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One of many roads to Industry 4.0? Technology, policy, organisational adaptation, and worker experience in 'Third Italy' SMEs

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Abstract

Industry 4.0 (I4.0) is a technological framework and policy programme that emerged in Germany in the 2010s, promising to revitalise manufacturing and revalue work by means of intelligent productive systems. The paradigm's cross-national diffusion raises questions about its context-dependent adaptation. This article focuses on the Italian I4.0 programme and its implementation among medium-sized manufacturing companies in the country's Veneto region. It analyses Italian policy and company strategies through the perceptions and experiences of managers, unionists, and workers. The research highlights how a system dominated by SMEs – one with limited technological investment and without a coordinated system of industrial relations – reshaped the I4.0 policy goals, technological developments, and work outcomes. The results show how the features of the productive context are associated with a far less ambitious I4.0 plan, the limited and selective adoption of technology at the level of firms, and modest top-down organizational changes that do not fulfil the promises of the project.

Keywords: Industry 4.0, Third Italy; technological change; firm strategy; digitalisation, worker experiences, SMEs.

1. Introduction

Initially coined by and circulated among IT and engineering specialists, high-tech companies, employer organisations, and policymakers in Germany (Kagermann *et al*., 2013), 'Industry 4.0' (I4.0) is a technological framework and policy programme that has become increasingly influential. As a technological framework, I4.0 represents the most recent stage in the digitalisation, automation, and robotisation of manufacturing and logistics and it relies on interconnected cyber-physical systems (CPS) (Brynjolfsson and McAfee, 2014; Cirillo *et al*., 2018; Ford, 2015; Kagermann *et al*., 2013; Pfeiffer, 2016). These intelligent productive infrastructures connect machines, processes, humans, and products in real time through the Internet of Things (IoT). The most developed version

of a CPS autonomously and proactively links all the stages of production based on external inputs, regardless of distance, thereby allowing the flexible organisation of production. Furthermore, I4.0 uses data technologies that analyse production flows, anticipate consumer demand, improve after-sales services, and monitor work performance. In the ideal, I4.0 entails an open-ended process of innovation based on artificial intelligence that learns either from humans or on its own. It combines increased mass customisation (Pfeiffer, 2016; Savul, 2020) with horizontally integrated production.

As a policy programme initiated in Germany, I4.0 refers to efforts to revitalise the industrial sector by promoting new technological strategies (Krzywdzinski, 2017; Pfeiffer, 2016). The *Forschungsunion*, an organisation that connects the worlds of production and scientific research, explicitly identified two industrial policy objectives. The first is to make German companies the leading players in the production and sale of I4.0-related technologies. The second is to become the primary market of those technologies (Santiago, 2018). At the company level, I4.0 offers two major technological promises: increased productivity, flexibility and efficiency, and the development of CPS that also allow for innovative business models (Reischauer, 2018). Technological change is also expected to produce organisational changes that place more value on worker participation (Cirillo *et al*., 2018; Magone and Mazali, 2016). The basic assumption is that CPS are a necessary and sufficient condition for autonomy, decentralisation, responsibility, and teamwork (Cirillo *et al*., 2018). Besides concerns about possible job losses (Ford, 2015; Frey and Osborne, 2013), novel technologies and subsequent organizational innovations are expected to improve and enrich the content and conditions of work (Brynjolfsson and McAfee, 2014). I4.0 carries the social promise of producing an 'augmented blue-collar worker' (Magone and Mazali, 2016): a multi-purpose operator who monitors complex systems without manually interfering, and an involved worker, who contributes knowledge, communication and cooperation skills towards solving problems and managing complexity, uncertainty and variability (Krzywdzinski *et al*., 2016; Magone and Mazali, 2016; Pfeiffer, 2016). Job opportunities for professionalised profiles would rise and assign a new centrality to workers within firms, requiring and enhancing worker participation (Bonekamp and Sure, 2015; Brynjolfsson and McAfee, 2015).

