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## Lean Production in Germany: A Contested Model

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# 21 Lean Production in Germany

A Contested Model

Martin Krzywdzinski

The first publications on lean production and the evidence of the competitive advantage Japanese companies held over German competitors (Womack et al. 1990) shocked the German automotive industry of the late 1980s and early 1990s, leading to difficult discussions within companies, trade unions and the academic community about the future development of production systems. While some of the actors pushed for radical change and the adoption of lean production, others pointed out specific conditions in Germany that made directly adopting Japanese models impossible (Turner/Auer 1994; Streeck 1996). The watchword of these latter contributions was “*Japan kapierten, nicht kopieren*” – understand Japan, but do not copy it.

The conditions specific to Germany included, first, co-determination, which grants German works councils considerable rights and influence in performance management and work organisation. In the automotive industry in particular, high membership rates in trade unions (up to 90 per cent of automobile factory employees, 40–60 per cent in supplier companies) strengthened the works councils’ legally guaranteed rights. Second, there were particular conditions in the labour market that need to be highlighted. These included above all Germany’s vocational training system and the high importance companies placed on skilled labour in their recruitment strategies. Another important factor was the high level of employment security, providing an incentive for long-term investment in employee training. Finally, some developments specific to Germany that predate the advent of lean production are also worthy of note, in particular the discussions of “new production concepts” and the “humanisation of work” in the 1970s and 1980s (Kern/Schumann 1984; Fricke 2003).

These contextual conditions had a marked influence upon the interpretation and implementation of lean production principles in Germany. Although, over time, lean production became a de facto standard, its practice in German companies represents a specific interpretation of lean principles. This development makes it clear that lean production itself is not a rigid concept, but one that can be implemented in different ways based on a set of principles.

The focus of this chapter is on the automotive industry and on those aspects of lean production that directly relate to work organisation and labour relations, in particular the standardisation of work, teamwork, process optimisation (*kaizen*) and performance management. Of course, lean production is much more than these aspects. Lean production was systematically developed over a long period of time, from the

mid-1940s to the 1970s at Toyota (Fujimoto 1999; Holweg 2007; Shimokawa/Fujimoto 2009). The just-in-time principle is at the heart of this system (Krafcik 1988) but the approach as a whole includes many other elements, ranging from process organisation principles (the pull principle, standardisation, the zero-defects principle and others) and personnel management principles (focussing on employee development, respect, consensus building, learning) to concepts of product development or supply chain management (cf. Liker 2004). While all these elements are highly important for the implementation of lean production, the focus of this chapter will be on questions related to work organisation and labour relations.

The second section of the chapter reviews the developments that took place before the emergence of lean production, specifically relating to the aforementioned discussions of new production concepts and the humanisation of work in the 1970s and 1980s. The third section covers the period in the 1990s that saw the implementation of lean production and its combination with other approaches. The fourth section examines the consolidation of lean production concepts in Germany in the 2000s and discusses the extent to which a country-specific variant is now emerging. The fifth section compares lean production approaches in Germany itself with production systems implemented by German companies abroad. The sixth section is devoted to the recent discussion of Industrie 4.0 and its significance for the design of production systems. The chapter closes with general conclusions.

### **Germany before Lean Production – 1970s and 1980s**

In the post-war period, the development of the German automotive industry was strongly influenced by the adoption of American automation principles (cf. Kuhlmann 2004). Mechanical component production was automated through the use and interlinking of single-purpose machines and testing stations; automation also increased in press shops. This change went hand in hand with the implementation of Taylorist principles of work organisation: while in the pre-war period the production workforce of German automobile manufacturers consisted of well over 50 per cent skilled workers, this number fell to around 30 per cent in the 1950s due to the recruitment of semi-skilled workers (Kuhlmann 2004: 4f).

However, in the 1970s, changes in market conditions transformed corporate strategies. Increases in customers' differentiation needs and in global competition forced companies to produce a greater variety of models with shorter life cycles (Kern/Schumann 1984; Jürgens et al. 1993). New automation technologies were regarded as a foundation for achieving higher manufacturing flexibility. Industrial robots were introduced on a large scale in body shops, leading to an automation rate of 80–95 per cent by the end of the 1970s; CNC machines became widespread in mechanical manufacturing. Progress in sensor technology and the interconnection of machines opened up new possibilities in process diagnostics (Kern/Schumann 1984), even though the era's computer and networking technologies were still rudimentary. With the introduction of CAD/CAM technologies, attempts were made to digitally link data from design, process planning and manufacturing, even

though at the time just a few isolated solutions were created and such integration remained only a promise (Hirsch-Kreinsen et al. 1990; Jürgens et al. 1993). The goal was to make computer-integrated manufacturing (CIM) into a solution for centrally controlled, end-to-end production automation. Manual assembly line work remained the default in the final stage of vehicle assembly, but here also individual manufacturers carried out experiments in automation; in particular, Hall 54 at the VW plant in Wolfsburg was considered a pioneer of assembly automation (Heßler 2014).

Research to date has agreed that the move towards higher automation rates in German manufacturing was associated with the increased use of skilled workers (Jürgens et al. 1993: 373). A prime example was that of the body shops in car factories, where companies, for reasons of speed and flexibility, significantly expanded the responsibilities of automated equipment operators: in addition to the classic task of equipment monitoring, these workers also handled the materials, maintenance (at least in part) and problem-solving (Kern/Schumann 1984: 73). The boundaries blurred between automated equipment operators and classic skilled trades (maintenance, tooling, etc.) and Kern and Schumann (1984) even predicted the emergence of a new type of “super-skilled” workers, whom they called “system regulators”. These changes were actively encouraged by the works councils and trade unions, especially since Germany lacked distinctions between skilled trades (as was the case in the United Kingdom and the USA), so the change of occupations took place without major conflict (Jürgens et al. 1993: 182). These new corporate strategies thus became a driver of the modernisation and expansion of vocational training.

The dynamics of these changes were interpreted differently. Kern and Schumann (1984: 19) predicted a fundamental shift away from Taylorist concepts and towards “new production concepts” and a reprofessionalisation of production work. Under the banner of “diversified quality production”, Sorge and Streeck (1988) took up these arguments, declaring these approaches to be the dominant trend in German industry (see also Sorge/Streeck 2018). Jürgens et al. (1993), on the other hand, maintained that the rise in importance of skilled labour was limited to a few areas of high automation and that the segmentation of the workforce into skilled and semi-skilled employee groups remained.

The discussion around “new production concepts” was complemented by “humanisation of work” programmes, which focussed on ergonomic improvements and the introduction of group work concepts. The “humanisation of work” was a governmental reform programme supported by trade unions, employers’ associations and academics between 1974 and 1980 and was intended to develop strategies for improving the quality of work. The original impetus for this came from the labour conflicts and shortages and the signs of stressful working conditions that confronted German industry in the early 1970s (Fricke 2003). With regard to work organisation, the emergence of the group work approach seemed to promise a win–win situation for trade unions and employers: it was intended to make industrial work more attractive while also improving flexibility in personnel deployment in view of increasing automation (Seltz 1994). IG Metall developed a twelve-point plan for an emancipatory form of group work that it hoped to propagate in companies (cf. Turner 1991: 113f).

Although group work played a significant role in the “humanisation of work” programme, no uniform concept of group work emerged. German industry carried out a large number of group work projects, ranging from elaborate approaches emphasising group self-organisation in work-process planning, training and process optimisation all the way to very restrictive approaches that reduced group work to mere job rotation (Schumann 1994; Muster 1988). Despite strong union support (Turner 1991: 111; Kuhlmann 2004), many union officials and works councils were ambivalent, fearing that self-regulated groups might end up competing with the works councils’ and shop stewards’ own functions. As seen by the companies themselves, however, the economic effects of group work were insufficiently clear-cut and resistance to these concepts grew over the years (Schumann 1994; Roth 1996). For example, according to a survey by the Fraunhofer Institute for Systems and Innovation Research (Dreher et al. 1995), only 14 per cent of companies in the manufacturing sector engaged in group work practices in the year 1993. A scant 8 per cent reported task integration in keeping with the “new production concepts” and only 6 per cent of the companies actively involved their production workers in the planning and implementation of new manufacturing processes.

