INSTITUTE
OF ECONOMICS

Scuola Superiore
Sant'Anna

LEM | Laboratory of Economics and Management

Institute of Economics
Scuola Superiore Sant'Anna

Piazza Martiri della Libertà, 33 - 56127 Pisa, Italy
ph. +39 050 88.33.43
institute.economics@sssup.it

LEM
WORKING PAPER SERIES

Trade unions' responses to Industry 4.0 amid corporatism and resistance

Valeria Cirillo †
Matteo Rinaldini ‡
Jacopo Staccioli §¶
Maria Enrica Virgillito ¶§

† Dipartimento di Scienze Politiche, Università degli Studi di Bari "Aldo Moro", Italy
‡ Dip. di Comunicazione ed Economia, Università degli Studi di Modena e Reggio Emilia, Italy
§ Department of Economic Policy, Università Cattolica del Sacro Cuore, Milan, Italy
¶ Institute of Economics, Scuola Superiore Sant'Anna, Pisa, Italy

2020/21 **August 2020**
ISSN(ONLINE) 2284-0400

Trade unions' responses to Industry 4.0 amid corporatism and resistance

Valeria Cirillo[*] Matteo Rinaldini[†]

Jacopo Staccioli[‡§] Maria Enrica Virgillito[§‡¶]

18th August 2020

Abstract

The aim of this paper is to shed light on the paths, directions, and ensuing degrees of technological adoption fostered by trade unions or, alternatively, forms of resistance thereof, in the so called 'Italian Motor-Valley', a distinctive technological district located in the outskirts of Bologna, Italy, specialised in the engineering/automotive industry. We find that the introduction of Industry 4.0 technology opens up a new space of action for trade unions in influencing firms' decisions on technological adoption. However, this new scope can have ambiguous effects, depending on how the process is governed. On the one hand, trade unions' involvement in said decisions might end up fostering corporatist tendencies, favouring the alignment of workers' and managers' objectives. On the other hand, such a major involvement can help both recompose old forms of dualism and revitalising workers' role in the crucial issue of work organisation.

JEL classification: L23, L6, M54, O33.

Keywords: Industry 4.0, Trade Unions, Organisational Change, Corporatism.

[*]Dipartimento di Scienze Politiche, Università degli Studi di Bari "Aldo Moro", Piazza Cesare Battisti, 3, 70121 Bari, Italy.

[†]Dipartimento di Comunicazione ed Economia, Università degli Studi di Modena e Reggio Emilia, Via Allegri, 9, 42121 Reggio Emilia, Italy.

[‡]Department of Economic Policy, Università Cattolica del Sacro Cuore, Via Ludovico Necchi, 5, 20123 Milano, Italy.

[§]Institute of Economics, Scuola Superiore Sant'Anna, Piazza Martiri della Libertà 33, 56127 Pisa, Italy.

[¶]To whom correspondence should be addressed: ✉ mariaenrica.virgillito@santannapisa.it

1 Introduction

The term 'Industry 4.0' (hereafter, I4.0) has been recently introduced to identify a new set of technological artefacts meant to stand at the core of the new 'intelligent factory'. These are characterised by a high degree of automation, digitalisation, and interconnection. Their introduction has produced a series of technological and organisational changes within the workplace of manufacturing firms, both within industrialised and catching up economies (see Cirillo et al., 2018). The degree and direction according to which the introduction of I4.0 artefacts and the ensuing transformation of organisational routines emerge are the result of the interaction between employers and employees. However, the presence or absence of an organised workforce can create major differences in the specific patterns of adoption. In particular, trade unions (hereafter, TUs) have proved to play a crucial role in influencing the implementation of technological and organisational practices (see Jürgens and Krzywdzinski, 2016; Smith and Vidal, 2019, for recent evidence).

The aim of this paper is to shed light on the paths, directions, and ensuing degrees of technological adoption fostered by trade unions or, alternatively, forms of resistance thereof, in the so called 'Italian Motor-Valley', a distinctive industrial district located in the outskirts of Bologna, Italy, specialised in the engineering/automotive sector. Our empirical investigation is based on one year of intense field-work activity consisting of semi-structured interviews with middle managers (manly in HR, planning, and R&D departments), workers, TU delegates, and focus groups with local TUs' leaders, the latter being responsible for the coordination with firm delegates.

The questions under scrutiny include whether and to what extent TUs have played a role in managing the process of technological change; in which respect TUs have facilitated, or rather prevented, the adoption of new organisational practices; to what extent TUs are empowered by new grounds of bargaining and able to widen the represented workforce composition (e.g. including white-collar workers). To this purpose, all interviews are decoded to detect the emergence of organisational practices typical of the lean I4.0 transformation, namely empowerment of the workforce (e.g. the designation of team-leaders), practices of job-rotation and mechanisms of active worker participation (e.g. teamwork), training practices, and monetary and non-monetary incentive schemes and career opportunities.

In line with the existing literature (see Haipeter, 2020, for supportive evidence on the role of TUs in German I4.0 factories), our results confirm that where the workforce is organised by means of a cohesive TU, their scope of action enables the firm to better appropriate the gains of technological and organisational improvements. Generally, the TU's negotiating role is significant during technological implementation phases (e.g. by opposing the introduction of intrusive forms of workers' surveillance) and related organisational changes. However, in all cases under study, we detect some important limits in the underlying bargaining process (e.g. in the absence of negotiation over internal working times and saturation) and a lack of TUs' involvement in the design phase of I4.0 artefacts, regardless of the degree of digitalisation and robotisation in progress. At the same time, our results highlight the presence of rather heterogeneous responses of local TU councils to I4.0. We do find that in the most digitalised firms, TUs show traits of corporatism, although still within a key role played by the national TU federation. Additionally, within these firms, I4.0 constitutes an opportunity to recompose old forms of dualism between white- and blue-collar workers, with white-collars' requests gaining more traction in the

bargaining process. Nevertheless, new forms of dualism emerge as well between core, specialised, permanent (white- and blue-collar) workers, and less-specialised, often temporary ones. We conclude that that the introduction of I4.0 technology opens up a new space of action for the role of TUs in influencing firms' technological adoption decisions. However, this new scope of action can have ambiguous effects, depending on how the process is governed. On the one hand, TUs' involvement in said decisions might end up fostering corporatist tendencies, favouring the alignment of workers' and managers' objectives. On the other hand, such a major involvement can help both recompose old forms of dualism and revitalising workers' role in the crucial issue of work organisation. Our findings are to be understood in light of a general weakening of industrial relations in Europe (Ebbinghaus and Visser, 1999) and a renewed progressive erosion of TUs' power under the Eurozone's institutional framework (Rathgeb and Tassinari, 2020).

The paper is organized as follows. In Section 2 we discuss the relationship between TUs and innovation both from an historical and theoretical perspective, with a comparative focus on other European instances. In Section 3 we present our research objectives and methodology, and provide a brief description of the firms under study. Section 4 outlines our empirical findings, distinguishing the role played by TUs in the technological adoption, work organisation, and working time. Finally, Section 5 concludes by positioning our findings with respect to the scope of representation, recomposition of old dualisms, and emergence of new ones.

2 The relationship between trade unions and innovation

What role have TUs historically played in the process of adoption and implementation of innovations? And how is this relationship changing in the wake of the current I4.0 wave? Without the ambition of revising the entire literature on these traditional topics for industrial relations (Hyman and Streeck, 1988), in the remainder of this section we provide some reconstruction of the importance of technological change as a space of negotiation within the Italian industrial relations system (Section 2.1), and of the emerging new roles and scope of actions of TUs as a result of I4.0 adoption and, more generally, of digitalisation, compared to other European countries (Section 2.2).

2.1 Trade unions and technological change in the Italian industrial relations system

Italian industrial relations have historically lacked of a proper set of regulation and bargaining agreement concerning the introduction, implementation, and adoption of technological and organisational innovations. According to Della Rocca (1985), until mid 1980s Italian collective agreements had not contained specific clauses to regulate work organisation and workers' welfare in the event of introduction of new technologies, the only exception being article 15 in the collective agreement of publishers and printers of registered newspapers and press agencies (ibid., p. 33). Two factors might explain this vacuum. First, a delay in the Italian productive structure when it comes to the degree of adoption of information and communication technology with respect to other European countries, which indirectly favoured a lack of contractual regulation. Second, the incremental nature of technological adoption, meant to face contingent operational problems rather than to promote radical technological upgrading or state-led industrial policies.