The German I4.0 policy project rests on specific conditions. The key to the success of I4.0 is not its technical potential as much as its strategic effort to increase the profitability of productive investments (Krzywdzinski *et al*., 2018; Pfeiffer, 2017, 2016; Salento, 2018). In turn, these strategic changes entail the pursuit of a position of global leadership in the digitalisation process (Krzywdzinski *et al*., 2018) and in manufacturing (Savul, 2020). Accordingly, large technology-producing companies and firms occupying dominant positions within global value chains assume a critical role in the German I4.0 plan and its implementation (Salento, 2018). In the framework of a complex governance, policymakers, companies, research and technology stakeholders and trade-unions have prompted simultaneous and coordinated actions, programmes, guidelines and financial support schemes (Schroeder, 2016). The adoption of new technologies and organisational experimentation occur in an environment of concerted efforts among businesses and trade unions, as well as improved access to research and training (Kagermann *et al.*, 2016; Santiago; 2018).

The 2008 financial crisis precipitated a strategic shift by major economic and political players, in which industrial production has become key to growth agendas (Krzywdzinski, 2017; Krzywdzinski *et al*., 2016; Krzywdzinski *et al*., 2018; Pfeiffer, 2016; 2017; Savul, 2020). Under the influence of the EU and expert communities, the I4.0 policy and technological paradigm has gained momentum and has exerted an increasing influence across European countries. In a 2017 communication, the European Commission set the goal that, by 2022, manufacturing should account for 20 per cent of the EU GDP (EC, 2017). Following Germany's lead, several European countries have launched industrial I4.0 plans.

The cross-national diffusion of I4.0 raises an important question: what will be the upshots of I4.0's technological and social promises in contexts which do not reproduce the features of the

German economy, its competitive position and industrial policy governance? Building on the literature on policy 'translation' (Prince, 2010; Stone, 2017), on approaches challenging technological determinism (Noble, 1979, 1984; Nye, 2007) and emphasising the context-dependent adoption and implementation of technologies (e.g. Krzywdzinski, 2017), the article explores the drastically different case of Italy's north-eastern region of Veneto. In stark contrast with German economic and production structures, their Italian counterparts are dominated by SMEs with low productivity and limited technological investments, figuring in international value chains as suppliers. In Italy, industrial policy governance is more fragmented and industrial relations are weaker, lacking consolidated co-determination and co-management practices. Among SMEs in the Veneto region, labour regulation is characterised by flexibility, wage moderation and paternalistic management. The study shows how these features are associated with a far less ambitious I4.0 plan, a limited and selective adoption of technology at the level of firms and modest and top-down organisational changes which do not meet the project's promises.

2. I4.0 policy and technology in context: the German way and the (third) Italian road

As a policy framework, I4.0 may be viewed as a case of 'transfer' through the reproduction, imitation, combination of and inspiration from ideas, policies and instruments which have originated elsewhere (Dolowitz and Marsh, 1996). Yet, when policies shift from one context to another, they are also 'translated': relevant actors engage in adapting, modifying or hybridising policy objectives, instruments and implementation, paving the way for deviations from the original policy (Prince, 2010; Stone, 2017). In a similar vein, the success of I4.0 as a technological framework implies technological and organisational innovation with conditional or contingent effects on labour use across socio-economic contexts, as suggested by critical approaches since the 1980s (Ackroyd et al., 1998; Elger and Smith, 1994; Stewart *et al*., 2009).

In what follows, we discuss the implications of this policy and technological transfer. We argue that three sets of factors contribute to the 'translation' of I4.0 through the definition and implementation of industrial plans at the policy level, and the adoption of new technologies and organisational changes affecting labour use at the level of firms. First, the economic and productive structure (the size of firms, the present degree of technological penetration, production sectors, the type of products and their degree of complexity and the positions in value chains) is likely to modify the definition of the industrial policy problems and the opportunities and constraints at the level of firms. Second, the governance of industrial policies (industrial relations, the degree and modes of unionisation, or co-management practices at the national, regional and firm level) will likely affect the focus and design of policies, as well as the take up of technology and changes in labour use. Third, the employment regime (comprising social institutions regulating labour markets, access to training and work, rates of pay, job security and flexibility and the local labour culture; see Soli, 2018) is expected to impact the implementation of technologies, influencing organisational strategies, worker experience, and job quality. We discuss this framework by analysing the case of Italy at the policy level (section 2.2) and that of the Veneto region at the level of firms (section 2.3), contrasted with the German context.

2.1.The translation of the I4.0 policy programme

A comparison of the German and Italian I4.0 plans suggests that the structure of the economy (the type of production, features of enterprises and their position in value chains) and the positioning of stakeholders (such as industrial policy governance and, in particular, the system of industrial relations) have translated into different I4.0 policy goals, instruments, and governance.