An important element common to the 1970s and 1980s experiments in new production concepts and group work was the assumption that more satisfying working conditions would increase employees’ motivation and flexibility. This assumption was strongly supported by the trade unions and it was attractive for the companies, given that currently prominent performance management tools (target agreements, performance appraisals) were not in place. Shop-floor performance management in German companies was a highly regulated and compromise-based process (Jürgens et al. 1993: 238f; Kern/Schumann 1984: 123f). At the core of this compromise was the definition of performance standards using concepts such as MTM (methods-time measurement), or its German equivalent REFA,<sup>1</sup> but this process was tightly controlled by both management and the works councils (Jürgens et al. 1993: 223f; Lacher/Springer 2002). The role of the works council in the performance management process results from the Works Constitution Act. Section 87 of the Works Constitution Act gives works councils a right to co-determination (i.e., a de facto veto right) when setting the reference values for performance-related remuneration components (e.g., premium rates, target/standard times) and when introducing technical devices that could be used for performance monitoring. Works councils used these rights to enforce a compromise: based on data accepted by the management and the works council, industrial engineers set the staffing numbers and performance standards, while the works council ensured that the standards remained reasonable from an employee perspective and that there was no slow tightening of performance standards in operational practice. The process

<sup>1</sup> The REFA was founded in 1924 as the *Reichsausschuss für Arbeitszeitermittlung* (Committee for Determining Working Time). The abbreviation REFA is still used today, but the organisation’s official name is now *Verband für Arbeitsgestaltung, Betriebsorganisation und Unternehmensentwicklung* (Association for Work Design, Plant Organisation and Business Development). The REFA develops methods for determining standard times for tasks and operations as well as broader standards for process organisation. A particularity of REFA is that it coordinates the standards with employers’ associations and trade unions and transfers them into textbooks and standard manuals.

prevented management from making unilateral changes to work processes and precluded attempts to increase efficiency using methods such as a stopwatch. Changes to performance standards were allowable only if the works council agreed, which reduced conflicts in factories, while also subjecting any implementation of productivity increases to negotiation between management and the works council.

### **The Lean Production Shock and Reactions to It in the 1990s**

The debate around lean production that began at the end of the 1980s had a profound impact on German industry, in particular the automotive industry. The study described in *The Machine That Changed the World* (Womack et al. 1990), based on the International Motor Vehicle Program (IMVP), clearly showed that European automobile plants were lagging behind their Japanese competitors. This assessment coincided with considerably heightened competition for many facilities in the German automotive industry; the fall of the Iron Curtain meant that Central and Eastern European lower-wage countries were beginning to attract investment, though the bigger trend in production relocation from Germany to Central and Eastern Europe did not begin until the second half of the 1990s (Jürgens/Krzywdzinski 2008, 2009). In addition, companies were increasingly becoming disillusioned with the automation approaches of the 1980s. The term “CIM ruins” was increasingly making the rounds in the auto industry as a denunciation of the automation euphoria of the 1970s and 1980s (Jürgens et al. 1993: 72; Roth 1996).

The discussion about lean production was very multifaceted, which was not surprising given that the initial study by Womack et al. (1990) had already described the different dimensions and areas of lean production: factory organisation, product design processes, supplier relations and customer relations. Later writings on lean production developed an even more differentiated understanding of its principles, as can be seen in Liker’s (2004) fourteen points of lean production, which, in addition to principles of shop floor organisation (pull systems, teamwork, *kaizen*, *heijunka* workload levelling, visual controls and others), also contained general management principles (such as an emphasis on employee development) and elements of corporate culture and governance (compromise orientation, respect and so on). In the following, the focus is on those aspects of lean production that are closely related to work design on the shop floor.

In the first half of the 1990s, it was the newly established facilities in the former GDR that became testing grounds for the implementation of lean production: the new Volkswagen plant in Zwickau and, more importantly, the new Opel plant in Eisenach (Jürgens 1998). The plant in Eisenach drew on General Motors’ experience with Toyota in their NUMMI and CAMI joint ventures (Jürgens 1998; Enderle 1994; see also Adler 1995; Rinehart et al. 1997). Vertical integration of production was very low and functions such as maintenance were partially outsourced. Although the body shop was highly automated (96 per cent), the automation itself was of reduced complexity and the final assembly involved no automation at all (Jürgens 1998: 330). In the context of process organisation, the



plant focussed on bufferless production, flow creation, the implementation of *kanban* and standardised work. With a cycle time of 150 seconds (Jürgens 1998: 330), the plant was following the industry trend toward short work cycles. A great deal of emphasis was placed on implementing teamwork: the term “teamwork” was used in the lean production discourse, while the term “groupwork” was preferred in a “humanisation of work” programme context. Small teams of six to eight people were created, which, in addition to direct work, also handled quality control, maintenance and material supply tasks. Eisenach was also the first plant in Germany to introduce the Andon rope as an instrument of quality control on the part of workers. Responsibility for monitoring and optimising standards also fell to the teams. Each team held yearly continuous improvement workshops (Jürgens 1998; Enderle 1994). In its recruitment for direct production, the plant reduced its focus on skilled workers. Vocational training rates remained much lower than in Opel’s West German plants. Recruitment emphasised motivation and teamwork; the concept of multiskilling played a greater role than vocational qualifications. In the German discussion, multiskilling refers to on-the-job training of workers so that they can perform several tasks or jobs. This kind of training can take several weeks to several months and represents a very different process than vocational training, which usually takes three to four years of on- and off-the-job training in the company and vocational school and that aims to develop a deep and broad mastery of the given occupation. Another important aspect of lean production at the Eisenach plant was the effort to find a new approach to performance management. Introducing half-yearly performance assessments and corresponding performance bonuses was meant to ensure employees’ willingness to participate in continuous improvement and increased productivity. Jürgens (1998: 327) stresses that the Eisenach works council regarded the new plant’s orientation towards lean production as a valuable opportunity and was more willing to compromise in matters of performance regulation than were the works councils at West German plants.

While the new plants, especially those in East Germany, were already turning to lean production as the “one best way”, a number of West German plants in the 1990s attempted to combine lean production with 1980s production concepts (Roth 1996). Actors from these plants attributed the superiority of Japanese companies (shown by the IMVP study) to the fact that German companies had pursued exclusively technological solutions for productivity and flexibility and had insufficiently explored the potentials of skilled work, task integration and new forms of work organisation (Jürgens/Naschold 1992; Roth 1996).

In practice, the plants hit upon a considerable variety of solutions. There were fundamental differences between highly automated areas (mechanical component production, press shop, body shop) and manual assembly areas (Schumann et al. 1994; Roth 1997). In the highly automated areas, work became increasingly skilled: recruitment focussed more and more on skilled workers with vocational training; task integration and worker self-organisation also increased (Schumann et al. 1994: 164). Assembly areas dominated by manual labour saw almost no such rise in the importance of skilled labour. However, there were isolated experiments in extending

the scope of work toward stationary assembly and away from the assembly line, some of which were inspired by experiences in Sweden and particularly at Volvo (Jürgens 1995).

One firm that initially tried to remain faithful to the production concepts of the 1980s and then made a radical break with them in the 1990s was Mercedes-Benz (Daimler). In the first half of the 1990s, the firm's focus was still on extending work cycles and on the partial introduction of stationary assembly – in some cases, assembly shops saw work volumes of up to thirty minutes (Springer 1996) – and on reinforcing the role of group work by integrating indirect activities (e.g., quality inspection and material supply) into the responsibilities of production workers (Jürgens 1995; Gerst et al. 1999). The continuing importance of skilled work also played a part. As Springer (1997) reported, 68 per cent of production workers had completed vocational training and therefore had higher expectations as to the content of their work. At the beginning of the 1990s, Daimler continued to implement “new production concepts” but also tried to break new ground in the realm of performance regulation. Team-based continuous improvement processes were introduced, similar to those in lean production practices, and the firm attempted to introduce performance-based pay through target agreements with teams (Springer 1996).

