Pearl-River Delta in particular, have extensive clusters of small and medium-sized battery makers with production experience from the electronics industry. This line-up is completed by large Chinese manufacturing operations of leading battery makers from Korea and Japan. In 2017, eight out of the 13 major Li-manufacturing sites in the world were in China (Sanderson, Hancock, and Lewis 2017).
4. **Car suppliers:** Car suppliers play a key role in the transformation of innovation and production networks. The situation of this sector in China mirrors the segmented structure of supplier pyramids under the joint-venture model. First-tier transnational suppliers are engaged in the development of

digital driving systems, and they are preferred partners for the Chinese big three Internet companies. Bosch has formed a strategic alliance with Ali Baba and Continental with Baidu (*Automotive News China*, May 2, 2017). There is no Chinese car supplier of significance that could play the role of system integrator and potential global champion in the NEV and digital supply chain. The middle and lower ends of the Chinese car supply industry remain heavily dependent on joint ventures and, as a result, are only slowly adopting NEV technology and products. Some mid-tier producers of car electronics, e.g., Desai in navigation and entertainment systems, are aggressively moving into digital car technologies but remain at the rank of mass manufacturers of standard components. The recent spree of transnational investment by Chinese car suppliers is creating some new global players in traditional car components, e.g., Citic Dicastal in wheels and alloys and Luxshare's acquisition of ZFs steering and body control business (*Automotive News China*, September 8, 2017). The mounting cost pressures in the supply chain for new types of vehicles will further increase outsourcing at lower ends of the supply chain and potentially drive further polarization between technology companies and manufacturers.

5. **Electronics contract manufacturers:** Mostly based in Taiwan, electronics contract manufacturers already play a major role in supply chains for car electronics and are moving into NEV and digital car electronics. Electronics manufacturing services (EMS) giant Foxconn has operations in car electronics, including some major facilities in the United States, and acts as a supplier to Tesla, among others.¹ Given the increasing commodification of NEV and digital car components, large IT contract manufacturers appear as potential mass producers for driverless vehicle (DV) and NEV components. They are also securing positions as investors in start-ups of all kinds: Ali Baba and Foxconn invested \$350 million in a NEV startup named Xiaopeng (*Automotive News China*, February 2, 2018).

Overall, it can be said that forms of vertical integration, production models, and value chains are highly unstable and changing rapidly. Obviously, the NEV industry in China is evolving along a modularized pattern, composed of a set of sub-industries that provide the major components and systems. The changing landscape of production may induce a significant decentralization of the Chinese car industry, after years of government policies to consolidate the sector under national and big-city SOEs.

Traditional carmakers—globally and in China—have recently responded with massive investments in NEV. Companies such as Volkswagen and Ford are planning to produce electric versions of most car models in the near future, and Volkswagen has announced that 50 percent of its sales in China will be NEV (*Automotive News China*, July 5, 2019). Volkswagen has created its own global platform, concentrating NEV manufacturing in two dedicated factories in Shanghai and Foshan (Guangdong Province), one for

¹ Foxconn CEO Guo Taiming stated that “Tesla’s EVs are virtually made in Taiwan” (*DT* January 8, 2018).

each joint venture. Among Chinese carmakers, Beijing and Guangzhou Automotive are leading the effort to “go electric.”

Traditional carmakers try to use their manufacturing expertise to keep the old model of vertical integration intact. Yet their production strategies for NEV appear to be highly modularized in ways that no longer resemble the existing hierarchical supplier pyramids based on proprietary technologies and product architectures. Volkswagen, BMW, and other global carmakers have decided to source battery cells externally under large-scale contracts with CATL and other East-Asian producers and to limit their own production activities to the assembly of battery cells into car frames. This model is already in place in relevant factories in China (2019 field interviews). At the same time, major carmakers are aggressively pushing cooperation and cost sharing under new alliances for NEV and self-driving technologies. In a major alliance with Ford, Volkswagen will license its newly developed platform for electric vehicles (called “MEB”) to Ford and potentially to other carmakers in the future (*Financial Times*, July 12, 2019). This represents a remarkable break with Volkswagen’s and other global carmakers’ traditional strategy to keep core manufacturing knowledge in-house.