In Germany, I4.0 has emerged as a technological and industrial policy which aims at consolidating the competitive hegemony of German industry, strengthening the market position of

national technology producers (Pfeiffer, 2017; Salento, 2018; Santiago, 2018; Savul, 2020) and ensuring their leadership in providing global technological standards (Salento, 2018; Santiago, 2018). The policy project is based on the German industrial sector's position in global value chains, and on the centrality of large technology-producing companies. Accordingly, the strong cooperation among key political, economic and research players serves as the basis for the plan. According to Santiago (2018), the German I4.0 programme can be understood as a policy experiment which unites a complex mix of industrial innovation, research, development and educational policies and which is part of a long-term innovation and coordination effort begun in the mid-2000s. In 2010, the German government, together with the *Forschungsunion*, developed a series of initiatives aimed at fostering cooperation between all innovation-related actors, allocating around 27 billion euro over three years (Santiago, 2018. The I4.0 terminology adopted at the 2012 Hanover Fair became one of the strategic initiatives of the HTS 2020 (High Tech Strategy) (See Santiago 2018 for an in-depth discussion). The German I4.0 strategy is marked by strong collaboration among various actors and their combined participation in single initiatives. This strong motivation for cooperation is particularly evident in what is known as *Platform I4.0*. Initiated unilaterally in the industrial sector, the German government later took up political leadership of the initiative (Santiago, 2018). Moreover, alongside employer representatives, trade unions have played a crucial role in designing the German model (Acatech and Forschungsunion, 2013). Social partners participated in drawing up guidelines for implementing the *Industrie 4.0* plan alongside public and private institutions and research centres. From the trade union perspective, I4.0 offers an opportunity to increase competitiveness while improving the quality of work. Through their participation in projects like *Arbeit 4.0*, German trade unions have shaped a vision of I4.0 alternative to the so-called 'digital Taylorism'. They have pushed towards a conception in which the decentralisation of the governance of the production process and worker involvement are promoted as key to the success of I4.0 (Bosch and Schmitz-Kießler, 2020). In this context, the issue of qualifying and training the workforce became central for German trade unions (Schroeder, 2016). In addition, Germany's dual education system appears well equipped to accommodate the possible adverse consequences of technological innovations for the labour market (Pfeiffer, 2017; Krzywdzinski, 2017; Savul, 2020).

The realities of the Italian economic structure are different: SMEs are prevalent, (particularly in the north-east), productivity is lower, technological penetration is limited (as only five per cent of enterprises are highly digitalised; see Istat, 2018) and demand for highly qualified labour is modest (Gubitta, 2018). These features have clearly influenced the goals set by policymakers and I4.0 policy design. In the 2016 *Industria 4.0* plan, the Italian Ministry of Economic Development listed nine 'enabling technologies' (later expanded to eleven) the adoption of which would provide access to public funding (Mise, 2018). This explicitly technology-neutral approach (Tiraboschi and Seghezzi, 2016) allowed companies the freedom to choose which technologies to implement with no minimal threshold. This approach represents a clear 'adaptation' of I4.0 policy to the needs of SMEs: it does not force them to make technological leaps or to take on technologies which they would not be able to make use of. Yet, the policy rests on generic financial support, with an allocation of around 18 billion euro in 2016, and inherently limits the potential support which specific industrial and technological developments may receive. Interestingly, one year after its launch, the plan's name changed to *Impresa 4.0* (Enterprise 4.0). Underlying this shift was the aim to target companies in the service sector, which are predominantly small and very small (Istat, 2020). As a result, the Italian plan is not only 'weaker' than its German counterpart, as it does not indicate a clear direction for development beyond the mere dissemination of technology. It is also less focused on strengthening industrial production. The Italian government launched their I4.0 plan unilaterally and defined it as a 'top-down' initiative that would depend on company decisions regarding the take-up of technologies. Alongside the creation of so-called competence centres which were meant to encourage investments in training, strengthen cooperation between universities, research centres and businesses, the plan's only collegial device – the *Cabina di Regia* with the participation of trade unions, employer

organisations and representatives of schools, universities and research centres – lacks clear responsibilities (Cappelin *et al*., 2017). Trade unions (which are involved only in implementation and monitoring functions) undertook autonomous initiatives to develop their vision of the transition to I4.0 (Gasparri and Tassinari, 2020). Little attention to the possible impacts the I4.0 policy might have on labour and working conditions (Gaddi, 2020) reflects this configuration. Both trade unions and employer organisations criticised the national I4.0 plan, in which the excessive emphasis on the dissemination of technologies obscured the role of other enabling factors like training and upgrading skills (Gasparri and Tassinari 2020).