At several companies in the early 1990s, experiments with stationary assembly, a fundamental alternative to lean production, were carried out that had many similar characteristics (Schumann et al. 1994: 280; cf. also Jürgens 1995). The assembly line principle was abandoned in favour of so-called assembly boxes, in each of which three to five workstations were combined. Each workstation typically had a task scope of fifteen to sixty minutes, but there were also more restrictive approaches in which the task scope was only a few minutes. The boxes were connected not by a line but by automatically guided vehicles (AGVs), which were equipped with components and a body, docked to the station and “parked” there. When work was finished at a given station, the car body either moved along automatically or the assembly box workers triggered its departure. The teams at the assembly boxes had target timeframes (calculated on the basis of MTM procedures) within which they had to complete the tasks. Compliance was monitored by the team itself and by the supervisor (*Meister*), which was the first level within the plant's hierarchy. One notable feature shared by these approaches was that they did not completely abandon the assembly line principle; instead, stationary assembly areas were mixed with areas employing traditional assembly line design (albeit with longer work cycles) (Jürgens 1995). The approaches differed, however, in how they used time buffers when combining stationary assembly and other upstream and downstream areas and logistics (Schumann et al. 1994: 280). While some approaches reduced the time pressure by using large buffers, in others tight time management was essentially forced in stationary assembly work due to the small or completely absent buffers.

As Schumann et al. (1994) noted, the approaches to work organisation also differed considerably between companies. In several cases, approaches to stationary assembly failed due to the persistence of a strong hierarchy, to teams lacking the resources and rights to self-organise and to insufficient investment in employee training. Under such conditions, teams had limited flexibility to deal



with absences and changing requirements, leading to frustration on the part of superiors and workers alike, particularly in approaches with no buffers and intense time pressure (Schumann et al. 1994: 282f). The experience was more positive where teams were given greater opportunities for self-organisation and time to react to disturbances and problems by virtue of larger buffers (Schumann et al. 1994: 285).

By the second half of the 1990s experiments with stationary assembly had been abandoned. Academic publications from this period emphasise a “return to Taylorism” (Springer 1997) and “rolling back cycle times” (Jürgens 1997a). As Jürgens (1997a: 267) describes, in the mid-1990s the principles of stationary assembly at Daimler were abandoned and the relevant equipment scrapped. The companies turned to standardised work with a strict zero-buffer, one-piece-flow orientation and short cycles of about a minute. At the same time, performance management policies changed: companies rushed to improve performance-related remuneration by introducing performance appraisals and target agreements and by linking remuneration to indicators of individual, team or plant performance (cf. Lacher/Springer 2002; Bispinck 2000).

The main reasons for this development as identified by research were both internal and external factors. As far as internal factors went, Jürgens (1997a) pointed out that the material flow process for stationary assembly and process synchronisation, both within assembly itself and with other areas, proved to be very complicated and prone to error. In addition, work enrichment and stationary assembly failed to have their desired effects on motivation and absence rates remained high (Jürgens 1997a: 268; cf. also Springer 1999: 163; Weltz 1997: 380). External influences on companies also underwent changes. Due to increasing competition from lower-wage locations, the pressure to make cost reductions increased significantly (Greer/Hauptmeier 2016; Doellgast/Greer 2007; Jürgens/Krzywdzinski 2008, 2009), especially with the growing influence of shareholder value, bringing with it a focus on short-term profit optimisation and a trend toward outsourcing (Schumann 2003; Kädtler/Sperling 2002; Jürgens et al. 2000).

It is worth mentioning that the shift towards lean production coincided with an increase in precarious employment in the German automotive industry, particularly in light of the growing use of temporary agency work. A primary driver of the growth in precarious employment, however, was less lean production itself than the deregulation of labour markets, which was promoted most significantly by the Social Democrat–Green government coalition that came to power in 1998. The use of temporary agency work allowed companies greater flexibility and lower labour costs, since temporary workers were not covered by the metal sector’s collective agreements (Mitlacher 2007; Jürgens et al. 2006). Until 2017, temporary agency workers in Germany could be paid different rates than permanent employees, even when job responsibilities were identical, due to a separate collective agreement specific to agency workers. It was not until 2017 that a general equal-pay regulation was introduced in Germany, though it takes effect only after ten months of employment. Although not responsible for the increase in temporary agency work, lean production helped broaden its adoption by dint of its focus on outsourcing component production and service areas (Benassi/Dorigatti 2015; Doellgast/Greer 2007; Jürgens et al. 2006).

## Lean Production Wins Out – Is There Still Room for Alternatives?

In the latter half of the 1990s, lean production became an ever more dominant production system in the German automotive industry, although it existed in numerous variants, differing depending on the institutional framework and the experiences of each company in the period before lean production. In many cases, companies avoided the term “lean production” itself, preferring instead the term “holistic production systems” (*ganzheitliche Produktionssysteme*). This term gained greater acceptance, despite the fact that both the core and the various elements of holistic production systems were clearly identical to those of lean production (cf. Gerst 2011; Dombrowski et al. 2006; Seibold et al. 2016).

Although the spread of lean production swept away most earlier approaches based on “new production concepts” and “humanisation of work” programmes, in some cases a particular interpretation of lean production prevailed that took the interests of the employees into greater account. Kuhlmann et al. (2004) describe this interpretation as an “innovative work policy”; it is found chiefly in companies where active works councils avail themselves of the provisions of the German Works Constitution Act and where management is willing to cooperate. The pervasiveness of such innovative approaches is difficult to quantify. They are characterised by the following four elements (cf. Kuhlmann et al. 2004):

- 1 Teamwork concepts that emphasise self-organisation and task integration, however within the parameters of short work cycles and highly standardised work contents. Particularly important – and characteristic of German approaches – is the principle that teams elect their own spokespersons. In addition, care is taken to ensure that teams have sufficient time per week to discuss questions of team organisation, problem solving and process optimisation. Quality control and maintenance tasks are integrated into the teams.
- 2 Team participation in continuous improvement processes (CIP). While all lean concepts include this point, the innovative aspect of some German approaches is that CIP is supported by plant-level collective agreements in which employees may not be dismissed due to efficiency gains from CIP and thus enjoy an extra degree of security.
- 3 Redefinition of the supervisor’s role. The supervisor (*Meister*) is the first formal hierarchical level on the shop floor. Here, the “innovative work policy” is above all a shift in the supervisor’s responsibilities: away from control and authoritarian leadership and towards leadership through goal setting, participation and coaching; away from their function as a hierarchical authority and towards greater professional responsibility for problem solving and process optimisation.
- 4 New forms of performance regulation. The aim is to replace Tayloristic performance regulation concepts with performance pay while avoiding performance pressure resulting from monetary incentives. Often the companies use target agreements linked to production teams’ performance targets. The role of the works council is particularly important here: it monitors the process to ensure

that goals are set based on a consensus of superiors and teams and that the teams' concerns are taken seriously and not simply ignored by their superiors. In the event of conflict, teams can call in the works council to mediate.

The concept of team self-organisation should not be confused with the concepts of self-managed, self-regulated or self-directed teams developed in the tradition of socio-technical systems (STS) design (cf. Batt/Doellgast 2006; Cohen/Bailey 1997; Appelbaum/Batt 1994; Cummings 1978). The STS approach emphasises several conditions for self-regulation (Barker 1993; Orsburn et al. 1990): task differentiation (including interdependent tasks that pertain to preferably complete products in the team's area of responsibility), boundary control (group members have the skills and right to control interactions with other areas like quality assurance, maintenance, other teams etc.) and task control (the group chooses work methods and is able to influence performance targets). Most of these conditions (in particular task differentiation and task control) are not present in the lean production environment in car companies. The self-organising teams on the shop floor of German companies therefore correspond more closely to those envisaged by typical lean teamwork concepts, however with certain modifications: first, because teams have the right to elect the team spokesperson and hold regular team meetings within working hours, there is an increased probability that decisions on issues like job rotation and vacation planning will actually be taken by the whole team and not just by the team leader. Second, the role of the works council increases the influence of teams on the setting and control of performance targets. Rules for work organisation and performance management are usually laid down in plant-level agreements between management and works councils.