As a result, the introduction, adoption, and ensuing consequences deriving from the use of new technological artefacts were considered both by TUs and managers as a minor, secondary topic across all sectors. The banking sector, one of the first to undergo major technological changes with the introduction of electronic data processing (EDP) (Caselli, 1982), constitutes an exception therein. In this case, employees' training was seen as a core strategy to avoid forms of resistance by the workforce, therefore representing a case where the direct impact on the work process deriving from technological adoption is taken into consideration. For the rest, more widespread areas of negotiation were related to production and investment plans, with attention to problems like lack of internal demand, need of product diversification, strategies to face economic downswings, and, certainly, wage negotiation.

The agreement on new forms of work organisation and the use of information rights were two instruments of contractual regulation against this trend. The so-called 'OdL's (Organizzazioni del Lavoro, lit. organisations of work) were a first attempt by Italian TUs to negotiate technological innovations and the organisation of the work process. As a further tool of intervention, the collective agreement encompassed the so-called 'diritti di informazione' (lit. information rights). Thanks to these, obtained in the late 1970s, TUs had the right to be informed on investment programs, innovations and technologies, decisions of production decentralisation, horizontal and vertical mobility. Despite being included in the collective agreement, information rights were exercised with heterogeneous degrees, depending especially on firm size and level of unionisation. In particular, the geographical region under investigation has been historically crossed by a twist of conflictual and participatory practices which led, in early 1990s, to the formalisation of technical bilateral commissions on work organisation which are still present nowadays, as we shall see later on. However, overall, the Italian system of industrial relations was characterised by the absence of bargaining over the organisation of the work process and technological innovations.

The advent of new organisational practices brought about by lean philosophy at the end of 1980s (including training, participatory practices, problem-solving, teamwork, reward schemes) did not witness a reversal in the aforementioned trend. Their modes of applications, legitimacy, and acceptance were generally excluded from the bargaining process despite standing at the core of the lean production model which, although not so widespread, has seen a gradual adoption within the Italian manufacturing system. These practices resulted from informal applications unilaterally set by managers, rather than being properly negotiated.

A turning point is constituted by the 2008 economic crisis, when firm-level agreements started to include negotiation concerning flexible production plans to cope with market fluctuations. Indeed, lean production and just-in-time demand satisfaction rely on new working arrangements, including part-time, flexible working hours, shift rearrangement, and even smart-working (Ponzellini, 2017).

A functionalist approach (see, among others, Ponzellini, 2013) explains the late inclusion of negotiations on flexible organisation of the work processes as a cultural delay by Italian TUs characterised by the persistence of an ideological conflictual culture (Campagna and Pero, 2011; Ponzellini and Della Rocca, 2015). Pero and Ponzellini (2015) consider the lean manufacturing principle of employee participation (one of the pillars of so-called 'high-

performance work practices') a crucial element for developing a new system of industrial relations at the plant level, in which workers play a pivotal role.

2.2 Alternative perspectives on trade unions and Industry 4.0

According to the aforementioned functionalist approach, I4.0 represents a lever for accelerating the implementation of lean production, since digital technologies and cutting-edge automation allow to achieve a higher level of intra- and inter- organisational integration on the basis of a 'pull logic' and 'total quality management' (Buer et al., 2018; Tortorella and Fettermann, 2018). Furthermore, with respect to the organisation of work, the characteristics of I4.0 technologies (in terms of data collection, processing capacity, speed of information transmission, flexibility, usability, etc.) (Liao et al., 2017) create the conditions for achieving unprecedented degrees of flexibility and decision-making decentralisation (Wang et al., 2016). At the same time I4.0 represents a chance to rejuvenate a fossil and sterile bargaining system with a new role for TUs as transmission channel of managerial decisions and facilitator for the implementation of digitalisation of the work process at the plant level. Challenges are represented by new pressures arising from competitive markets environments, delays due to the adoption of new technologies, and tensions in the implementation of lean organisation and cultural changes which might create friction between aspirations and effective performances. Opportunities mainly consist in the urge of transforming the historical conflicting approach to be more participatory and collaborative, by allowing TUs to have an 'informative' role, therefore becoming an actor creating consensus. In this respect, it is envisaged the complete transformation of TUs from a general macroeconomic institution (Streeck, 1998), towards a local company-level actor.

In line with the new corporatist aspiration of TUs, a recent study focussing on the relationship between I4.0 and work councils in the German manufacturing sector (Haipeter, 2020), foresees a new repertoires of actions on behalf of TUs based on the activation of work councils and on cooperation between employers and delegates. Given that the founding pillars of I4.0 pose serious challenges for unions in terms of employment stability, work organisation, deskilling processes, and working conditions, it is recognised that conciliatory and collaborative practices are indeed required. This project, dubbed 'Work2020' (ibid.), envisages a new strategic role for work councils, ranging from consultancy to the company (identifying diffusion and new forms of digitisation), to strategy, defining problems and domains of analysis, and marketing, promoting plant level agreements. The Work2020 project also envisions a major involvement of workers' delegates concerning the organisation of work and degrees of power and hierarchies at the plant level, technological adoption and implementation, occupational training and working conditions (Armaroli, 2019). Overall, the workplace significantly increases its importance as a locus of negotiation in Germany, similarly to the efforts to realise a shift in the Italian collective bargaining from the national/sectoral level towards individual firms (Armaroli and Spattini, 2018; Harbecke and Filipiak, 2018). According to this view, the promotion of what has been defined a 'proactive' approach of work councils to digital transformation requires a strong combination of institutionalised forms of workers' participation through the implementation of practices devoted to train workers' representatives.

Similarly, the study by Genz et al. (2019) provides empirical support on the relationship between establishment-level workforce representation and digital adoption in Germany. By making use of the IAB Establishment Panel and administrative German labour force

data, they examine the effect of work councils on the implementation of digital technologies. The authors find a robust negative relationship between the presence of work councils and equipment incorporating digital technology. Additionally, work councils support the implementation of digitalisation in those establishments which display a high share of workers performing physical demanding tasks. The implementation of digital technologies enlarges the responsibility of work councils to mediate as a conflict-solving institution between employers and employees.

From a different perspective, another group of empirical and theoretical contributions highlight that the purported participatory culture at the core of the lean production system only concerns micro-organisational tasks and does not allow a genuine involvement of employees and their representatives on managerial decisions (Antonioli and Pini, 2005); nor it is related to an increase in workers' autonomy (Cirillo et al., 2018). These critical approaches consider I4.0 mainly as a continuation of a paradigm in which TUs' power is weakened and emphasise the necessity for TUs to mobilise workers and exert a conflictual role. Challenges clearly arise from technological unemployment, tasks intensification and/or deskilling, working time saturation, organisational changes, value chain disintegration, market pressure, change in workforce composition and related class identity. However there are rooms to react and resist to new forms of exploitation brought by I4.0. Objectives like 'bargaining the algorithm', rebuilding general representation, recomposing a new and diverse workforce, massively negotiating on work organisation, technological design and implementation, are viable and should be pursued (Moore et al., 2018).

These studies usually focus on the consequences of a pervasive adoption of digitalisation on workers. Indeed, they highlight new possibilities of pervasive forms of control over the work process (Cetrulo and Nuvolari, 2019; Moro et al., 2019; Tubaro and Casilli, 2019), in terms of continuous monitoring of workers performance and reward schemes and disciplinary usage of collected data. In this context of pervasive surveillance, Moore et al. (2018) outline forms of TU-led resistance and, more generally, TU responses. In many countries, TU have proposed guidance, policies, and codes of practice on workplace digitalisation, including proposals to update workplace-specific data protection and privacy legislation. Indeed, multi-employer bargaining lacks regulation on privacy and technology use, although TUs have negotiated some forms of protection against a pervasive use of digital technology (ibid., pp. 33-34). In Belgium, for instance, the 2002 National Collective Agreement on the protection of employees' private lives limits the use of digital data. In 2014, Swedish TUs played a key role in obtaining a new law protecting workers against technology-related stress at the workplace. Further examples are French TUs supporting the so-called 'right to disconnect' clause in the 2016 reform and Danish TUs striking an agreement concerning the introduction of new forms of control at the workplace. Apart from being proactive, TUs have pushed to implement rules which limit monitoring and control possibilities enabled by digital technologies and exercised unilaterally by firms.

Overall, the empirical literature, both qualitative and quantitative, is quite scant and is usually more devoted to analysing the extent to which the implementation of direct and indirect employees' participation practices is associated to major technological and organisational changes at the workplace level (Addison et al., 2017, 2001), neglecting the role that TUs might play along the process of technological change, from initial concept to actual deployment. When we focus on the recent wave of technological change, the number of empirical contributions is even smaller due to the lack of adequate quantitative

data and the specificities of I4.0 adoption within few large companies.[1] The present study aims at filling this gap by providing empirical evidence on the role played by TUs in the negotiation of I4.0 technologies.