2.2 The translation of the I4.0 techno-organisational framework

At the level of firms, the adoption of new technologies does not solely depend on their technical feasibility, but also on economic considerations. For this reason, the financial incentives introduced by I4.0 plans are likely to influence the actual take up of new technologies (Salento, 2018). In addition, we can expect the strategies and technological adoption of individual firms to be influenced by the governance and power structures of the relevant value chains (Pfeiffer, 2016; Salento, 2018; Savul, 2020). In turn, it is not technology *per se* but the implications which technology has on other features of organisations which have important effects on work, including the skilling or deskilling of workers and additional changes to authority relations, levels of autonomy, satisfaction and alienation (e.g. Briken *et al*., 2017; Jürgens *et al*., 1993; Orlikowski, 1992). Similar degrees of technological innovation may result in disparate labour use strategies and competence upskilling, depending on where they are positioned in global value chains and on the policies of particular workplaces (Briken *et al*., 2017; Edwards and Ramirez, 2016; Krzywdzinski, 2017; Smith and Thompson, 1998). As the diffusion of Japanese organisational models and lean production methodologies show, the influence and mediation of social, institutional and political forces point to variable results and unexpected outcomes (Ackroyd et al., 1998; Coriat, 1993; Elger and Smith, 1994; Harrison 1994; Stewart *et al*., 2009). Many different factors are expected to contribute to the 'translation' of technological and organisational innovation across socio-economic contexts. These include the degree and modes of unionization, co-determination and co-management practices; the characteristics of the local production systems such as wage levels, labour regulations, the degree of conflict, training and skills available locally (Krzywdzinski, 2017); or specific local employment regimes, including representations, expectations, strategies of social reproduction, dominant social and cultural values (Soli, 2018).

The German system of industrial relations is based on co-determination, especially in large manufacturing companies. As such, it provides worker representatives with influence on the adoption and use of technology (Jürgens *et al*., 1993; Krzywdzinski, 2017). Over the past thirty years, the power of German trade unions has been gradually eroded (Hassel, 1999). Whereas this erosion has been shown by the halving of union density and the reduction in the coverage of collective agreements, trade unions continue to wield considerable political power (Bosch and Schmitz-Kießler, 2020) due to the persistence of the dual system based on the complementarity between collective bargaining and works councils within key sectors of the German economy (Hessel, 1999).

By contrast, in Italy, industrial relations, which deviate from the historically established continental and Southern European models (Regalia and Regini, 2018), do not permit trade unions to participate directly in the governance of enterprises through co-determination. A plurality of trade union actors who diverge in ideological positions, political traditions and the orientation of their practices increases that fragmentation (Gasparri and Tassinari, 2020). Lacking formalised rules and procedures (Cella, 1989; Pulignano *et al*., 2018), the low degree of institutionalization in Italian industrial relations (Regalia and Regini, 1998) has allowed industry to be more adaptable to changing circumstances and resilient against economic crises. But it also translates into a formally limited involvement of industry representatives in policymaking dynamics (Regalia and Regini, 2018). While

these features of the industrial system have not prevented trade unions from participating in consultations with public decision-makers (Regalia and Regini, 2018), that involvement's effectiveness is conditional on the orientations of political and governmental actors. In addition, trade unions and employers have agreed, through a formal covenant, on a new framework of rules and procedures for industrial relations – the 'factory pact' – highlighting the centrality of the dual system of collective bargaining (Gasparri and Tassinari, 2020; Treu, 2019). Yet, the most critical aspect of this agreement concerns its implementation, as it is subordinate to the peculiarities of sectors, regions, and companies (Gasparri and Tassinari, 2020 p. 806).