The Auto5000 project at Volkswagen was a prime example of the German interpretation of lean production. The project began in 1999 and was presented by the company and the works council as an alternative to the Toyota Way (cf. the contributions in Schumann et al. 2006). From the outset, the proposal was accompanied by systematic research (Schumann et al. 2006). For this project, 3,500 unemployed individuals were recruited to produce a new vehicle model in a newly built factory at the VW plant in Wolfsburg. A new collective agreement was created specifically for Auto5000 in which IG Metall accepted a number of concessions: the pay level matched that of the collective agreement for metal workers in Lower Saxony, but was approximately 20 per cent lower than that specified by VW's own in-house collective agreement; working time amounted to 35 hours a week (higher than VW's then-standard 28.5 hours) and was very flexible. One other experimental new provision was the uniform wage rate for all blue-collar workers, making no distinction between skilled and semi-skilled workers. Although this idea caused no major conflicts, it remained controversial, with the skilled workers repeatedly arguing for a differentiation of wages (Sperling 2006).

In exchange for these collective bargaining concessions, the Auto5000 works council was granted extensive co-determination rights beyond the legal standards. In addition, Volkswagen promised to develop a new form of work organisation based on self-organisation and extensive training.

As far as the basic elements of process organisation were concerned, Auto5000 clearly followed the principles of lean production: strict flow production, JIT and so on. At the same time, it represented a particularly German path for three reasons.

First, when defining the organisation of work, great importance was attached to improving the teams' self-organisation (cf. Kuhlmann 2006). Team sizes ranged from seven to seventeen employees. In highly automated areas there was less of a separation between skilled and semi-skilled workers and maintenance tasks were integrated into the production teams, doubtless facilitated by the uniform pay level for all blue-collar workers. In assembly areas the work remained repetitive, with cycle times of roughly 1.5 to 2 minutes, but attention was paid to systematic job rotation and multitasking. To facilitate self-organisation, team spokespersons were elected and weekly team meetings held. Problem solving and process optimisation were also defined as team responsibilities to be carried out with the participation of all team members, assisted by the team spokesperson and the supervisor. Team members took it in turns to lead the group in process optimisation activities; individual team members also adopted the role of "multipliers", who were responsible for communicating with the other shifts, other work areas and superiors. This multiplier role was seen as an important learning opportunity for the team members as it allowed workers to break out of the "mill" of line work. Yet another role within the teams was the "development and training consultant". In this role, team members took on the task of coaching the entire team in the available training and development opportunities. An important element and prerequisite of this entire teamwork concept was the training and preparation of the supervisors. Their role was intended to be less focussed on control and more on supporting the teams in their self-organisation and process optimisation.

Second, the systematic training concept developed by Auto5000 encouraged part-time vocational training, the establishment of process-related training centres in the shops and intensive process-related employee training (Sanders 2006).

Third, a new form of performance regulation was introduced. The teams gained considerable influence on the setting of performance standards. Although industrial engineering (IE) saw to the planning of manufacturing processes, plans for staffing and the setting of performance standards were then worked out in concert with the teams and required their formal approval. All subsequent process changes and optimisations could be introduced only with the participation and approval of the teams (cf. Sperling 2006: 77). At the same time, a target-setting system was introduced where productivity and quality targets were set at team level and the workers' performance bonuses incorporated these team-based criteria. The works council acted as a controlling body for the process and ensured that the teams were consulted and their positions taken into account when setting targets.

Certainly Auto5000 did not constitute an alternative to lean production; it was rather an implementation of lean production strongly influenced by German institutions and actors. Its emphasis on self-organisation and its performance-policy compromise distinguished it from pure lean production team concepts (Babson 1993; Dohse et al. 1985). In the opinion of company actors, trade unions and academics, the model worked very well (Kuhlmann 2006) but it ultimately failed because of the

underlying wage policy. Over time, employees (and IG Metall) were less and less willing to accept the differences in compensation between Auto5000 and the VW collective agreement. In 2009, Auto5000 was integrated into Volkswagen AG and the former's special collective agreement was abandoned. The concepts of process-related training and personnel development pioneered within Auto5000 were adopted at VW, but other elements – in particular its strong focus on team-based improvement processes – were implemented only to a limited extent.

### German Companies Abroad

We can clearly see the peculiarities of the company cases in question, such as that of Auto5000, and the role played in Germany by institutional factors (co-determination, vocational training systems) and industry-specific traditions (e.g., humanisation of work), when we look at German automotive companies' production systems in their factories abroad.

First, while it is not surprising that German companies invest in building vocational training facilities and programmes in their plants abroad (in contrast to Japanese and American companies, cf. Krzywdzinski 2011), what is striking is the fact that the number of apprentices at foreign facilities is considerably smaller than at facilities in Germany (Krzywdzinski/Jürgens 2019). Abroad, German companies employ vocational training specifically and exclusively in indirect work areas such as maintenance and production jobs are filled almost completely by semi-skilled workers. Accordingly, the workforce composition in German companies' foreign plants is different to that of their factories in Germany: these companies do not place skilled workers into direct production roles and, as a consequence, they are under less pressure to enrich the work and to integrate indirect tasks into production jobs.

Second, studies show that the fairly clear focus on team self-organisation in Germany is not widely practised at German companies' foreign locations (Jürgens/Krzywdzinski 2016). One reason for this is the differing systems of industrial relations. In Germany, works councils push for the creation of self-organisation opportunities; at German automobile companies' foreign plants, this focus on self-organisation can be observed chiefly where strong trade union representative bodies exist that resemble German works councils (cf. Krzywdzinski 2017). Another factor here is the precedent of group work set by the "humanisation of work" programmes in Germany, which offer an important point of reference for works councils.

Third, the lack of works councils at German companies' foreign locations reflects the fact that performance standards in those locations are typically unilaterally controlled by management. Performance appraisals, target agreements and performance pay are not negotiated with a balance of employee and employer interests that is characteristic of the German plants. Exceptions are found only in establishments with strong industrial traditions and trade union organisations, and where trade union representatives can to some extent assume a function similar to German works councils, such as in Brazil (Jürgens/Krzywdzinski 2016; Krzywdzinski 2017).

It should be noted, however, that German companies appear to be somewhat more open than Japanese companies to integrating the traditions and approaches of their foreign locations. For example, Jürgens and Krzywdzinski (2015, 2016) showed how Volkswagen, much more so than Toyota, integrated the Chinese traditions of vocational certification and their conceptions of development paths into the company's own approaches to skilled worker training.

### From Lean Production to Industrie 4.0 – the 2010s

Since the beginning of the 2010s, we have seen technology-related issues once again dominating the discussion around the development of production systems in the German automotive industry. The discussion involves a set of technological innovations, designated *Industrie 4.0*, which are expected to lead to fundamental changes in production. The main focus lies in the introduction and adoption of the Internet of Things, regarded as driving the networking of components, transport carriers, machines and measuring devices in the manufacturing process. New forms of digital process control, analysis and optimisation will be made possible thanks to real-time information exchange, big data and machine learning, as well as the use of assistance systems meant to provide real-time, situation-specific insight into the work process (Kagermann 2014; Butollo et al. 2018).

Although the discussion of *Industrie 4.0* is characterised by markedly revolutionary rhetoric, current studies show the changes to be more gradual (cf. Butollo et al. 2018; Hirsch-Kreinsen 2018) and reveal continuity with lean production (cf. Dombrowski et al. 2017; Schlick et al. 2014; Rüttimann/Stöckli 2016; Meier 2017; Buer et al. 2018).

In the context of work, however, *Industrie 4.0* seems merely to reinforce certain elements of lean production. The promise of data-based analysis and optimisation is that they will allow mastery over increasing demands on quality, time-to-market and interdependencies in supply chains. In addition, the expansion of digital knowledge management and assistance systems should facilitate the standardisation of processes.