The restructuring of production systems and value chains opens up considerable potential for flexible specialization. Production of specialty cars, delivery trucks, buses, and public-transport systems provides a major opportunity for growth of NEV. In these markets, as well as in passenger NEV, volumes tend to remain relatively small. Changes in technology as well as government regulations and standards require frequent changes in model line-ups and components. To cope with such insecurities, major Chinese firms tend to keep their operations highly integrated, but with low degrees of automation. BYD, in particular, pursues a strategy to produce new energy systems of all kinds (including smart phones, urban grids, and solar systems), in which cars are only one downstream product. Under this model, new-energy technologies are employed in a large variety of products and systems, and economies of scale are mainly leveraged on the side of battery production (Huizhou field research 2017).

In this context, new regional centers of production and innovation and new power relations between the central government and local and state governments are emerging. Most of the new players and industry segments are located outside traditional centers of car manufacturing. Shenzhen and the Pearl-River Delta (with BYD, Tencent, Foxconn, and a huge base of electronics manufacturing), Hangzhou (with Geely and Ali Baba), and Fujian Province (with CATV) can be seen as new core locations. These cities have proven relatively successful in the development of emerging industries and could therefore increase their clout vis-a-vis the central government. The forms of government-industry relations in these regions are essentially different from those in the traditional centers of the auto industry with their strong state-capitalist traditions. The new centers are governed by network-capitalist forms of regulation, with arms-length relationships between activist local governments and privately owned firms. Shenzhen, for example, started early to

build charging stations for electric vehicles and rapidly expanded the use of locally made electric vehicles in public transportation. The city now has the most complete infrastructure of this kind in China and is actively developing integrated supply chains for the production of batteries and NEV (2017/8 field interviews).

Regimes of production: “Foxconnization” of car manufacturing?

The changes in value chains have a potentially huge impact on work and employment in the car industry. Early estimates of job reductions among global carmakers indicate that substantially fewer workers will be needed for NEV manufacturing and that the traditional mechanical skills of car workers and engineers will be devalued (HBS 2012). The impact of changing value chains and relocation are not included in most studies, however. As demonstrated by the electronics industry, the revolutions in technologies and business models in the 1990s initiated a massive transformation of manufacturing, in the course of which most traditional computer and telecommunications production in industrialized countries was closed down or sold to contract manufacturers. Contract manufacturing became the dominant model of global electronics production, concentrated in the newly emerging mass production sites of China, Southeast Asia, Mexico, and Eastern Europe (Lüthje, McNally, and ten Brink 2013).

The situation in the car industry today is different in three major ways. First, massive state-of-the-art production bases have already been developed in China and in other emerging economies. Job losses due to transnational relocation have been less severe than in electronics, since most carmakers duplicated their production networks rather than using China as a location for low-cost export production. Second, the transformation of industry structures now plays out to a large extent within emerging economies. In China, this implies a break in the existing competitive structure and production models between the existing joint ventures in the car industry, with relatively favorable wages and working conditions, on the one side and competing independent carmakers and the IT industry on the other. The latter mainly rely on low-wage manufacturing workforces with high proportions of rural migrant workers. Third, the car industry, and NEV in particular, is involved in China’s massive efforts to automate and digitalize manufacturing, as outlined in the Made in China 2025 plan. Therefore, digitalization may become a major cause of job losses.

The sectoral transformation of China’s car industry also involves a complex restructuring and recombination of the existing regimes of production. These regimes of production, in turn, shape the trajectories of digitalization and automation at the shop-floor level (Lüthje and Butollo 2017) as well as the larger transformation of production and supply chains (Lüthje, Luo, and Zhang 2013).

Joint ventures: In China’s existing joint ventures, the globalized model of state-capitalist regulation is aligned with regimes of production that combine the practices of transnational auto makers with the party-based management systems of their Chinese partners, resulting in the characteristic twin structure of

Western and East Asian corporate lean management and state-bureaucratic practices on the shop-floor (Lüthje and Tian 2015). Production systems are highly automated, but there has been no dedicated push into digital manufacturing or restructuring of supply chains. The core factories of the joint ventures suffer from increased cost competition, slower market growth, and government efforts to curb car prices and corruption. Massive workforce reductions and plant closures are imminent in major centers of car manufacturing in China.