More specifically, the Veneto region belongs to what Bagnasco (1977) termed 'Third Italy': north-eastern and central Italian regions featuring crafts-based small firms clustered in specialised industrial districts, contrasting with the under-industrialised South of the country and the traditionally more Fordist north-western regions. Here, SMEs are spread throughout the territory according to the logic of flexible specialisation (Bagnasco, 1977; Harrison 1994; Piore and Sabel, 1984). A successful alternative to Fordism (Piore and Sabel, 1984), this industrial arrangement rests on the basic features of low levels of conflict between capital and labour, wage moderation, shared values and objectives among stakeholders. Certain observers consider the social and productive relations typical of the industrial districts of Third Italy to be more humanely satisfying and more egalitarian compared to the hierarchical authority of the Fordist system, since they were built out of cooperative relations between labour and capital (Berger and Locke, 2001). Other scholars have pointed out that 'flexible specialisation', efficiency and cost competitiveness derive mainly from a combination of social and political factors such as an extensively developed informal economy, (self-)exploitative working conditions and coercive gender and family relations (Mingione, 1991) and the diffusion of disintermediated relations between capital and labour (Sacchetto, 2004). The availability and flexibility of the workforce, widespread craftsmanship and a widespread propensity towards cooperation have allowed flexibility, increased productivity and innovation (Soli, 2018) even in the absence of significant technological investments (Tattara and Anastasia, 2003). In this industrial framework, worker organisations have historically struggled to establish themselves as actors in the governance of labour relations and in the management of industrial relations (Sacchetto, 2004).

In all, the nature of the Italian I4.0 plan – open-ended with respect to the level and type of newly-introduced technologies and lacking effective guidelines and participatory instruments – suggests that structural factors might be crucially important in the choice of technology to be adopted. Consequently, we expect that the size of the enterprises limits the possibilities for technological innovation. Further, their positioning as suppliers in global value chains makes their technological innovation partially dependent on the needs of their business partners. These circumstances suggest that, in comparison to the German model, the introduction of new technology and organizational change might occur with little or no formalised involvement by trade unions. The extent to which these factors limit the development of managerial models based on autonomy, decentralised responsibilities and participatory mechanisms is likely to be left to company management in the framework of 'traditional' relationships with workers based on their flexibility, expertise and availability. The relatively weak relationship between technological and organizational change, on the one hand, and research and training, on the other, is likely to limit the extent of deviation from this traditional model.

3. Methods and data

The empirical evidence on which this article is based was collected in the framework of a research programme studying the diffusion of I4.0 in the Veneto region and its effects on labour.[1] The research programme encompassed two sub-projects.

The first sub-project focused on the role of stakeholders in the diffusion of I4.0 and on the analysis of the diverse processes of technological transformation undergone by manufactures. We conducted thirty-four semi-structured individual interviews with experts and stakeholders, including unionists, employers, representatives of employer's organisations, managers, and business consultants; three focus groups with trade unionists, shop stewards from four manufacturing companies; and one focus group with provincial officials from one of the largest Italian trade unions.

The second sub-project aimed to understand how technologies are adopted within companies, the organisational transformations which they prompt, and the consequences of that adoption for work experience and capital-labour relations at the point of production, based on a non-comparative multi-sited case study (Marcus, 1995). To identify relevant case studies, we selected manufacturing companies in the region based on three criteria: active investments in relevant technology, participation in the national I4.0 programme and being 'medium-sized' (50–249 employees). Interviews with stakeholders and documentary sources helped us to compile a list of thirty-nine companies which met these inclusion criteria. We contacted each of them, illustrated the research objectives and methods, and requested the opportunity to interview a representative and visit the factory. Twelve companies agreed to an interview with a manager, and these interviews were subsequently completed. Of these, six companies also allowed a period of non-participant observation, including interviews with workers and the administration of a survey questionnaire. The subsequent inspection revealed that most of these six companies displayed a limited degree of technological innovation. Therefore, we continued in-depth case studies with two companies, selected for their pertinent degree of technological innovation. Both companies offer a remarkable synthesis of the social, economic and financial peculiarities of the productive and entrepreneurial model characteristic of the Third Italy: they are medium-sized, family-run businesses, developed from the unique entrepreneurial and craft skills of their owners. Both adopt flexible organisational models of specialisation and internationalise their business through integration into global value chains.