One example is the use of “assistance systems” in assembly processes. In some cases, these assistance systems are based on a detailed representation on a monitor or tablet of the assembly steps to be performed, where each task performed must be acknowledged. In other cases, execution is also monitored by RFID<sup>2</sup> chips in the workpiece and sensors. In some contexts, cameras track workers' actions, which are then displayed on a projection screen to determine their correctness. These systems are meant to ensure that tasks are completed according to predefined standards and down to the smallest detail (e.g., how components are gripped and fitted). They thus enforce standardised work as a core concept of lean production.

2 Radio Frequency Identification (RFID) is a central technological element that facilitates the coordination of logistics. A contactless and unique identification of objects is enabled by RFID.



Even in the realm of skilled work in maintenance, changes are becoming visible (Acatech 2015). Günther et al. (2015: 20) stress that the maintenance profession is moving away from the image of the “machine whisperer” and towards a focus on data analysis. The concept of “smart maintenance”, as formulated by Acatech (German Academy of Science and Engineering), emphasises the potential of centralising plant monitoring and problem-solving processes through newly available data and real-time data analysis. In such a maintenance centre, academically trained equipment specialists and data analysts work together. The maintenance staff simply carry out the centre’s instructions, requiring less experience and specialist knowledge.

On the one hand, this rationalisation of maintenance is consistent with lean production. Systematic process monitoring and statistical process control were among the core ideas taken up by Japanese companies and further developed into TPM concepts (total productive maintenance). Using data on material loads, wear times, etc., forecasts of possible equipment failures were developed and used for planning maintenance work (Wireman 1991). However, the TPM literature still emphasises the need for cross-functional and cross-hierarchical improvement processes, in which the shop floor teams should also be included (Shirose 1996; Japan Institute of Plant Maintenance 1996). The maintenance concepts of *Industrie 4.0*, on the other hand, suggest that investments in shop-floor knowledge should be rendered superfluous by technology. Whether this technology-focussed approach is effective remains in doubt. Experience with past automation processes suggests that eliminating opportunities for experience and learning via data-based process control, monitoring and optimisation can lead to a dearth of human problem-solving competence in the event of unexpected system failures (Bainbridge 1983; Weyer 1997, 2007).

The speed with which *Industrie 4.0* technologies are implemented remains to be seen and it is not yet clear how disruptive their impact will be. Current studies show that works councils are attempting to ward off these new technologies’ negative effects, such as de-skilling and increased technical monitoring and performance control (Evers et al. 2018; Kuhlmann et al. 2018; Haipeter et al. 2018). To date, past compromises between management, works councils and trade unions have not been called into question. In any case, technology-oriented approaches are once again having a profound influence on discussions around production systems. But in contrast to the last automation debate in the 1980s (a debate about CIM), in which importance was placed on bolstering skilled work, today the academic discussion is more controversial and we see scenarios involving both a rise in skilled work and its degeneration.

## Conclusions

The history of lean production’s implementation in Germany shows the importance of institutional conditions, actor constellations and discursive traditions in manufacturing. This was due first to the German system of industrial relations and in particular to the role of works councils. Their powers to regulate performance

control and incentives meant that it was not possible to develop a form of lean production in Germany that relied on “management by stress” – at least in the automotive industry, which was and is dominated by strong trade unions and works councils. Second, the specific form of labour market regulation played a significant role. Employment relationships in German industry are notable for their high level of employment security, which precludes extracting performance from workers through the threat of dismissals. Third, the vocational training system and the resulting availability of highly qualified skilled labour created a special situation for companies. Skilled workers form a considerable part of the production workforce. Their professional ethics, motivation and participation in problem solving and company improvement demand a job design that allows for self-organisation and broad, interesting tasks. Fourth, the ideas of “new production concepts” and the “humanisation of work” played and still play a role, especially in the strategies of works councils and trade unions.

The specifically German implementations of lean production includes, to begin with, an emphasis on teams’ self-organisation skills, highlighted by the fact that the teams elect their own spokespersons instead of having them designated by superiors. There is real effort to integrate quality assurance, improvement and maintenance tasks into the teams’ responsibilities, but we see this implemented primarily in areas with more automation and less so in manual assembly areas. Further, an emphasis on team self-organisation goes hand in hand with redefining the supervisor’s role, giving higher priority to team involvement and coaching. The final relevant characteristic of performance regulation in Germany is that the works council moderates the negotiation of performance targets between teams, supervisors and management. The works council thus plays an important role in ensuring a balance between business objectives and team concerns.

While these characteristics have conditioned the development of lean production approaches in Germany, it should also be noted that explicit alternatives to lean production have been unsuccessful. Such alternatives were still evident at the beginning of the 1990s, for example in the stationary assembly approaches inspired by Swedish predecessors. These were abandoned, and today the core ideas of lean production organisation (one-piece flow/just in time) and a focus on standardisation of work serve to define the current state of German automotive companies and limit the possible variance in the forms of work design.

This development can be explained in various ways. Smith and Meiskins (1995) refer to the dominance effects that have contributed to the spread of lean production and to the rejection of other approaches. The strength of Japanese companies and the adoption of lean production concepts by American firms have increased the pressure for their adoption in Europe. In addition, global competitive conditions changed after the lower-wage countries in Eastern Europe and Asia entered the world market. This more heated competition sparked considerable efforts in German companies to achieve efficiency, rationalisation and cost savings and made lean production more attractive. However, dominance effects cannot explain the extent of lean production’s success. An important reason for the dominance of lean production is that alternative production systems encountered internal problems, such as those arising

in stationary assembly systems; these systems were abandoned due to the efficiency of lean production.

Since the beginning of the 2010s, lean production systems have once again become a topic of discussion in German companies, with an eye toward the technological boost that digitalisation/*Industrie 4.0* may provide. The discussion places a strong focus on the Internet of Things, data gathering and the use of data for process monitoring and optimisation. This focus foregrounds the role of experts and engineering staff and calls into question the importance of workers' shop floor experience. The new technologies allow for a better monitoring and standardisation of work processes, which also reduces the scope for decisions and independent problem solving on the shop floor. There is thus a danger that more technocratically oriented interpretations of lean production will become more significant. This has become a crucial field of negotiation and conflict for management, works councils and trade unions.

## References

- Acatech. 2015. *Smart Maintenance für Smart Factories*. Munich/Berlin: Acatech.
- Adler, Paul. 1995. "Democratic Taylorism": The Toyota Production System at NUMMI." pp. 207–219 in: Steve Babson (Ed.), *Lean Work: Empowerment and Exploitation in the Global Auto Industry*. Detroit, MI: Wayne State University Press.
- Appelbaum, Eileen and Rosemary Batt. 1994. *The New American Workplace*. Ithaca, NY: ILR Press.
- Babson, Steve. 1993. "Lean or mean: the MIT model and lean production at Mazda", *Labor Studies Journal* 18(1): 3–24.
- Bainbridge, Lisanne. 1983. "Ironies of automation. Analysis, design and evaluation of man-machine systems", *Automatica* 19(6): 775–779.
- Barker, James. 1993. "Tightening the iron cage: concertive control in self-managing teams." *Administrative Science Quarterly* 38(3): 408–437.
- Batt, Rosemary and Virginia Doellgast. 2006. "Groups, Teams, and the Division of Labor: Interdisciplinary Perspectives on the Organization of Work", pp. 138–161 in Stephen Ackroyd, Rosemary Batt, Paul Thompson and Paul Tolbert (Eds.), *The Oxford Handbook of Work and Organization*. New York: Oxford University Press.
- Benassi, Chiara and Lisa Dorigatti. 2015. "Straight to the core – explaining union responses to the casualization of work: the IG Metall campaign for agency workers". *British Journal of Industrial Relations* 53(3): 533–555.
- Bisping, Reinhard. 2000. *Tarifentgelt nach Leistung und Erfolg* [Regulating Performance-based Pay in Collective Agreements]. Düsseldorf, Germany: WSI.
- Buer, Sven-Vegard, Jan Ola Strandhagen and Felix T. S. Chan. 2018. "The link between Industrie 4.0 and lean manufacturing: mapping current research and establishing a research agenda". *International Journal of Production Research* 56(8): 1–17.
- Butollo, Florian, Ulrich Jürgens and Martin Krzywdzinski. 2018. "From Lean Production to Industrie 4.0. More Autonomy for Employees?" WZB Discussion Paper SP II 2018–303, Berlin: WZB.
- Cohen, Susan and Diane Bailey. 1997. "What makes teams work: group effectiveness research from the shop floor to the executive suite". *Journal of Management* 23 (3): 230–290.