Most carmakers have started to incorporate manufacturing of electric or hybrid vehicles into their existing production lines, adding new flexibility requirements for factory organization and workers. Increased pressures have led to workers' dissatisfaction over deteriorating pay, benefits, and employment prospects, especially for temporary workers. In one case—FAW-Volkswagen in Changchun—this led in 2017 to a massive labor conflict with temporary workers over principles of equal pay for equal work. The increased pressure on core workforces is potentially exacerbated by the fact that most foreign carmakers have set up new joint ventures or cooperative agreements with smaller Chinese carmakers to manufacture NEV, such as the joint venture between Volkswagen and JAC (2017/8 field interviews).

Independent carmakers and EV and battery producers: Most independent companies rely on vertically integrated production with high flexibility and workforces with wages substantially lower than those paid by the joint ventures. The rule of thumb among industry experts is about US\$9.00 as a standard hourly wage at the top joint ventures, as compared with US\$4.00–4.50 at independent carmakers such as Geely or BYD (*Automotive News China*, August 29, 2017). The lower wage scale is especially prevalent among companies with a background in the electronics industry such as BYD and most battery makers. Their regimes of production represent a high-performance type of labor relations, which has been copied from Korean, Taiwanese, and US models. Wages and employment conditions are fairly decent, but the system is highly incentive based. Skilled employees can achieve considerable extra income and promotions, but work organization is based on relatively low base wages and salaries, usually less than 50 percent of regular monthly incomes. Production workers, many of them migrants, are forced to work overtime to achieve a living income (Lüthje, Luo, and Zhang 2013).

The production systems of these companies are very flexible but 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 employing 20,000–30,000 workers and the other more than 70,000. Most of these workers are housed in factory dormitories, as is standard for electronics and other low-wage industries in the region. Work organization is highly flexible, designed to make relatively small volumes of quality vehicles with frequent changes in production runs and technical requirements. Automation is much lower than in joint-venture car plants; manual labor seems better suited than automation to meet the frequent changes in emerging industries, especially in final assembly. Battery

production has recently seen a significant push toward digital automation, related to the Made in China 2025 plan. Automation is mostly introduced to improve quality standards, since most standard procedures, such as ultrasonic welding of battery components, can be performed manually (2017/18 field research and interview data; IPRD 2018).

Electronics contract manufacturers: Electronics contract manufacturers are notorious in China for their poor working conditions and low wages. Their very large factories, many of them with 100,000 or more workers, represent a regime of flexible mass production that draws its unique characteristics from China's system of internal labor migration (Lüthje, Luo, and Zhang 2013). This regime is based on large-scale employment of rural migrant workers in coastal provinces or big-city inland locations with base wages at the local legal minimum and massive overtime work (often beyond legal limits). Work is extremely segmented and deskilled, designed to facilitate mass recruitment and lay-offs according to market conditions. Most workers are housed in dormitories, often under harsh living conditions. The social consequences of this regime have been amply analyzed, but conditions have not changed much in the course of China's rebalancing and industrial upgrading (Butollo and Lüthje 2017). With the increasing role of electronics contract manufacturers in NEV and digital car production, such working conditions are expected to penetrate supply chains. Leading trade unionists in developed countries speak of the "Foxconnization of car manufacturing".

Car suppliers: Car suppliers have diverse regimes of production, reflecting the segmented structure of the industry and their positions in the supply chain. First-tier multinational car suppliers have high-performance production regimes, while those in joint ventures with state-owned Chinese carmakers have state-bureaucratic forms (Lüthje, Luo, and Zhang 2013). The car-supply industry in China generally offers much lower wages than the core joint ventures, including first-tier multinationals such as Bosch or Denso. The lower levels of car suppliers are typically traditional low-wage industries, comparable to the flexible mass-production regimes in the IT industry or the "classic" low-wage environment of labor-intensive small and medium enterprises.

A recent study of the car-supply sector in South China indicated that the shift to NEV car manufacturing has not yet caused major restructuring at the middle and lower tiers, since most of the car manufacturers in the region still focus on traditional car technologies (Yang, Luo, and Lüthje 2019). Automation, however, is beginning to have an impact. Some Chinese second-tier firms, such as Desai or Citic Dicastal, play an important role in the Made in China 2025 plan and heavily promote factory automation. Although these companies have not yet adopted changes in value chains related to digitalization, automation does have a potentially large 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) lead to massive replacement of manual labor,

often affecting the most experienced workers in physically challenging labor processes such as machining of metal or polishing of stainless parts (Huang and Sharif 2017).