Company A, with 240 employees, is a first-level supplier in an automotive value chain. It produces a moderately sophisticated component. The production is limited to the outer shell, together with the assembly of other pieces from external suppliers, mainly chosen by the client company. This implies Company A's strong integration with the leading company concerning product quality parameters and the choice of materials, suppliers and design. The company is divided into several production departments – logistics, prototyping, carpentry, welding, pre-assembly and assembly – as well as departments concerned with technical design and planning management and administration. Company A is partially unionised, with slightly fewer than 100 union members – all blue-collar workers – and three shop stewards. The union is active in second-level bargaining concerning corporate welfare, bonuses and working time flexibility. The organisation of production and technological choices fall outside the union's bargaining competencies.

Company B, with seventy employees, produces industrial furniture and heating systems – products with a low level of technological sophistication – which are sold under various retailer brands. The company is integrated in value chains which are characterised by market governance, with limited integration between leading companies and suppliers. The company is an example of a 'pocket-sized multinational'. Although it is very small, it relies on a global market stretching as far

[1] Project: PReST: Processi, Relazioni, Spazio e Tempo. Valorizzare il lavoro umano nella transizione all'Industria 4.0 (Processes, Relations, Space and Time. Enhancing human labour in the transition to Industry 4.0) funded by European Social Fund – Veneto Region (2018-19).

as South America. The company is not unionised and does not feature a corporate bargaining process: decisions concerning production processes and technological choices are made wholly by the owners.

The biographical background of workers in both companies is similar. Most employees are local adult men who have a medium-to-long working experience at the same workplace. Women are overrepresented in administrative departments but virtually absent from management. The mean age of the employees in both companies is forty-five years. The level of education varies across functions: 48 per cent of workers have completed eight years of school, 36 per cent completed high school, and 5 per cent hold a university degree. All the employees holding university degrees work in technical or administrative departments.

The uncovered, non-participant observation took place in the Spring of 2019. In each company, observations lasted two weeks and included all departments. In addition, 114 anonymous questionnaires were collected (out of 125 distributed): ninety in the first company and twenty-five in the second. We distributed the questionnaires by random hand sampling, covering about one-third of the workers in each department. Questions concerned the biographical and employment information of workers, the technologies they used, and the perceived impact of technological and organisational innovation on their autonomy, control, and the content of their work. Finally, we conducted forty-four semi-structured interviews: twenty-nine in Company A (four managers and middle managers, six programmers and developers, three administrative employees and sixteen blue-collar workers) and fifteen in Company B (four managers and middle managers, two programmers and nine blue-collar workers). The interviews explored the subjective experience of work, the subjects' perception of technological change, and its impact on their work.

For the analysis of the empirical material, we followed a three-step procedure: (a) selective coding and identification of the most recurrent observations; (b) descriptive analysis and construction of macro-categories like narratives, processes, relationships and experiences; and (c) macro-category linkage and explanatory analysis (Rubin and Rubin, 2005).

4. I4.0 policy in practice

The consensus among local and regional policymakers is that the new production paradigm must be adapted to national and 'local' characteristics. However, this attention to the specificities of production models refers almost exclusively to the size of companies, and to related features such as production volumes and financial capacity. The main concern of policymakers is adapting the new industrial paradigm to a context primarily made up of small and medium-sized enterprises.

'I like the phrase "Veneto's road to Industry 4.0" [...] I like it because it focuses on small businesses, ninety-eight per cent are SMEs.' *Officer at an employer organisation.*

To date, the diffusion of I4.0 technologies remains quite limited and selective. According to a 2018 sample survey conducted by the Italian Ministry of Economic Development, only 12 per cent of companies in the Veneto region used at least one 'enabling technology', compared to 8.4 per cent of Italian companies nation-wide (Mise, 2018). Figures also clearly indicate that data technologies and ICT solutions are by far the most widely used in the region: IoT was being used by 5.7 per cent of companies, horizontal integration systems by 4.3 per cent and cloud technologies by 2.9 per cent. Collaborative robots and 3D printers were present in 2.4 per cent of companies. Only 1.6 per cent of firms had introduced big data collection and analysis systems, while only 0.3 per cent used augmented reality systems.

Indeed, firm managers confirm that companies prioritise the adoption and digital integration of processes compared to renewing and investing in automatic machines.