- Cummings, Thomas. 1978. "Self-regulating work groups: a socio-technical synthesis". *The Academy of Management Review* 3(3): 625–634.
- Doellgast, Virginia and Ian Greer. 2007. "Vertical disintegration and the disorganization of German industrial relations". *British Journal of Industrial Relations* 45(1): 55–76.
- Dohse, Knuth, Ulrich Jürgens and Thomas Malsch. 1985. "From 'Fordism' to 'Toyotism'? The social organization of the labor process in the Japanese automobile industry". *Politics & Society* 14(2): 115–146.
- Dombrowski, Uwe, Markus Palluck and Stefan Schmidt. 2006. "Strukturelle Analyse Ganzheitlicher Produktionssysteme" [Structural analysis of holistic production systems]. *ZWF Zeitschrift für wirtschaftlichen Fabrikbetrieb* 101(3): 114–118.
- Dombrowski, Uwe, Thomas Richter and Philipp Krenkel. 2017. "Interdependencies of Industrie 4.0 & lean production systems: a use cases analysis". *Procedia Manufacturing* 11: 1061–1068.
- Dreher, Carsten, Jürgen Fleig, Monika Harnischfeger and Matthias Klimmer. 1995. *Neue Produktionskonzepte in der deutschen Industrie* [New Production Concepts in the German Manufacturing Sector]. Heidelberg, Germany: Physica.
- Enderle, Peter. 1994. "Das Opel-Produktionssystem im Werk Eisenach" [The Opel Production System in the Eisenach Plant], pp. 160–166 in: Wilfried Brokmann (Ed.), *Lean Production II. Erfahrungen und Erfolge in der M+E-Industrie* [Lean Production II. Experiences and Achievements in the Metal and Electrotechnical Industry]. Köln, Germany: Institut für angewandte Arbeitswissenschaft.
- Evers, Maren, Martin Krzywdzinski and Sabine Pfeiffer. 2018. "Designing wearables for use in the workplace: the role of solution developers", WZB Discussion Paper SP III 2018–301, Berlin: WZB.
- Fricke, Werner. 2003. "Dreißig Jahre staatlich geförderte Arbeitsgestaltung – eine Bilanz" [Taking Stock of Thirty Years of State-supported Work Design], pp. 51–66 in: Jürgen Peters and Horst Schmitthenner (Eds.), *"Gute Arbeit": Menschengerechte Arbeitsgestaltung als gewerkschaftliche Zukunftsaufgabe* [Good Work: Human-focused Work Design as a Future Task for Trade Unions]. Hamburg, Germany: VSA.
- Fujimoto, Takahiro. 1999. *The Evolution of a Manufacturing System at Toyota*. New York: Oxford University Press.
- Gerst, Detlef. 2011. "Sind ganzheitliche Produktionssysteme und Gute Arbeit vereinbar?" [Can we combine holistic production systems and good work?] *Arbeit* 20(3): 246–250.
- Gerst, Detlef, Thomas Hardwig, Martin Kuhlmann and Michael Schumann. 1999. "Group Work in the German Automobile Industry: The Case of Mercedes-Benz", pp. 366–394 in: Jean-Pierre Durand, Paul Stewart and Jorge Carillo (Eds.), *Teamwork in the Automobile Industry*. London: Palgrave Macmillan.
- Greer, Ian and Marco Hauptmeier. 2016. "Management whipsawing: the staging of labor competition under globalization". *ILR Review* 69(1): 29–52.
- Günther, Georg, Michael Benisch, Andreas Dankl and Jutta Isopp. 2015. *Roadmap der Instandhaltung 4.0*. [Maintenance 4.0 roadmap]. Salzburg, Austria: Salzburg Research.
- Haipeter, Thomas, Inger Korflür and Gabi Schilling. 2018. "Neue Koordinaten für eine proaktive Betriebsratspolitik. Erfahrungen aus dem Gewerkschaftsprojekt 'Arbeit 2020 in NRW'" [New directions for active works councils: Experiences from the trade union project "Work 2020 in Northrhine-Westfalia"]. *WSI-Mitteilungen* 70(3): 219–226.

- Heßler, Martina. 2014. "Die Halle 54 bei Volkswagen und die Grenzen der Automatisierung. Überlegungen zum Mensch-Maschine-Verhältnis in der industriellen Produktion der 1980er Jahre". [Plant 54 at Volkswagen and the limits of automation. Reflections on the human-machine relation in the industrial production in the 1980s]. *Zeithistorische Forschungen* 11(1): 56–76.
- Hirsch-Kreinsen, Hartmut. 2018. "Arbeit 4.0: Pfadabhängigkeit statt Disruption", Soziologisches Arbeitspapier 52/2018 [Work 4.0: Path dependency or disruption]. Dortmund, Germany: Technical University Dortmund.
- Hirsch-Kreinsen, Hartmut, Rainer Schultz-Wild, Christoph Köhler and Marhild von Behr. 1990. *Einstieg in die rechnerintegrierte Produktion: alternative Entwicklungspfade der Industriearbeit im Maschinenbau*. [First Steps Towards Computer-integrated Production: Alternative Development Paths of Manufacturing Work in the Machine-building Industry]. Frankfurt/Main, Germany: Campus.
- Holweg, Matthias. 2007. "The genealogy of lean production". *Journal of Operations Management* 25(2): 420–437.
- Japan Institute of Plant Maintenance. 1996. *Autonomous Maintenance for Operators*. Portland, OR: Japan Institute of Plant Maintenance.
- Jürgens, Ulrich. 1995. "Group work and the Reception of Uddevalla in German Car Industry", pp. 199–213 in: Ake Sandberg (Ed.), *Enriching Production. Perspectives on Volvo's Uddevalla Plant as an Alternative to Lean Production*. Aldershot, UK: Avebury.
- Jürgens, Ulrich. 1997a. "Rolling Back Cycle Times: The Renaissance of the Classic Assembly Line in Final Assembly", pp. 255–273 in: Koichi Shimokawa, Ulrich Jürgens and Takahiro Fujimoto (Eds.), *Transforming Automobile Assembly. Experience in Automation and Work Organization*. Berlin: Springer.
- Jürgens, Ulrich. 1997b. "Germany: Implementing Lean Production", pp. 109–116 in: Thomas Kochan, Russell Lansbury and John Paul MacDuffie (Eds.), *After Lean Production. Evolving Employment Practices in the World Auto Industry*. Ithaca, NY: ILR Press.
- Jürgens, Ulrich. 1998. "Implanting Change: The Role of 'Indigenous Transplants' in Transforming the German Productive Model", pp. 319–341 in: Robert Boyer, Elsie Charron, Ulrich Jürgens and Steven Tolliday (Eds.), *Between Imitation and Innovation*. Oxford: Oxford University Press.
- Jürgens, Ulrich and Martin Krzywdzinski. 2008. "Relocation and east-west competition: the case of the European automotive industry". *International Journal of Automotive Technology and Management* 8(2): 145–169.
- Jürgens, Ulrich and Martin Krzywdzinski. 2009. "Changing East-West division of labour in the European automotive industry". *European Urban and Regional Studies* 16(1): 27–42.
- Jürgens, Ulrich and Martin Krzywdzinski. 2013. "Breaking off from local bounds: human resource management practices of national players in the BRIC countries". *International Journal of Automotive Technology and Management* 13(2): 114–133.
- Jürgens, Ulrich and Martin Krzywdzinski. 2015. "Competence development on the shop floor and industrial upgrading. Case studies of auto makers in China". *International Journal of Human Resource Management* 26(9): 1204–1225.
- Jürgens, Ulrich and Martin Krzywdzinski. 2016. *New Worlds of Work. Varieties of Work in Car Factories in the BRIC Countries*. Oxford: Oxford University Press.