Policy challenges

This paper has developed a conceptual framework to help understand the “green” and “digital” transformation of the Chinese car industry and its implications for production models and value chains. Current changes are clearly disruptive for the established regime of accumulation in the car industry and its model of political-economic regulation. This process is not merely a result of heavy-handed government policies and subsidies to create “national champions” and Chinese global leadership, however, as the rhetoric of today’s “trade wars” suggests. Rather, these transformations reflect deep-ranging structural problems of the “post-Fordist” regime of accumulation in the global car industry and the strategies to extend and renew it in China in the wake of the financial and economic crisis of 2008–09. The segmentation of production networks and industrial policies established since the 1990s now shape the conditions and options available to address today’s complex shifts in technologies and social norms of production and consumption.

The phenomenal growth of the Chinese car industry after the dismantling of the socialist planning system has resulted in the re-development of state-of-the-art “post-Fordist” production systems in China led by refurbished state-capitalist Chinese carmakers and their joint ventures with global brands. This model has largely failed to create indigenous innovation and brand-name capabilities among established Chinese carmakers, however. The dominance of joint ventures has left little room for independent car firms and has continued China’s technological dependence on global brands. At the same time, the supply pyramids of the Chinese car industry have remained highly segmented, resulting in a polarization between first-tier joint ventures and a vast sector of lower-end suppliers that operate under market-despotic regulations and regimes associated with low-wage production. Technologically sophisticated Chinese tier-one car suppliers cannot develop under this model, and the number of specialized firms that can integrate digital electronics and advanced mechanics remains small.

Under these conditions, the massive shift in China’s industrial policies to NEV and digital car technologies, documented under the Made-in-China 2025 strategy, can be seen as a strategic break with the existing mode of regulation based on the alliance between multinational carmakers, Chinese state-owned carmakers, and the Chinese government. Such joint ventures are no longer regarded as potential “national champions” in the automotive sector.

This policy change has opened up the field to a growing array of new players, including independent carmakers, electronics component producers, and China’s big Internet firms. It opens the door for Chinese brand-name and technology leadership in core sectors of the future global car industry. At the same time, it

has changed the regional and spatial structure of innovation, with centers of private high-tech enterprise such as Hangzhou and Shenzhen taking the lead to support new energy infrastructure, shared mobility, and production networks for vehicles and components. China's industrial policy increasingly relies on network capitalism as a mode of regulation in these locations, eyeing the success stories of Huawei and other Chinese multinationals in the IT industry.

Under these conditions, many new players have emerged with core knowledge of NEV and digital-car technologies, but the structure of the industry is highly segmented and very much in flux. In spite of rapidly rising production volumes and the impressive scale of some Chinese players, there are no companies that appear to be potential “system integrators” of far-flung technology chains and production networks. The strongest players in hardware components are based in the field of battery production (CATL and BYD), with differing strategies of vertical integration. At the same time, there is a widespread separation of technological innovation from manufacturing, especially among the NEV start-ups. All this favors vertical disintegration—albeit in uncoordinated and sometimes chaotic fashion—and uneven regional distribution of various industry segments.

These transformations imply far-ranging changes in work and production regimes. China's NEV sector is mostly dominated by Chinese-style regimes of high performance or flexible mass production that are very different from the corporate-bureaucratic production regimes of the core joint ventures. Although the employment impact of NEV production has hardly been researched (not only in China) and is difficult to predict, it seems evident that the growth of independent carmakers, new component suppliers, and electronics contract manufacturers will lead to the growth of new segments of relatively low-wage, de-skilled mass production, employing large workforces of migrant workers in the Chinese automotive industry. These conditions have already been observed in the electronics industry as well as the lower and middle tiers of the car-supply industry. Upgrading employment conditions, labor standards, and vocational training in these sectors is one of the major challenges to make China a “strong manufacturing power” in this field. Yet these problems have hardly been addressed in the Made in China 2025 plan or in most local industrial policies (Lüthje 2017).

Will this transformation finally lead to a “Wintelist” restructuring of the car industry in China and globally? The industrial architecture of the emerging NEV sector is distinctively different from the “post-Fordist” car industry and its Chinese version under the joint-venture model. Clearly, the established structure of production networks in the automotive industry, which is dominated by final assemblers based on their proprietary production architectures, is under assault. But which will be the lead firms or system integrators in a vertically disintegrated car industry, defining the core technological standards and innovation platforms of the car or the mobility systems of the future? The question remains open.