> In manufacturing companies, the trend is to move towards the integration of production processes. So, the Internet of Things and other things like this that produce data which are analysed and based on those waste is reduced, times, stocks are reduced […] more than automation, digitalisation is at the heart of the transformation process. *Manager of a manufacturing company.*

The preference for data technologies and the emphasis on a gradual and transformative dynamic involving the organisational dimension also emerge in our case studies. Company A and Company B display similar dynamics of process digitalisation. In both companies, the reorganisation of production is at an advanced stage, due to the adoption of the *lean* paradigm. In particular, data technology is used to improve market responsiveness and to reduce unnecessary inventory and downtime. With respect to automation and robotisation, the two companies are both at a medium to low level: technologies of different generations are present in the carpentry and welding departments. According to managers, the crucial reasons for the limited investments in robots are the low production volume and modest financial capacity, in addition to the semi-artisanal character of production. By contrast, the respondents do not mention skill gaps and skill mismatches as possible limits.

> Here, Industry 4.0 means process integration. There are robots in some parts of the process, but not total automation. Not least because we do not need it at the moment, considering the production volumes. See the assembly department. Can we automate the assembly process? […]. Yes, but in how many years would the cost of doing something like that pay off? *Process Development Manager, Company B.*

Yet, the size of manufacturing companies is but one of many obstacles on Veneto's road towards the uptake of industrial technology. Notwithstanding the importance of the financial sustainability of investments (and therefore of public subsidies), stakeholders identify firm position as drivers of technological advance within the global market. As one business consultant underlines, individual firms also develop their strategies, which are crucially important for the diffusion and selection of technology, based on their specific position within value chains:

> So industrial policies help. However, the diffusion of technologies is not just a matter of incentives. It is more related to the position in the value chains, in the market. It is my client that drives the adoption of these technologies, especially for the smaller firms. They say, 'I feel the need to equip myself because it is the market that asks me to do so in some way'. That seems more significant to me. *Business consultant.*

Our case studies confirm that company position in value chains to some extent determines the features of the technological upgrading process. Company A's integration into a hierarchical value chain is typical of the automotive sector. Explicit requests from the leading company prompted the firm to invest in new technology:

> One of our major clients told us that they were running a production digitization project with all of their suppliers. The aim was to have immediate control over the state of production and to manage orders better. We first completed the integration of our internal manufacturing processes and then linked them to their management system. It was a great stimulant to us. Perhaps, we would have done anyway it after some time, but their request made us act quickly. It also gives you a chance to grow more rapidly. *Processes development manager, Company A.*

One of I4.0's fundamental objectives is the creation of cyber-physical production systems. But that objective must be reconciled with companies striving to innovate while maintaining their specificities. Attempting to develop what company managers call a tailored I4.0 model, companies deploy innovative technologies and organisational models in a selective and evolutionary manner.

> Industry 4.0 is a kind of definition, but every company somehow has its adaptation. The goal is to have a leaner entity that is also more responsive, more able to adapt to the situation that the market imposes on you every day. However, how they do it, both from a qualitative and quantitative point of view, cannot be standardised. Everyone has their model. *Manager Company B.*

As this testimony indicates, technological advance is expected to accommodate not only the size, sector and position of companies. It should also be sensitive to their unique production abilities and the competitive advantage of the so-called flexible specialisation which characterises Veneto and the Third Italy. I4.0 and its promise of mass customisation is perceived as consistent with the production model which has already been adopted by local companies and not as a fundamentally destructive transformation:

> What is concretely new about industry 4.0? It is the idea that you use these technologies to make a customised production with industrial plants. It means the ability to produce customised products at an acceptable cost. This is Industry 4.0. In the end, what is it? It is the end of Fordism. A process that began many years ago and was successful in the north-east and today, through these technologies, makes it possible to achieve maximum customisation. *ICT process developers, Company A.*

Selective and non-disruptive technological upgrades aim to guarantee the survival of Veneto's production model. In that regard, technical innovation parallels adapted firm-level governance. Many trade unionists emphasise the importance of continuity in local and firm-level industrial relations throughout the process of adopting new technologies.

> There is undoubtedly a Veneto model in the implementation of digitisation. It is clear that in contexts where a particular type of industrialisation has emerged in terms of enterprises' dimension, products, management and where a particular type of labour relation, labour organisation and therefore also a particular type of union and collective bargaining have emerged. These contexts are not neutral from the point of view of how these technologies are concretely implemented. *Provincial trade union officer*.

Trade unionists maintain that the features of the regional production regime shape the implementation of a new techno-productive paradigm. In that paradigm, firms, managers and owners are described as 'culturally closed' to the active involvement of worker representatives in decisions about technological development. They describe how companies view the trade union as a rival decision-making centre that threatens company monopoly on organisational and social decisions.