- Jürgens, Ulrich, Martin Krzywdzinski and Christina Teipen. 2006. "Changing work and employment relations in German industries: breaking away from the German model?", WZB Discussion Paper No. SP III 2006–302, Berlin: WZB.
- Jürgens, Ulrich, Thomas Malsch and Knuth Dohse. 1993. *Breaking from Taylorism. Changing Forms of Work in the Automobile Industry*. Cambridge, UK: Cambridge University Press.
- Jürgens, Ulrich and Frieder Naschold. 1992. "Arbeitsregulierung in der Bundesrepublik Deutschland im Spannungsfeld zwischen nationalen Gestaltungsstrategien und internationaler Produktivitätskonkurrenz" [Labour regulation in Germany between national strategies and international productivity competition], pp. 361–394 in: Klaus Grimmer, Jürgen Häusler, Stefan Kuhlmann and Georg Simonis (Eds.), *Politische Techniksteuerung* [Politics of Technology]. Opladen, Germany: Leske & Budrich.
- Jürgens, Ulrich, Katrin Naumann and Joachim Rupp. 2000. "Shareholder value in an adverse environment: the German case". *Economy and Society* 29(1): 54–79.
- Kädtler, Jürgen and Hans Joachim Sperling. 2002. "After globalisation and financialisation: logics of bargaining in the German automotive industry". *Competition & Change* 6 (2): 149–168.
- Kagermann, Henning. 2014. "Chancen von Industrie 4.0 nutzen" [Using the Chances of Industry 4.0], pp. 603–614 in: Thomas Bauernhansl, Michael ten Hompel and Birgit Vogel-Heuser (Eds.), *Industrie 4.0 in Produktion, Automatisierung und Logistik* [Industry 4.0 in Manufacturing, Automation and Logistics]. Wiesbaden, Germany: Springer VS.
- Kern, Horst and Michael Schumann. 1984. *Das Ende der Arbeitsteilung. Rationalisierung in der industriellen Produktion*. Munich, Germany: C.H. Beck.
- Krafcik, John. 1988. "Triumph of the lean production system". *Sloan Management Review* 30 (1): 41–52.
- Krzywdzinski, Martin. 2011. "Exporting the German work model to Central and Eastern Europe", pp. 99–116 in: Silvie Contrepois, Violaine Delteil, Patrick Dieuaide and Steve Jefferys (Eds.), *Globalizing Employment Relations*, London: Palgrave Macmillan.
- Krzywdzinski, Martin. 2017. "Accounting for cross-country differences in employee involvement practices: comparative case studies in Germany, Brazil and China". *British Journal of Industrial Relations* 55(2): 321–346.
- Krzywdzinski, Martin and Ulrich Jürgens. 2019. "Transfer deutscher und japanischer Ansätze der Facharbeiterausbildung an die BRIC-Standorte: Volkswagen und Toyota im Vergleich" [Transfer of German and Japanese Approaches to Skilled Work to the BRIC Countries: Volkswagen and Toyota in Comparison], pp. 281–319 in: Michael Gessler, Martina Fuchs and Matthias Pilz (Eds.), *Konzepte und Wirkungen des Transfers Dualer Berufsausbildung* [Concepts and Outcomes of the Transfer of Dual Vocational Training]. Wiesbaden, Germany: Springer.
- Kuhlmann, Martin. 2004. *Modellwechsel? Die Entwicklung betrieblicher Arbeits- und Sozialstrukturen in der deutschen Automobilindustrie* [Model Change? The Development of Workplace Social Structures in the German Automobile Industry]. Berlin: edition sigma.
- Kuhlmann, Martin. 2006. "Good Practice einer integrierten Fabrikorganisation" [Good Practice of an Integrated Factory Organisation] pp. 90–117 in: Michael Schumann, Martin Kuhlmann, Frauke Sanders and Hans Joachim Sperling (Eds.), *VW*



- Auto5000: ein neues Produktionskonzept. Die deutsche Antwort auf den Toyota-Weg?* [VW Auto5000: A New Production Concept. The German Answer to the Toyota Way?]. Hamburg, Germany: VSA Verlag.
- Kuhlmann, Martin, Hans Joachim Sperling and Sonja Balzert. 2004. *Konzepte innovativer Arbeitspolitik. Good-Practice-Beispiele aus dem Maschinenbau, der Automobil-, Elektro- und Chemischen Industrie*. [Concepts of Innovative Work Policy. Good Practices from the Machine-building, Automobile, Electrotechnical and Chemical Industry]. Berlin: sigma.
- Kuhlmann, Martin, Barbara Splett and Sascha Wiegrefe. 2018. "Montagearbeit 4.0? Eine Fallstudie zu Arbeitswirkungen und Gestaltungsperspektiven digitaler Werkerführung" [Assembly work 4.0? A case study on work design and work outcomes of digital assistance systems]. *WSI-Mitteilungen* 70(3): 182–188.
- Lacher, Michael and Roland Springer. 2002. "Leistungspolitik und Co-Management in der Old Economy" [Performance politics and co-management in the "Old Economy"]. *WSI-Mitteilungen* 54(6): 353–359.
- Liker, Jeffrey. 2004. *The Toyota Way*. New York: McGraw-Hill.
- Meier, Klaus-Jürgen. 2017. "Lean QRM 4.0 –Das Beste aus Lean Production, QRM und Industrie 4.0 vereint in einem gemeinsamen Managementansatz" [Lean QRM 4.0 – The Best of Lean Production, QRM and Industry 4.0 in a Unified Management Approach], pp. 119–135 in: Reinhard Koether and Klaus-Jürgen Meier (Eds.), *Lean Production für die variantenreiche Einzelfertigung* [Lean Production for High-Variant Single-Piece Production]. Wiesbaden, Germany: Springer.
- Mitlacher, Lars. 2007. "The role of temporary agency work in different industrial relations systems – a comparison between Germany and the USA". *British Journal of Industrial Relations* 45(3): 581–606.
- Muster, Manfred. 1988. "Zum Stand der Gruppenarbeit in der Automobilindustrie in der Bundesrepublik" [The State of Group Work in the German Automobile Industry], pp. 259–281 in: Siegfried Roth and Heribert Kohl (Eds.), *Perspektive Gruppenarbeit* [Perspectives on Group Work]. Frankfurt/Main, Germany: Bund Verlag.
- Orsburn, Jack, Linda Moran, Ed Musselwhite and John Zenger. 1990. *Self-Directed Work Teams: The New American Challenge*. New York: McGraw-Hill.
- Rinehart, James, Christopher Huxley and David Robertson. 1997. *Just Another Car Factory? Lean Production and its Discontents*. Ithaca, NY: ILR Press.
- Roth, Siegfried. 1996. "Wiederentdeckung der eigenen Stärke? Lean-Production-Konzepte in der deutschen Autoindustrie" [Rediscovering Own Strengths? Lean Production Concepts in the German Automobile Industry], pp. 109–139 in: Leo Kißler (Ed.), *Toyotismus in Europa: schlanke Produktion und Gruppenarbeit in der deutschen und französischen Automobilindustrie*. [Toyotism in Europe: Lean Production and Group Work in the German and French Automobile Industry]. Frankfurt/Main, Germany: Campus.
- Roth, Siegfried. 1997. "Germany: Labor's Perspective on Lean Production", pp. 117–136 in: Thomas Kochan, Russell Lansbury and John Paul MacDuffie (Eds.), *After Lean Production. Evolving Employment Practices in the World Auto Industry*. Ithaca, NY: ILR Press.
- Rüttimann, Bruno and Martin Stöckli. 2016. "Lean and Industry 4.0 –twins, partners, or contenders? A due clarification regarding the supposed clash of two production systems". *Journal of Service Science and Management* 9(6): 485–500.