Two scenarios can be derived from this analysis:

1. Refurbishing the vertically integrated mass-production models of global carmakers: This strategy underlies the present drive of traditional carmakers to “electrify” their products and to integrate large-scale manufacturing of NEV into their existing networks of production. This trajectory can build on the enormous capacity of global carmakers in research and development (R&D) and production, but it may lead to distinctively new forms of modularity under which key components will no longer be developed and produced by the carmakers themselves, but rather by vertically integrated component suppliers such as Panasonic, LG, or CATL in batteries or some global tier-one car suppliers and their Chinese Internet-platform partners in digital driving systems. Carmakers will remain potential system integrators or flagship firms, but this type of shared control over production networks will be very different from the “Fordist” or “Toyotist” models of vertical integration.
2. Emergence of a vertically disintegrated mass-production model similar to the electronics industry: Such a model would consist of layers of vertically specialized high-volume production separated between brand-name carmakers, providers of core components, and contract manufacturers. Unlike the “Wintel” transformation of the electronics industry in the 1990s, China now controls technologies and advanced mass-production capabilities in core hardware components, system software, and artificial intelligence, as well as key infrastructure technologies (5G). At the same time, China is the home of large-scale chains of network-based mass manufacturing, especially in its vast electronics manufacturing industries. In global production networks of this kind, however, brand-name control could still rest with global technology leaders in developed industrial countries. And network-based mass production in China’s car industry would most likely continue to offer poor wages and employment conditions to large sectors of the workforce.

Further developments in this transformation will depend on the political and social power relations that shape it. The challenge for China’s industrial policy is twofold. On the one hand, government policies have to further emancipate themselves from the innovative pitfalls of the joint-venture model and related strategies of “post-Fordist” mass manufacturing. On the other hand, a replication of the “Wintel” model under Chinese leadership, as currently pursued in the battery sector, has the potential to create segmented systems of mass production, in which product innovation remains disconnected from innovation in manufacturing processes and low-wage working conditions prevail (Butollo und Lüthje 2017; Lüthje and Butollo 2017).

Flexible specialization clearly appears as a strategic alternative. The challenge is to create integrated supply chains with co-development of core technological innovations that result in quality manufacturing, based on small to medium-sized, innovative firms with high-quality products, management, and workforces.

Given the continuing insecurity about the future patterns of industry organization, as well as the relatively small production volumes in the NEV industry, the creation of interconnected clusters of specialized suppliers and component and software producers could be a reasonable strategy for combining flexibility with quality and overcoming China's notorious weakness in transforming indigenous innovations in product architectures into high-value manufacturing. At the same time, such industry networks could leverage the potentials of flexible specialization inherent in IoT/Industry 4.0 technologies and create opportunities for decentralization of car manufacturing to meet the needs of local markets, mobility systems, and communities (Lüthje 2019).

Conditions for such an approach exist at the local level, particularly in the aforementioned high-tech centers (for a detailed study of battery manufacturing in South China, see IPRD 2018). Yet the scattered structure of regional industries under network-capitalist modes of regulation, the financialization of their innovation systems, and their dependence on business tycoons and real-estate developers hinder the creation of industrial chains and the simultaneous upgrading of manufacturing and new product architectures. At the same time, the upgrading of work and vocational training remains a blind spot in most regional development strategies—even in locations that have seen advances in collective bargaining, workplace representation, and trade union reform, such as the automotive supply industry in some areas of the Pearl-River Delta (Yang et al. 2019).

On the whole, recent changes create huge new challenges for China's automotive industry and its model of socio-economic development. Since the 1990s, the state has been accustomed to managing growth. Now about the emphasis is on the restructuring of highly modern production infrastructures and the creation of new, complex networks of production and innovation in an emerging industry, with potential labor conflicts in some areas. Overcapacity in the traditional car sector has to be downsized simultaneously with the development of new production networks in NEV, but under the scattered structure of the sector and its competing modes of regulation, a smooth transition from "old" to "new" seems highly problematic. As the leading industrial nations increasingly pursue protectionist policies that decouple global value chains, China will have to reassemble the pieces from below.

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