3 Research objectives and methodology

The empirical analysis is conducted with the aim at detecting the relationship between: (i) TUs and the process of technological change, distinguishing between *design phase* and *implementation phase*; (ii) TUs and organisation of work; (iii) TUs' response and attitude towards the ongoing transformation. The choice of these domains of analysis is motivated by our interest in the effective role played by TUs when facing technological and organisational transformations. Additionally, we are interested in knowing whether dichotomies are emerging in terms of participatory vs. conflictual practices, in terms of the role actually played by union delegates, whether being a transmission channel for managerial decisions or raising collective workers' claims, and, together with their functions, also the scope of actions in terms of recomposition of a disaggregated workforce.

The analysis is to be understood inside an overall tendency of decentralisation of the bargaining process characterising Europe as a whole, although with some heterogeneity across different countries. Most European countries in the second half of the 20th century have progressively introduced a 'hybrid' system where 'multi-employer' collective bargaining conducted at a centralised level coexists with 'single-employer' collective agreements signed locally at the firm level, allowing derogation to specific provisions stipulated at the central level (Braakmann and Brandl, 2016). While the 'Northern' approach has represented the archetype of promoting decentralised bargaining, with emphasis on flexicurity and agile models, the industrial relations system in Germany still sees the role of regional/sectoral level negotiation as relevant in defining industry standards, although strongly eroded by derogation clauses (Doellgast and Greer, 2007), with France resorting to a massive usage of local bargaining, weakening the favourability principle (Béthoux and Mias, 2019), and Italy, wherein the second-level bargaining process is consolidated particularly in big firms, representing the lowest fraction of productive activities (Leonardi and Pedersini, 2018).

Our analysis is based primarily on semi-structured interviews carried out within four automotive firms located in the outskirts of the city of Bologna (Emilia-Romagna, Italy): Bonfiglioli Riduttori SpA (hereafter, Bonfiglioli), Toyota Material Handling Manufacturing Italy SpA (formerly known as Cesab, hereafter Cesab-Toyota), Ducati Motor Holding SpA (Ducati), and Automobili Lamborghini SpA (Lamborghini). The four cases represent examples of companies which borrow practices, systems, and models ranging from the Italian family business (Bonfiglioli), Japanese Toyotism (Cesab-Toyota), a mix of Taylorism and co-determination (Ducati), up to the instance most similar to the experiences of German '*Mitbestimmung*' (Lamborghini). Table 1 provides a picture of the current imple-

[1] Focussing on recent data on Italian engineering companies, Cirillo et al. (2020) highlight an overall scattered adoption of I4.0 technologies. A 'single technology' adoption approach seems to prevail over a 'multi-technology' strategy based on simultaneous investments in complementary I4.0 artefacts. The presence of company-level agreements is positively associated to investments in I4.0 mainly in manufacturing and SMEs. However, it does not provide information on the role of TUs in the bargaining process of new technologies, nor it provides details on the content of second-level bargaining.

mentation of I4.0 technology and organisational practices within these firms. For further analysis see Cirillo et al. (2018).[2]

Bonfiglioli

Bonfiglioli manufactures gearboxes and other transmission elements. As of 2019, revenues amount to 630 million euros and employees to 1,501 units. At the time of interviews, it is experiencing a phase of transition in terms of market demand satisfaction. In particular, it is moving from an old-style inventory management towards a just-in-time system. As a matter of fact, even today there is no strict takt-time enforced. The production activity entails plenty of phases with little value added, comprising the transportation of both equipments and components. The firm has experienced a long phase of stagnation since the 2008 crisis, with prolonged periods of redundancy fund, thereby reducing individual working time. In the last few years the firm has decided to invert the decadent trajectory with a new phase of investment and market demand management, with the so-called 'EVO' project. The internal organisation of the firm reflects a change in ownership, still in the hand of the Bonfiglioli family, from the old style enlightened master represented by the initial funder, to his much more market-oriented and management respondent daughter. In fact, even though there is a general constructive environment, many organisational participation practices are still rather underdeveloped. There is a strong degree of solidarity among workers, who do not appreciate potential incentive schemes fostering internal competition. Job rotation is not a standard practice: many workers have been operating the same tasks for many years. Across different manufacturing stages, workers execute repetitive and often rather arduous work, especially for women. Workers typically do no talk too much to one another and show little knowledge of the overall production process. Given this low degree of job rotation, manufacturing is heavily dependent on individual know-how, meaning that, within certain departments, the absence of a single worker might arrest production. The schemes of performance evaluation are not clearly defined and a high level of discretionary practices regulates both horizontal and vertical mobility. There is no formalised practice fostering workers' participation to the production process design; teamwork has just been introduced. Some workers, in particular maintenance technicians, have received vertical training consisting of formal class hours. But this is far from standard practice and strictly depends on the tasks performed by single workers and their relevance to the production process. There is no formal practice to collect workers' suggestions aimed at improving the production system, and the hierarchical structure is rather strict.

Cesab-Toyota

Cesab-Toyota manufactures forklifts and other small material handling vehicles, such as hand pallet trucks and light tow tractors. As of 2019, revenues amount to 506 million euros

[2]The study of these companies is part of a larger research programme (started in 2016 and still ongoing) by the Claudio Sabattini Foundation, commissioned by FIOM-CGIL (one of the leading Italian TUs) and involving researchers from several universities and research institutes. The main purpose is to understand main trends concerning the organisation of work and working conditions occurred in recent years alongside the introduction of technological practices related to I4.0. In line with the general objectives and methodology of the research programme, we decided, supported by experts, union leaders, and other scholars in the field, to select a few engineering firms deemed to be particularly advanced on technological grounds. These companies, called 'focal firms', give rise to case studies within the present research.

Industry 4.0 technology			
Bonfiglioli	**Cesab-Toyota**	**Ducati**	**Lamborghini**
◇ MES software ◇ AGvs ◇ collaborative robots	◇ digital utensils (e.g. torque wrenches) and their data analytics ◇ digital internal communication via tablet computers ◇ 3D printing (prototyping) ◇ ERP software ◇ M2M communication	◇ digital utensils (e.g. torque wrenches) and their data analytics ◇ partial paperless factory ◇ 3D printing ◇ pick-to-light ◇ virtual configurators ◇ AGVs ◇ collaborative robots ◇ M2M communication	◇ IoT ◇ big-data analytics (in early stage) ◇ MES software ◇ AGVs ◇ collaborative robots ◇ M2M communication
Organisational practices			
Bonfiglioli	**Cesab-Toyota**	**Ducati**	**Lamborghini**
◇ Introduction of job-rotation ◇ No existence of working teams ◇ Head of Department, strong hierarchies	◇ Job-rotation ◇ *Asaichis* ◇ *Kaizen* ◇ *Andon* ◇ Team Leader and Jolly hybrid hierarchies	◇ Job-rotation ◇ Briefing ◇ Processes of continuous improvements (GMK) ◇ Individual zero-error prizes ◇ Team Leader, hybrid hierarchies	◇ Job-rotation ◇ Team-meetings ◇ Processes of continuous improvements (management of ideas) ◇ Flexibility matrix ◇ Report card ◇ Team Leader, soft hierarchies

Table 1: Specific implementation of Industry 4.0 technology and organisational practices within our case study firms.

and employees to 542 units. Since 2001 Cesab-Toyota has been a subsidiary of Toyota group. This takeover marked the introduction of the so-called Toyota Production System and the implementation of the 'Toyota way' at the plant level. It also marked a wider product gamma diversification and customisation. From the organisational standpoint, a few substantial changes have recently taken place. Among others: the elimination of local crafting 'islands' in the plant, substituted by a fully fledged towed assembly line; a drastic reduction in inventories; the introduction of a *kanban* system; a complete reorganisation of workstations and the implementation of the so-called '5S' (Sort, Set in order, Shine, Standardise, and Sustain); the introduction of continuous improvement processes; a complete reorganisation of hierarchical levels in the manufacture division, with the introduction of the TL and of the jolly figures. Team domains vary between 10 and 25 workers, depending on the underlying department. Another major transformation has been the introduction of the concept of 'tense' production flow. Currently, the plant manufactures 75 forklifts per day and the lead time (order to delivery) averages to about a week. A stronger organisational integration with external suppliers (the majority of which are located within 200 km from the plant) has been crucial in providing finer product customisation and reducing overall manufacturing time. Recently, coordination teams devoted to a finer integration with suppliers and the implementation of lean principles within these latter have been set up. For the sake of example, the tense production flow mechanism together with the Toyota Production System have been gradually reducing the takt time in the 'inspection' department from 19 minutes across 3 workstations in 2007 to 6½ minutes across 5 workstations nowadays. Another consequence has been the overall intensification of working times and their flexibility, and more frequent requirement of long hours from workers.