- Sanders, Frauke. 2006. "Verknüpfung von Arbeit und Lernen" [Combining Work and Learning], pp. 79–89 in: Michael Schumann, Martin Kuhlmann, Frauke Sanders and Hans Joachim Sperling (Eds.), *VW Auto5000: ein neues Produktionskonzept. Die deutsche Antwort auf den Toyota-Weg?* [VW Auto5000: A New Production Concept. The German Answer to the Toyota Way?]. Hamburg, Germany: VSA.
- Schlick, Jochen, Peter Stephan, Matthias Loskyll and Dennis Lappe. 2014. "Industrie 4.0 in der praktischen Anwendung" [Industry 4.0 in Practice], pp. 57–84 in: Thomas Bauernhansl, Michael ten Hompel and Birgit Vogel-Heuser (Eds.), *Industrie 4.0 in Produktion, Automatisierung und Logistik*. [Industry 4.0 in Manufacturing, Automation and Logistics]. Wiesbaden, Germany: Springer.
- Schumann, Michael. 1994. "Gruppenarbeit und neue Produktionskonzepte" [Group Work and New Production Concepts], pp. 186–203 in: Peter Binkelman, Hans-Joachim Braczyk and Rüdiger Seltz (Eds.), *Entwicklung der Gruppenarbeit in Deutschland. Stand und Perspektiven*. [Development of Group Work in Germany. State and Perspectives]. Frankfurt/Main, Germany: Campus.
- Schumann, Michael. 2003. "Frisst die Shareholder-Value-Ökonomie die Modernisierung der Arbeit?" [Does the Shareholder Value Approach Roll Back the Modernization of Work?], in: Michael Schumann (Ed.), *Metamorphosen von Industriearbeit und Arbeiterbewusstsein*. [Metamorphoses of Manufacturing Work and Workers' Consciousness]. Hamburg, Germany: VSA.
- Schumann, Michael, Volker Baethge-Kinsky, Martin Kuhlmann, Constanze Kurz and Uwe Neumann. 1994. *Trendreport Rationalisierung. Automobilindustrie, Werkzeugmaschinenbau, Chemische Industrie*. [Rationalisation Report. Automobile Industry, Machine-Tool Industry, Chemical Industry]. Berlin: sigma.
- Schumann, Michael, Martin Kuhlmann, Frauke Sanders and Hans Joachim Sperling (Eds.). 2006. *VW Auto5000: ein neues Produktionskonzept. Die deutsche Antwort auf den Toyota-Weg?* [VW Auto5000: A New Production Concept. The German Answer to the Toyota Way?]. Hamburg, Germany: VSA.
- Seibold, Bettina, Martin Schwarz-Kocher and Rainer Salm. 2016. *Ganzheitliche Produktionssysteme* [Holistic Production Systems], HBS Study No. 340. Düsseldorf, Germany: Hans-Böckler-Stiftung.
- Seltz, Rüdiger. 1994. "Gruppenarbeit in der Produktion. Ein Beitrag zur Systematisierung von Entwicklungsstand und -perspektiven" [Group Work in Production. Developments and Perspectives], pp. 33–73 in: Peter Binkelman, Hans-Joachim Braczyk and Rüdiger Seltz (Eds.), *Entwicklung der Gruppenarbeit in Deutschland. Stand und Perspektiven*. [Development of Group Work in Germany. State and Perspectives]. Frankfurt/Main, Germany: Campus.
- Shimokawa, Koichi and Takahiro Fujimoto. 2009. *The Birth of Lean: Conversations with Taiichi Ohno, Eiji Toyoda, and Other Figures who Shaped Toyota Management*. Cambridge, MA: Lean Enterprise Institute.
- Shirose, Kunio. 1996. *TPM—Total Productive Maintenance: New Implementation Program in Fabrication and Assembly Industries*. Tokyo: Japan Institute of Plant Management.
- Smith, Chris and Peter Meiskins. 1995. "System, society and dominance effects in cross-national organisational analysis". *Work, Employment and Society* 9(2): 241–267.
- Sorge, Arndt and Wolfgang Streeck. 1988. "Industrial Relations and Technical Change: The Case for an Extended Perspective", pp. 19–44 in: Richard Hyman and Wolfgang Streeck (Eds.), *New Technology and Industrial Relations*. Oxford: Blackwell.

- Sorge, Arndt and Wolfgang Streeck. 2018. "Diversified quality production revisited: its contribution to German socio-economic performance over time". *Socio-Economic Review* 16(3): 587–612.
- Sperling, Hans Joachim. 2006. "Flexibilisierte und beteiligungsorientierte Lohn-Leistungspolitik" [Flexible and Participatory Wage-Performance Policy], pp. 72–78 in: Michael Schumann, Martin Kuhlmann, Frauke Sanders and Hans Joachim Sperling (Eds.), *VW Auto5000: ein neues Produktionskonzept. Die deutsche Antwort auf den Toyota-Weg? [VW Auto5000: A New Production Concept. The German Answer to the Toyota Way?]*. Hamburg, Germany: VSA Verlag.
- Springer, Roland. 1996. "Neue Formen der Arbeitsorganisation – Ursachen, Ziele und aktueller Stand in der Mercedes-Benz AG" [New Forms of Work Organization – Origins, Goals and Current State at the Mercedes Benz AG], pp. 61–80 in: Leo Kießler (Ed.), *Toyotismus in Europa: schlanke Produktion und Gruppenarbeit in der deutschen und französischen Automobilindustrie*. [Toyotism in Europe: Lean Production and Group Work in the German and French Automobile Industry]. Frankfurt/Main, Germany: Campus.
- Springer, Roland. 1997. "Rationalization also Involves Workers – Teamwork in the Mercedes-Benz Lean Concept", pp. 274–288 in: Koichi Shimokawa, Ulrich Jürgens and Takahiro Fujimoto (Eds.), *Transforming Automobile Assembly. Experience in Automation and Work Organization*. Berlin: Springer.
- Springer, Roland. 1999. *Rückkehr zum Taylorismus? Arbeitspolitik in der Automobilindustrie am Scheideweg* [Comeback of Taylorism? Work Policies in the Automobile Industry at the Crossroads]. Frankfurt/Main, Germany: Campus.
- Streeck, Wolfgang. 1996. "Lean Production in the German Automobile Industry: A Test Case for Convergence Theory", pp. 138–170 in: Susan Berger and Ronald Dore (Eds.), *National Diversity and Global Capitalism*. Ithaca, NY: Cornell University Press.
- Turner, Lowell. 1991. *Democracy at Work. Changing World Markets and the Future of Labor Unions*. Ithaca, NY: Cornell University Press.
- Turner, Lowell and Peter Auer. 1994. "A diversity of new work organization. Human-centered, lean, and in-between". *Industrielle Beziehungen* 1(1): 39–61.
- Weltz, Friedrich. 1997. "Anspruch und Wirklichkeit von arbeitspolitischen Ansätzen: das Beispiel Gruppenarbeit" [Claims and Reality of Work Design: The Case of Group Work]. *Arbeit* 6(4): 379–391.
- Weyer, Johannes. 1997. "Die Risiken der Automationsarbeit" [The Risks of Work in Automated Environments]. *Zeitschrift für Soziologie* 26(4): 239–257.
- Weyer, Johannes. 2007. "Autonomie und Kontrolle. Arbeit in hybriden Systemen am Beispiel der Luftfahrt" [Autonomy and Control. Work in Hybrid Systems in the Aviation Industry]. *Technikfolgenabschätzung – Theorie und Praxis* 16(2): 35–42.
- Wireman, Terry. 1991. *Total Productive Maintenance: An American Approach*. New York: Industrial Press.
- Womack, James, Daniel Jones and Daniel Roos. 1990. *The Machine That Changed the World*. New York: Rawson.