Ducati

Ducati is a high-end motorcycle manufacturer. As of 2019, revenues amount to 744 million euros and employees to 1,339 units. Since 2012 Ducati has been a subsidiary of the Audi group, in turns a subsidiary of the Volkswagen group. The product gamma includes around ten distinct models, all powered by a smaller range of 2-3 engine blocks. Both motorcycles and engines are assembled in-house. There are 4 vehicle assembly lines and 3 engine assembly lines. Chronologically older lines are of the stop-and-go type, while newer ones are continuously towed. Once a motorcycle is fully assembled, two consecutive test drives and a final aesthetic check are performed. Ducati suffers from strong seasonality of orders, given that leisure driving of motorcycles peaks during warm seasons. Accordingly, manufacturing volumes vary widely over the course of the year, and can range between 140 to 410 vehicles per day. Overall, the Audi takeover has marked an increase in both production volumes and product customisation, which coincided with an intensification of working times and overall just-in-time orders evasion. Currently, the majority of assembly lines are organised in a modular fashion; each is composed by multiple 22 minutes long micro-phases. Whether an assembly worker continuously repeats a single micro-phase or rather follows the engine/vehicle along the entire line depends on contingent orders and daily production plan. Depending on the latter, a worker may be required to assemble differently customised products in random order within the same day. Size of teams also oscillates depending on seasonal production plans (and on department specific requirements) and typically ranges between 5 and 20 units. Along with motorcycle manufacturing, there exists a fully autonomous and self-contained department,

called Ducati Corse, uniquely aimed at managing the racing team of the company, which currently competes in MotoGP and other similar events. In particular, this department includes its own R&D division, assembly and test-drive facilities, and managing team, all acting independently of the main manufacturing plant. The very area it operates in is 'hermetically' sealed from view to other Ducati workers and visitors due to the secret nature of racing industrial blueprints.

Lamborghini

Lamborghini is a luxury sports car manufacturer. As of 2019, revenues amount to 1.87 billion euros and employees to 1,685 units. Since 1998 Lamborghini has been a subsidiary of the Audi group, in turns a subsidiary of the Volkswagen group. Traditionally, the product gamma has included two 2-seat sports car models, together with their convertible adaptation. Both target the very high end segment of the market, although one is advertised as superior and carries a price tag that doubles the other. Every few years a brand new model is launched and immediately replaces the one in its associated tier. Since 2018 Lamborghini manufactures a third model, a luxury SUV which caters to a family audience, expected to double overall production volumes. At the time of our field work, production of the SUV had yet to commence. Each model comes with innumerable customisation options and has a dedicated assembly line (L-shaped for the superior model and U-shaped for the inferior). The inferior sports car model has both the engine and the aluminium shell prefabricated by external providers. Regarding the superior model, which enjoys a more 'handcrafted' reputation, both the engine block and the carbon-fibre shell are produced in house, the former in a dedicated assembly line and the latter in a fully autonomous and self-contained department. The CFK (Carbon Faserverstärkter Kunststoff, German for carbon fibre reinforced polymer) employs 200 people and acts as a firm-within-the-firm, in that it consists of dedicated entities which regulate R&D, industrialisation methods and timekeeping, and is tasked with the whole transformation of raw carbon filaments into vehicle shells and other parts (such as spoilers and rear mirrors). The process is complex and entails, among others, cutting, pressing, bonding, sandblasting, and lamination. Work is organised in teams in virtually all departments. Small teams of 4-6 are typical of quality checks and the trim department, while along the assembly line teams reach around 15 units, including a TL and a jolly. The Audi group takeover marked the passage to a more serialised and procedurally standardised production, from a process which previously was more artisanal and 'piece-by-piece' structured. In particular, assembly lines have been progressively computerised and cycle times have been strictly fixed. Working times have intensified in the last decade as production volumes have stably soared (for example, manufacturing of the superior sport car model doubled from 3 to 6 vehicles per day between 2010 and 2018). However, compared to other automotive companies, takt times remain fairly wide (37 minutes for each workstation of vehicle assembly and 75 minutes for engine assembly). Synergies have also been established with the parent group, especially regarding supplies of pre-assembled components.

3.1 Field-work analysis

The four case studies considered in this paper started with a series of discussion groups among researchers and union delegates of the underlying firms. The discussion groups (around 3, each consisting of about a dozen people) had the following objectives: preliminarily exploring the issues under study with union representatives; reconstructing the layout of the plant and its workflow; identifying potential interviewees; building the relevant access channels for researchers. Access of researchers to the firm premises had been therefore mediated by TUs. However, the sample of interviewees was designed to include also non-unionised workers and to be balanced with respect to the various departments.

Subsequently, semi-structured interviews with the identified candidates were carried out. In this paper we analyse a set of 49 interviews with workers at the four plants, distributed according to Table 2 in the Appendix. A non-exhaustive list of topics covered during the interviews include, among others, the level of contractual framework, career paths, performed tasks and work process, technological innovation and adoption, human-machine relationship, formal and informal training, ergonomics, practices of labour management and organisation, forms of recruitment, union membership and relationship with union delegates, forms of resistance (such as strikes), content of firm-level contractual agreements. The pool of interviewed workers is heterogeneous in terms of departments, ranging from process design, R&D, assembly line, quality control, testing, logistics, purchase and sales, and in hierarchical layers, including different levels of contractual framework (third, fourth, fifth, sixth), and functions (ordinary operator, team leader), encompassing both blue- and white-collar workers[3] with seniority ranging from 5 to 25 years. Interviews were conducted at the production plants in areas made available by the company or by union delegates. The interview activity had been preceded by a visit to the different areas and departments of the plant; this represented a good opportunity of directly observing the state of technology in place and the organisation of work. In parallel, 6 other interviews were conducted with managers of the companies and other technical figures, the selection of whom varied depending on the specific characteristics of the plant. The interviews also gave us the opportunity of collecting business documents and other publications relevant to the current research.

The collection of this material lasted for about one year and has given rise to a corpus of text on which, starting from the theoretical framework illustrated above, we carried out the analysis through a textual content dissection according to a general to specific 3-layer coding system, reported in Table 3 in the Appendix. This entailed an iterative, rather than linear, process between our data and the emerging patterns, while also looking for relevant 'breakdowns' that could challenge the interpretation of what was occurring in the field (Alvesson and Karreman, 2011).

Consistently with the outlined methodology, the interviews, the collection of other informational material, and the process of analysis, did not follow a principle of statistical representativeness, but rather of concept saturation. Our results therefore do not aim at formulating proper causal generalisation.

[3] White-collars are actually under-represented in our sample. Transformations involving their work process usually conflate in the increasing standardisation of times and procedures dictated by the interaction with the network in which they operate, comprising of the parent-company, clients, suppliers. In the following, we mainly report evidence from blue-collar workers.

4 Empirical findings

In this section we present our empirical findings listed according to domains of analysis, namely technology (Section 4.1), work organisation and related working time (Section 4.2), and general TUs responses (Section 4.3).

4.1 TUs and technology

In terms of TUs' role in influencing the process of technological change in the design phase, TUs manifest a general acceptance of the ongoing process of transformation. They seem to play little role in the design phase overall (e.g. no interaction with the R&D department) and tend to consider technology as a datum.

One might ask whether it is legitimate to require TUs' intervention in the phase of technological design which should be firmly in the hands of the management. Nonetheless, if less so at the micro-scale, TUs have rather been pivotal in influencing the process of technological adoption at the macro-scale. Indeed, they exert a crucial role in promoting huge investment plans involving complete technological upgrading, together with the development of new products. This seems to occurred in all our firms except Cesab-Toyota. At Lamborghini, TUs have been able to obtain an investment plan of 50 millions euros to locally manufacture a brand new SUV model (known as URUS) instead of at an Audi plant in Bratislava, Slovakia. Similarly, at Bonfiglioli, TUs have strongly pushed for the recent EVO project, foreseeing massive I4.0 adoption (still under development at the time of interviews). TUs have also played a major role to promote investment in innovation and new product lines at Ducati. Overall, whenever technology assumes its labour-augmenting nature, say, whenever it entails expansionary investments, construction of new productive capacity, elimination of old vintages, and new product lines, TUs have manifested a clear proactive role in the firms under study.

Their role in the implementation phase is even more pronounced. In fact, TUs recognise the importance of participating therein, as demonstrated by the presence of technical bilateral commissions called 'New products and new processes'. These commissions are a typical, long-lasting trait of the forms of organisation of TUs in Emilia Romagna. Within all firms, technical bilateral commissions are either established to oversee work organisation and technology or explicitly mentioned in contractual agreements to be activated later on. In some establishments, respondents report that technical bilateral commissions were already in place since the 1990s. Bilateral commissions composed by elective TUs delegates and white-collars from the timekeeping department have informative, consultative and, in some cases, proposing roles. Additionally, by means of the active role exercised within the aforementioned commissions, TUs have explicitly reacted to the adoption of I4.0 technologies. At Bonfiglioli, a contractual agreement explicitly set boundaries to the use of MES (Manufacturing Enterprise System) software, ruling out the possibility of collecting data on individual rhythms of production and individual performance, and their use for disciplinary purposes.

> As a trade union, we are not able to design technologies since we don't have competencies, but we are able to set limits to technologies' use and their repercussions on the social system. For instance, the MES helps in making the production process more efficient and we favour it, but we oppose its use for other objectives, such as pervasive surveillance. [TU delegate]

Overall, TUs have demonstrated some negotiation ability on technological implementation, advancing on the possibility of 'bargaining the algorithm'. Indeed, TUs acknowledge the underlining threats of deskilling related to the introduction of I4.0 technologies.

> The introduction of new technological systems has implications for the organisation of labour, especially when it comes to increasing production saturation. The goal is something akin to the [Elementary Technological Unit] of FIAT (an Italian automotive manufacturer), with less complex and articulated tasks, actually deprofessionalised, with segmentation in the organisation of highly specialised work in the various phases, therefore very replaceable. As a TU, we lag behind in the analysis of organisational flexibility and the consequences on contractual practices. From the point of view of the effects, we have tried to limit the social control of the worker, from surveillance to performance evaluation, without objecting the introduction of technology. [TU delegate]

4.2 TUs and work organisation

In terms of organisational change, our research material points at the role of four relevant domains of analysis, namely training activities, general high-performance work practices (HPWPs), career paths, and evaluation procedures.

In all contractual agreements, TUs have obtained the formal recognition of education achievements, such as diplomas, bachelor's and master's degrees. The recognition consists both of monetary awards and time off to attend class. With respect to informal, on-the-job-training, at Cesab-Toyota and Bonfiglioli no mention appears in the contract, while at the two 'Audi' firms, Ducati and Lamborghini, specific internal training programs and even dedicated places on the factory floor have been created. Additionally, in the latter firms, TUs have been rather active in launching and promoting internship programs targeting young students. Many interns undergo training and are later hired by the company. This initiative, known as DESI (Dual Education System Italy) is the result of the interaction between the typical German vocational training system and regional and state initiatives promoting active educational programs.[4]

With regard to HPWPs, namely job-rotation schemes and participatory practices such as suggestions for improvement, team meetings, teamwork, and kaizens, their deployment vary across firms, from widespread and generally formalised activities to informal and scattered (cf. Table 1).

> They listen to you, however, in order to get [a specific type of cart], it took 5 years and only half of the problem was solved. I wrote on the register at the end of the line, but the sheet has disappeared. One of my proposals was [to introduce this cart] for that and another location, where it did not arrive because, they say, that otherwise they would steal it. They had given us a kind of hook that was almost worse. It went better with a type of grease that was really smelly and irritating: my mouth and respiratory tract were irritated. I prepared a safety sheet, the union endorsed me and the grease was replaced.

[4]The current DESI call for applications, in Italian, is available here: https://bur.regione.emilia-romagna.it/bur/area-bollettini/bollettini-in-lavorazione/luglio-periodico-parte-seconda-2a-quindicina.2018-07-24.9634416374/approvazione-schema-di-intesa-fra-regione-emilia-romagna-ufficio-scolastico-regionale-per-lemilia-romagna-ducati-motor-holding-s-p-a-automobili-lamborghini-s-p-a-per-la-realizzazione-del-progetto-dual-education-system-italy-iii-desi-iii-attraverso/allegato-2

> Maybe I should have insisted more. But even if you are backed by the TU it is not easy, even though this is a company that has always met me.
>
> [Assembly line worker, Bonfiglioli]

In general, organisational practices stand at the core of TUs negotiations when drafting the content of the contractual agreement, as demonstrated by the existence of a technical bilateral commission on 'work organisation'. For instance, TUs at Ducati are pushing to obtain transparent and formalised criteria when acknowledging operators' versatility and multifunctionality, which arise when operators are able to execute tasks at different phases of manufacturing. Continuous improvement systems are established at Lamborghini, while *asaichi* and *andon* are present in Cesab-Toyota. However, when HPWPs are less formalised or still prospective, as is the case of Bonfiglioli, TUs seem to lack the ability to intervene and their influence is limited. For instance, job-rotation practices have been acknowledged as important by managers at Bonfiglioli, but their implementation has not been shared with workers. It appears that the negotiation phase can start only after the organisational decision has already been taken.

> I created a file in which each production location lists the operators able to use the underlying machines. If one or more operators stay at home, I don't have the opportunity to replace them. The machine must always run. I have some areas where we are not covered. If an operator is absent, we have to leave the machine idle. We're trying to put in place side-by-side training, so to increase operators' versatility. This is costly because one works and the other does nothing. Learning is a cost, and it doesn't always end well. Some take a months, others take three months. We have a versatility plan because if someone is at home, I don't want to slow down production. Currently, some areas are critical. As soon as we have reached optimality, we will see if manpower is 'real' or not. We might end up remove some. [Timekeeper, Bonfiglioli]

The negotiation of assessment procedures and career paths is characterised by a more passive role of TUs at Cesab-Toyota and Bonfiglioli, while a more active role characterises TUs in the two German cases. A clear distinctive element has been the introduction of the Audi workers chart, which is helpful in formalising the latter schemes, at least in the contractual agreement. In spite of clear similarities between Ducati and Lamborghini in terms of their industrial relations system and proximity with HR department, the two firms sharply differ in their effective internal organisation. Indeed, their respective contractual agreements are almost identical, but the actual implementation of the contract at Ducati manifests a lower degree of pervasiveness. In fact, on the one hand, TUs have negotiated and permanently monitor the assessment and career systems based on hard competencies and employees' seniority, such as professional integration skills, job management skills and versatility, continuous improvement skills. On the other hand, TUs have no voice on the introduction of specific assessment systems (e.g. evaluation cards with grades A, B, C) introduced by managers and focussed on soft skills, which however seem to count for career prospects, together with the prominent role exercised by team-leaders to get advancements, particularly at Ducati wherein hierarchies are more marked.

In all case studies, a generalised intensification of working time is registered. Takt-time and dead time have been generally reduced. This is the result of the introduction of the just in time principle of production and of the general tendency to keep the production flow

'tense'. Although no explicit mention to the issue of saturation of working time is present in the contractual agreement, at Bonfiglioli there exists a process of information sharing between the timekeeping department and assembly line workers: times and methods of execution, when introduced for the first time, are formally explained to the operators involved in a given assembly line, with the presence of TU delegates. Then a synthetic written chart is also provided. The timekeeper finds it useful to have this informative process because this prevents possible complaints later on. It seems an effective way of managing and eventually neutralise potential conflicts.

> Initially, I was a little hesitant and I saw them very attentive to many things which I took for granted were ok. Initially, they considered me almost like a slave driver, too harsh with the operators. Then I had to change my attitude a little. The union takes care of workers. In the company where I was before, I didn't have any kind of disagreement; they almost didn't care. Coming here and seeing a very interested union which wanted to scrutinise all your work for taking care of workers left me a little hesitant. Then I saw that we work well and we get a result in which no one complains because the work has been shared and socialised. While in my previous workplace I was keeping times and workers were not questioning, without knowing why. More than improving efficiency, it improves connection; I had to change my mind. I'm now used to listening to them, because working all day on the assembly line, they are the only ones who know 'life, death and miracles' of machines. I can stay 20 hours in front of a machine but maybe I don't notice things that happen once a month, and when they happen, a lot of time is wasted. The mood has improved a lot. Previously, they thought they had to blindly trust me. Here, they made me understand that everyone has to be made aware. In my previous company, it wasn't required. If operators know everything, they will not tell you that you are making them do something wrong. [Timekeeper, Bonfiglioli]

TUs exhibit a low degree of bargaining power when it comes to relaxing internal working times (intended as the relationship between working hours and activities that take place therein, namely pace, saturation, rhythm, etc.), meaning that the general trend towards increasing saturation, detectable at all firms except Lamborghini, is hardly counterbalanced. At Ducati, TUs had to negotiate for lunch break, colloquially called 'pausa saponetta' (lit. soap break), not to be deducted from the working shift time.

External working time (intended as the duration of shifts and overall hours worked) has also increased. However, differently from internal working time, it has been characterised by a stronger level of negotiation. At Lamborghini and Ducati, for instance, TUs have negotiated to better achieve flexibility and work-life balance by introducing in the contractual agreement the possibility of teleworking (known as 'smart working' in Italy) for white-collars, well before the explosion of the COVID-19 pandemic in 2020, entry and exit flexibility, seasonal working time (summer working-time reduction), holidays redistribution, possibility of substitution of extra-time with a hourly flexibility package, extension of the 'bank of time' (to 50 hours per year). Working shifts are a major topic of bargaining since there is a clear tendency of increasing time saturation, rather than hiring more workers. Shifts have been reorganised recently at Ducati and Bonfiglioli. Workers typically prefer individual, voluntary extra-time rather than compulsory, equal for all, longer shifts.

4.3 TUs and representation

With respect to our empirical findings, TUs are working to recompose different forms of dualism: traditionally, a dualism between blue- and white-collars, new forms of dualism between permanent and temporary contracts, and a dualism between the parent company and its subcontractors in the industrial network (Greer, 2008). With respect to traditional dualisms, TUs at Lamborghini have actively worked to reduce the separation between blue- and white-collars, with the former increasing in terms of membership (Russo et al., 2019), and with a growing number of new contractual elements more directed towards white-collars, especially regarding teleworking. Indeed, in the most *knowledge based* firms, TUs are working to thin the traditional blue vs. white. However, the by-product is that TUs are manifesting an increasingly corporatist behaviour, in perfect continuity with the general tendency towards the growing importance of decentralised bargaining and the proactive role advocated for work councils by the functionalist approach to deal with I4.0. One element which deserves consideration is that Lamborghini represents more the exception than the norm, in terms of both product segment and internal industrial relations system. It is hardly conceivable for the latter to be extended nationwide, given the backward industrial structure characterising Italian firms and the reticent approach towards forms of collaborative working practices (Cetrulo et al., 2019). Additionally, the German experience of vertical disintegration in the automotive sector, even for luxury products, should warn against the endless stability of this system (Greer, 2008).

At the opposite end of the spectrum, Bonfiglioli is still characterised by a 'rough' worker consciousness, and the separation between blue- and white-collars remains quite strong.

> It's a company which has never been afraid of going on strike. It is not easy to compare with Lamborghini, which is a jewel. Hyper-protected models lead to very dangerous corporatist dynamics. At Bonfiglioli, corporatist dynamics is not high. By corporatist dynamics, we mean a union that makes excellent contracts but never conflicts with the company. [...] There is a sense of belonging. Workers here are a little more rough. [TU delegate]

In this firm, workers exhibit solidarity, and the permanent vs. temporary workers dichotomy is not overly strong.

> The new ones are a Romanian, a Sardinian. They are temporary. I have an excellent relationship with them. They do a different machining, but they are in close proximity to me. If we go on strike, they are terrified. They can not. If there's an assembly, they ask if they can come. [...] We have done a nice thing with the internal contract: prizes are awarded to the new ones. I went to the head of the department told him not to let them go. And in fact they renewed their contract first from February to March, then from March to June, then until December. We try to cheer them up. New workers are all temporary.
>
> [Mechanical machining worker, Bonfiglioli]

In spite of the relatively underdeveloped level of horizontal practices, the degree of unionisation is rather strong and cohesive: many workers have reported their participation to conflictual episodes, such as strikes, resistance to outsourcing and relocation of some production units in other plants. The single union representation is showing particular ability in managing this new technological wave, with particular attention to preventing

use of the MES as a form of control. In general, the degree of overlap between workers' and managers' objectives is scant. Union delegates always refer to the firm using the third person 'them', as opposed to 'us', which is instead widely used at Lamborghini and Ducati. However, although more corporatist, the old vs. new generation dichotomy is strongly perceived at Ducati, where interviewees report that temporary workers tend to work more and somewhat 'compete', with the aspiration of getting hired permanently. This creates some tension between the two groups and challenges for TUs, which, to our understanding, have yet to fully grasp the stress generated by the vertical part-time system both on full-time workers and newcomers.

> I see the union is very active. So far I haven't joined because I don't yet feel the need, and since I'm part time and work 6 months a year, I am waiting for the union to give us support. In August I'll go home and have to look for another job. I also have a mortgage in Bologna, thanks to help from my parents. I would like a battle on this. If the company has kept me for 5 years, there must be a reason. My goal is to work. If I work until the end of July and then I find myself out on the street, I'm forced to look elsewhere.
>
> [Assembly line worker, Ducati]

5 Final considerations and conclusions

We analyse the role played by trade unions with respect to technological adoption and work organisation spurring from the Industry 4.0 wave of innovation. A somewhat tangential domain of interest is represented by workers' representation. In our case studies, all highly unionised workplaces, trade unions overall pave the way for Industry 4.0 adoption and implementation, although they still largely represent the 'old labour aristocracy', prioritising the defence of claims by senior/permanent, national workers, and possibly feeding dichotomies among the workforce (e.g. part-time vs. full-time, internal vs. external, junior vs. senior workers).

Indeed, the role of trade unions vary across firms and over time. In some instances, they foster the adoption of high-performance work practices (see Gill, 2009; Gill and Meyer, 2013, an the case made by Shaiken et al., 1997), while in others they hamper the implementation of new forms of coordination, when perceived as a threat by unions themselves (Herrigel and Sabel, 1999). In terms of union coverage, contingent and temporary workers present specific needs (Lautsch, 2002; Vidal and Tigges, 2009), at times in apparent conflict with the rest of the workforce, as the former typically tend to rush the takt-time to signal efficiency and tend to refrain from strikes, under the threat of dismissal. In this respect, the use of contingent employment might be due to cost-compression strategies aiming at managing volatility of demand (Houseman and Osawa, 2003) and to leverage on vertical disintegration in order to reduce unions' power, amid the emergence of a core-periphery structure (Doellgast and Greer, 2007). Additionally, union coverage might be also driven by institutional considerations relative to sheer work organisation and the coverage by trade unions of temporary workers (Osterman, 2011, 2018).

To sum up, we are able to identify two alternative responses by trade unions, either *reactive* or *proactive*, vis-à-vis the introduction of Industry 4.0 technology. Rather interestingly, the higher the level of technological innovation already present, the higher the degree of union participation. This type of proactive attitude applies in particular to Ducati and

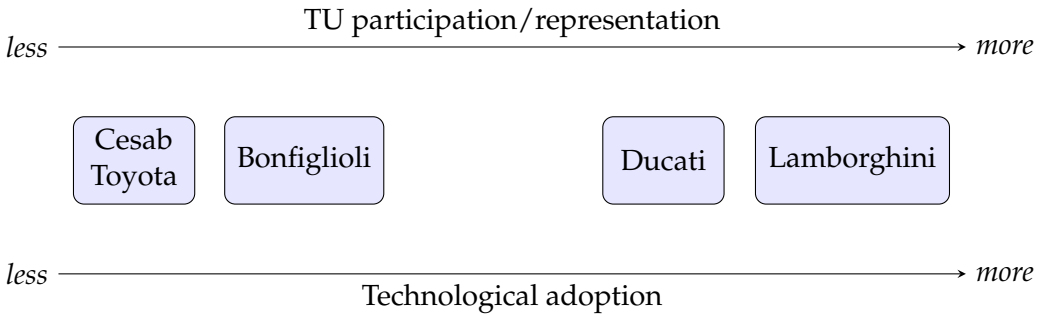

Figure 1: Illustrative positioning of our case studies along the dimensions of TU participation and representation, and of I4.0 technological adoption.

Lamborghini. At Lamborghini, the role of trade unions is considered fundamental, even by white-collars, when introducing technological innovations. Indeed, this circumstance may have been inherited by their common parent company, Audi, which is known to introduce a 'workers chart' defining given standard of work organisation in all its subsidiaries. However, this is coupled with the pre-existent system of industrial relations typical of the Bologna area.

> Without support from the trade union, nothing can happen here. Neither organisational, nor technological change. [Technologist, Lamborghini]

On the opposite side, a more reactive role is instead discovered at Cesab-Toyota and Bonfiglioli, where trade unions display a lower degree of participation in managing the process of technological adoption. Specifically, at Bonfiglioli, trade unions have been able to limit the potential surveillance threat of the MES software in the contractual agreement.

It is generally the case that, the higher the level of technological adoption, the higher the degree of unions' participation in the different phases. Fig. 1 provides an illustrative sketch of how the case study firms distribute along the two dimensions of trade union's participation and representation, and of Industry 4.0 technological adoption. Besides the evident clustering therein, Cesab-Toyota and Bonfiglioli to the left, and Ducati and Lamborghini to the right of the picture, some findings characterise all the studied firms. In particular:

- ◇ The *technological design phase* is outside the scope of trade unions' power: we have not detected a pivotal role by unions in influencing the technological design phase; however they have been rather crucial in promoting investment plans.
- ◇ The *internal working time* is rarely bargained, and it resides firmly in the hand of managers: in all our firms, the internal working time has largely intensified, without being put under scrutiny by trade unions. In none of the studied firms we find bargaining or agreement on this domain.

Overall, our research findings revitalise the importance of trade unions and, in general, of workers' organisations as both a channel to favour transformative processes, say technological or organisational innovations, and the only remaining collective protection against forms of pervasive control, excessive saturation of working time, and overtime activities. Indeed, the active role of trade unions is even more necessary amid a pandemic

phase, wherein firms are invested by the need to reorganise the work process, rearrange shifts, and potentially reshape their network of commercial flows, with the overriding problem of how to turn work from home into a sustainable, non disruptive solution for those who can, and with the necessity to ensure sanitary and safety conditions for workers performing physical tasks on the factory floor.

Against a pure functionalist approach, our study reveals that even in the absence of a strong corporatist culture, trade unions are able to improve working conditions and direct technical change towards more inclusive implementations and less predatory scopes. Indeed, trade unions need not to forget their institutional macroeconomic role in counterbalancing managers' power, inequality, and hierarchies, and in guaranteeing not only workers' rights, but also social rights as a whole. This is especially crucial during times of disintegration of political parties' power, in which trade unions represent one of the last remaining form of collective organisation. With respect to the importance of our findings and their degree of generalisation, the emerging proactive attitude of trade unions towards Industry 4.0 has been empirically recognised in Germany, which indeed tends to confirm the new corporatist-local trait of trade unions (see the Work2020 programme in Haipeter, 2020), even in a country historically characterised by centralised bargaining. However, to the best of our knowledge, the literature still lacks a detailed comparative study of European countries, also focussing on forms of union resistance, which we deem an interesting avenue of future research.

Acknowledgements

The authors wish to thank Giovanni Dosi, Francesco Garibaldo, Angelo Moro, participants to the SASE Conference (2018, Kyoto, Japan), the SISEC Conference (2018, Milan, Italy), the Workshop "A new Industrial Revolution? Labour, Technology and the Automotive Industry" (2018, Pisa, Italy), the Roundtable on the Digital Economy (2018, Rome, Italy), and the ENEF Conference (2018, Brighton, UK) for helpful comments and insightful suggestions at various stages of this work. The authors wish to thank the Claudio Sabattini Foundation (Bologna, Italy) and the Institute of Economics of Scuola Superiore Sant'Anna (Pisa, Italy) for their support during field-work.

References

Addison, John T., Paulino Teixeira, André Pahnke and Lutz Bellmann (2017). 'The demise of a model? The state of collective bargaining and worker representation in Germany'. *Economic and Industrial Democracy* 38(2), pp. 193–234. DOI: 10.1177/0143831X14559784.

Addison, John T, Claus Schnabel and Joachim Wagner (2001). 'Works councils in Germany: their effects on establishment performance'. *Oxford economic papers* 53(4), pp. 659–694. DOI: 10.1093/oep/53.4.659.

Alvesson, Mats and Dan Karreman (2011). *Qualitative Research and Theory Development: Mystery as Method*. SAGE Publications.

Antonioli, Davide and Paolo Pini (2005). 'Partecipazione diretta, partecipazione indiretta e innovazioni tecnoorganizzative. Alcuni risultati per il sistema locale di Reggio Emilia'. Quaderni CREIC n. 1.

Armaroli, Ilaria (2019). 'Progettare l'innovazione: la nuova frontiera dell'azione sindacale?' *Economia & lavoro* 1/2019, pp. 115–130. DOI: 10.7384/93832.

Armaroli, Ilaria and Silvia Spattini (2018). *National Report: Italy. Case study on FIM-CISL*. Tech. rep. SUNI – Smart Unions for New Industry. URL: http://suniproject.adapt.it/wp-content/uploads/2018/07/italy.pdf.

Béthoux, Élodie and Arnaud Mias (2019). 'How does State-led decentralization affect workplace employment relations? The French case in a comparative perspective'. *European Journal of Industrial Relations*. Forthcoming. DOI: 10.1177/0959680119852268.

Braakmann, Nils and Bernd Brandl (2016). 'The efficacy of hybrid collective bargaining systems: An analysis of the impact of collective bargaining on company performance in Europe'. Munich Personal RePEc Archive, MPRA paper 70025, Munich.

Buer, Sven-Vegard, Jan Ola Strandhagen and Felix T. S. Chan (2018). 'The link between Industry 4.0 and lean manufacturing: mapping current research and establishing a research agenda'. *International Journal of Production Research* 56(8), pp. 2924–2940. DOI: 10.1080/00207543.2018.1442945.

Campagna, Luigi and Luciano Pero (2011). 'Innovazione organizzativa e partecipazione diretta'. *Quaderni di management* 50, pp. 63–73.

Caselli, Rossana (1982). *Nuove forme di organizzazione del lavoro nelle banche*. Etas Libri.

Cetrulo, Armanda, Dario Guarascio and Maria Enrica Virgillito (2019). 'Anatomy of the Italian occupational structure: concentrated power and distributed knowledge'. LEM Working Paper Series 2019/34.

Cetrulo, Armanda and Alessandro Nuvolari (2019). 'Industry 4.0: revolution or hype? Reassessing recent technological trends and their impact on labour'. *Journal of Industrial and Business Economics* 46(3), pp. 391–402. DOI: 10.1007/s40812-019-00132-y.

Cirillo, Valeria, Lucrezia Fanti, Andrea Mina and Andrea Ricci (2020). 'Digitizing firms: skills, work organization and the adoption of new enabling technologies'. INAPP WP n. 53.

Cirillo, Valeria, Matteo Rinaldini, Jacopo Staccioli, Maria Enrica Virgillito et al. (2018). 'Workers' intervention authority in Italian 4.0 factories: autonomy and discretion'. LEM Working Paper Series 2018/13.

Della Rocca, Giuseppe (1985). *L'innovazione tecnologica e le relazioni industriali in Italia*. Fondazione Adriano Olivetti.

Doellgast, Virginia and Ian Greer (2007). 'Vertical Disintegration and the Disorganization of German Industrial Relations'. *British Journal of industrial relations* 45(1), pp. 55–76. DOI: 10.1111/j.1467-8543.2007.00602.x.

Ebbinghaus, Bernhard and Jelle Visser (1999). 'When Institutions Matter:Union Growth and Decline in Western Europe, 1950–1995'. *European Sociological Review* 15(2), pp. 135–158. DOI: 10.1093/oxfordjournals.esr.a018257.

Genz, Sabrina, Lutz Bellmann and Britta Matthes (2019). 'Do German Works Councils Counter or Foster the Implementation of Digital Technologies?' *Jahrbücher für Nationalökonomie und Statistik* 239(3), pp. 523–564. DOI: 10.1515/jbnst-2017-0160.

Gill, Carol (2009). 'Union impact on the effective adoption of High Performance Work Practices'. *Human Resource Management Review* 19(1), pp. 39–50. DOI: 10.1016/j.hrmr.2008.08.002.

Gill, Carol and Denny Meyer (2013). 'Union presence, employee relations and high performance work practices'. *Personnel Review* 42(5), pp. 508–528. DOI: 10.1108/pr-07-2011-0117.

Greer, Ian (2008). 'Organised industrial relations in the information economy: the German automotive sector as a test case'. *New Technology, Work and Employment* 23(3), pp. 181–196. DOI: 10.1111/j.1468-005X.2008.00212.x.

Haipeter, Thomas (2020). 'Digitalisation, unions and participation: the German case of 'industry 4.0''. *Industrial Relations Journal* 51(3), pp. 242–260. DOI: 10.1111/irj.12291.

Harbecke, Tim and Kathrin Filipiak (2018). *National Report: Germany. Case Study on IG Metall*. Tech. rep. SUNI – Smart Unions for New Industry. URL: http://suniproject.adapt.it/wp-content/uploads/2018/06/germany.pdf.

Herrigel, Gary and Charles F. Sabel (1999). 'Craft Production In Crisis: Industrial Restructuring in Germany During the 1990s'. In: *The German Skills Machine: Sustaining Comparative Advantage in a Global Economy*. Ed. by Pepper D. Culpepper and David Finegold. Berghahn Books.

Houseman, Susan N. and Machiko Osawa (2003). *Nonstandard Work in Developed Economies: Causes and Consequences*. W. E. Upjohn Institute for Employment Research.

Hyman, Richard and Wolfgang Streeck, eds. (1988). *New technology and industrial relations*. Basil Blackwell.

Jürgens, Ulrich and Martin Krzywdzinski (2016). *New Worlds of Work: Varieties of Work in Car Factories in the BRIC Countries*. Oxford University Press.

Lautsch, Brenda A. (2002). 'Uncovering and Explaining Variance in the Features and Outcomes of Contingent Work'. *ILR Review* 56(1), pp. 23–43. DOI: 10.1177/001979390205600102.

Leonardi, Salvo and Roberto Pedersini (2018). *Multi-employer bargaining under pressure: decentralisation trends in five European countries*. ETUI.

Liao, Yongxin, Fernando Deschamps, Eduardo de Freitas Rocha Loures and Luiz Felipe Pierin Ramos (2017). 'Past, present and future of Industry 4.0 - a systematic literature review and research agenda proposal'. *International Journal of Production Research* 55(12), pp. 3609–3629. DOI: 10.1080/00207543.2017.1308576.

Moore, Phoebe V., Martin Upchurch and Xanthe Whittaker (2018). *Humans and machines at work: monitoring, surveillance and automation in contemporary capitalism*. Palgrave Macmillan. DOI: 10.1007/978-3-319-58232-0.

Moro, Angelo, Matteo Rinaldini, Jacopo Staccioli and Maria Enrica Virgillito (2019). 'Control in the era of surveillance capitalism: an empirical investigation of Italian Industry 4.0 factories'. *Journal of Industrial and Business Economics* 46(3), pp. 347–360. DOI: 10.1007/s40812-019-00120-2.

Osterman, Paul (2011). 'Institutional Labor Economics, the New Personnel Economics, and Internal Labor Markets: A Reconsideration'. *ILR Review* 64(4), pp. 637–653. DOI: 10.1177/001979391106400401.

Osterman, Paul (2018). 'In Search of the High Road: Meaning and Evidence'. *ILR Review* 71(1). DOI: 10.1177/0019793917738757.

Pero, Luciano and Anna M. Ponzellini (2015). 'Il nuovo lavoro industriale tra innovazione organizzativa e partecipazione diretta'. In: *La partecipazione incisiva. Idee e proposte per rilanciare la democrazianelle imprese*. Ed. by Mimmo Carrieri, Paolo Nerozzi and Tiziano Treu. Il Mulino.

Ponzellini, Anna M. (2013). 'Piani, non solo premi'. *Quaderni di Rassegna Sindacale* 2.

Ponzellini, Anna M. (2017). 'Organizzazione del lavoro e relazioni industriali. Una rassegna degli studi degli ultimi 20 anni in Italia'. *Economia & lavoro* 51(1), pp. 147–164. DOI: 10.7384/87128.

Ponzellini, Anna M. and Giuseppe Della Rocca (2015). 'Continuità e discontinuità nelle esperienze di partecipazione dei lavoratori all'innovazione produttiva. Partecipazione istituzionale e partecipazione diretta'. *Economia & lavoro* 49(3), pp. 55–66. DOI: 10.7384/82272.

Rathgeb, Philip and Arianna Tassinari (2020). 'How the Eurozone disempowers trade unions: the political economy of competitive internal devaluation'. *Socio-Economic Review* [in press]. DOI: 10.1093/ser/mwaa021.

Russo, Margherita, Pasquale Pavone and Armanda Cetrulo (2019). 'Conflict and Participation in Bargaining at Company Level: The Lamborghini Case'. *Economia & lavoro* 1/2019, pp. 53–74. DOI: 10.7384/93830.

Shaiken, Harley, Steven Lopez and Isaac Mankita (1997). 'Two Routes to Team Production: Saturn and Chrysler Compared'. *Industrial Relations* 36(1), pp. 17–45. DOI: 10.1111/0019-8676.21997002.

Smith, Chris and Matt Vidal (2019). 'The lean labour process: Global diffusion, societal effects, contradictory implementation'. In: *International Handbook of Lean Organization*. Ed. by Thomas Janoski and Darina Lepadatu. Cambridge University Press.

Streeck, Wolfgang (1998). 'The Internationalization of Industrial Relations in Europe: Prospects and Problems'. *Politics & Society* 26(4), pp. 429–459. DOI: 10.1177/0032329298026004002.

Tortorella, Guilherme Luz and Diego Fettermann (2018). 'Implementation of Industry 4.0 and lean production in Brazilian manufacturing companies'. *International Journal of Production Research* 56(8), pp. 2975–2987. DOI: 10.1080/00207543.2017.1391420.

Tubaro, Paola and Antonio A. Casilli (2019). 'Micro-work, artificial intelligence and the automotive industry'. *Journal of Industrial and Business Economics* 46(3), pp. 333–345. DOI: 10.1007/s40812-019-00121-1.

Vidal, Matt and Leann M. Tigges (2009). 'Temporary Employment and Strategic Staffing in the Manufacturing Sector'. *Industrial Relations* 48(1), pp. 55–72. DOI: 10.1111/j.1468-232x.2008.00545.x.

Wang, Shiyong, Jiafu Wan, Daqiang Zhang, Di Li and Chunhua Zhang (2016). 'Towards smart factory for industry 4.0: a self-organized multi-agent system with big data based feedback and coordination'. *Computer Networks* 101, pp. 158–168. DOI: 10.1016/j.comnet.2015.12.017.

Appendix

Table 2

Firm	**Department***	**Task***
Bonfiglioli	assembly line	gearbox assembly (×2)
	mechanical machining	screws turning (×2) screws rectification
	logistics	warehouse movements (×4) providers relations logistics planning
	quality control	intermediate quality control final quality control supplies quality control
	production planning	new technology integration assembly planning times and methods planning
	maintenance	machines maintenance
	claims office	claims handling
Cesab-Toyota	assembly line	vehicle assembly (×2)
	customisation	installation of cabin and optionals welding of cabin
	logistics	incoming supplies handling
	warehouse	assembly lines supplies
	quality control	intermediate quality control
Ducati	assembly line	engine assembly (×2) vehicle assembly (×4)
	process design	engine production designer
	product R&D	engine testing-room service
	quality control	process quality control
	testing	test drive
Lamborghini	assembly line	engine assembly vehicle assembly (×2)

Continues on next page

Continued from previous page

Firm	Department*	Task*
	carbon fibre composites	carbon fibre lamination shell assembly
	pre-series center	carbon fibre process development
	process R&D	MES implementation human-machine interface development
	purchases department	parts purchases
	quality control	final quality control
	sales department	franchise and business development
	'task-force'	incoming supplies quality control
	'torque team'	control of electric screwer systems
	prototypes development	process industrialisation

* At the time of the interview.

Table 2: Classification of interviewees by firm, department, and task.

Table 3

1st level code	2nd level code	3rd level code
technological and organisational change	change in tasks	◇ up-skilling processes ◇ de-skilling processes
	training programmes linked to I4.0 technology introduction	◇ specific training programmes
	technology and industrial relations	◇ role of trade unions ◇ perception of trade unions as idle and useless ◇ smart-working aimed at aligning employees' and unions' interests ◇ retaliation on a unionised workers' career prospects ◇ human-machine relationship

Continues on next page

Continued from previous page

1st level code	2nd level code	3rd level code
	I4.0 technology applications	◇ MES, aimed at monitoring and efficiency gains ◇ IoT, aimed at data collection, and related risk ◇ process-product relationship ◇ collaborative robots and their ergonomics
	organisational change	◇ change in ownership structure ◇ introduction of new production lines and products
characterisation of TL	hierarchical modularity of middle management	
	hierarchical structure and department specificities	
	multi-functionality and competition with union delegates	◇ competences on which its authority is based ◇ hierarchical function ◇ coaching function ◇ problem solving function ◇ evaluation function ◇ team integration function ◇ motivating function ◇ competition with union delegates
	head of department: the summit of middle management	◇ hierarchical reference for TL ◇ recruitment function ◇ evaluation function
	jolly as a substitute for the operator	◇ problem solving function
job rotation	differing degrees	◇ weak job rotation systems ◇ structural job rotation systems
	aims and objectives	◇ welfare ◇ efficiency ◇ production-flow tension
	potential issues	
performance evaluation systems	contractual level upgrade as individual incentive	◇ discretion in level upgrade attribution ◇ clarity of evaluation criteria
	influential figures	◇ influence of the TL (not formalised)

Continues on next page

Continued from previous page

1st level code	2nd level code	3rd level code
	flexibility, monetary incentives and company welfare	◇ uncertainty about monetary incentives ◇ company welfare and smart-working
mobility paths	limited vertical mobility, scarce formalisation and individual negotiation	◇ ambiguity and discretion about level upgrades ◇ appointment of TLs on a discretionary basis ◇ unclear and non-formalised vertical mobility criteria ◇ rare and challenging vertical mobility paths
	strong vertical mobility	◇ fast career advancements
	horizontal mobility	◇ mobility between different departments
workers' participation devices	knowledge diffusion	◇ formalisation of suggestions collection procedures ◇ perception of being listened to and speed of improvements implementation
	attribution of responsibilities to workers	◇ smoothness of knowledge flow between different departments
	diffusion of teamwork practices	◇ structure of teamwork ◇ presence of individual work among white collar workers
	worker-firm relationship	◇ alignment of firm's and workers' objectives ◇ opinion on trade unions

Table 3: Interviews' 3-level codification scheme.