> We do not have the co-determination model of German industrial relations. Here we are in Italy, and we are in Veneto where unions have historically struggled to enter and remain in companies. Companies see the union as a useless embellishment, they do not consider that unions are essential for governing the workplace. Companies introduce Industria 4.0; they call us to see how much flexibility with respect to the national bargaining agreement they can obtain. When we ask: 'What about Industry 4.0?' The answer is 'Already done. We manage it.' *Provincial trade union officer* (*metalworkers).*

These difficulties for trade unions are particularly clear at Company A. There, the presence of trade unions does not seem to influence decisions regarding the adoption and use of new technology. At the same time, trade unionists speak of how their difficulties reflect general trends in the development and crystallisation of labour relations and labour culture in the region. As stated by a shop steward in an eyewear company during one of our focus groups, even within the north-eastern area, there can be significant differences in the governance of labour relations. Yet, even in large companies with an advanced system of industrial relations, trade unions find it difficult to take part

in decision making processes concerning the organisation of labour and technological and production choices.

Finally, although all trade unionists who participated in this research express the need for unions to play a more incisive role in industrial relations, many reject a pre-defined model. This model, they allege, neglects the specificities of the context and the particular traditions, characteristics and role of trade unions:

> There was a time when we fell in love with the German-style co-determination. I must say that I do not like it because it changes the nature of the Italian unions, which is not IG Metal; we are something else. *Provincial trade union officer* (*metalworkers).*

The role of the local production regime emerges even more clearly when considering I4.0's impact as a technological shift on work and on workers, as shown in the next section.

5. I4.0 technology in practice

According to workers in the two companies studied, technological changes produce diverse effects on organisation and on work.

Workers expressed different opinions regarding the impact of the technical and organisational transformation on their autonomy. Slightly more than a third of respondents considers their work autonomy to have somehow increased, albeit only the programmers are almost unanimous on the issue. Moreover, the interviews reveal a nuanced meaning of autonomy: according to expectations, the technological shift should not only make possible discretionary decisions, but also provide opportunities for subjective participation in the production process. The sense of an autonomy which is promised, but missing, entails the lack of recognition of one's personal contribution:

> But this autonomy is not there; it is linked to the seniority of the workers. However, seniority gives you experience in your work, but what you have inside you is something else. It is what you have, the motivation to go on with certain things, the ability that you cannot make yourself recognised. These things are not there. *Carpentry worker, Company A*

Worker opinion of the impact of technology on skills is also polarised. About half of the respondents believe that technology improves their work through the development of new skills, while the other half think the opposite. Except for programmers, these polarised judgments are similar across those whose positions involve interacting with simple and advanced technology. For the latter, the loss of manual and craft skills due to the implementation of new technology is not always matched by an increase in management and control skills.

What seems to matter is how technologies are implemented and used. Above all, the workers connect the absence of a link between technology and upskilling with scarce opportunities for and investments in training. Two-thirds of the workers claim that they have not received sufficient training following their workplace's digitisation and technological transformation. Also, workers report that training often consists merely of receiving instructions on the use of digital machinery and devices. This process is completed in few hours, while training courses oriented towards the development of broader competencies and fostering the ability to interpret increasingly complex production processes are limited.

> If I lose a skill that used to be manual and now I have to reach a skill that is of control, that is fine [...] on the other hand, who is preparing me? Because there is an investment in physical capital, but human capital also needs to be formed. What I have noticed is that it is the machine that forms man. *Welding worker, Company B.*

Also, all the trade unionists interviewed identified training and retraining as the most crucial issue to address the possible adverse outcomes of I4.0. At the national level, the 2016 metalworkers'

collective agreement already declared permanent training as a worker right. At the local level, several union agreements foresee an increase in company training. The I4.0 plan also supports training activities by offering tax credits for companies. However, according to many unionists, both the plan's guidelines and the choices of companies feature an important flaw. In both, a prevailing instrumental approach favours technical training related to individual technologies, exposing workers to the premature obsolescence of their skills.

> There is some conflict because, on the one hand, there are government incentives for training, which you get if you stick to a set path, and, on the other hand, the companies themselves want to provide training that is immediately spendable for them. However, in doing so, since the innovation runs, the risk is that the skills they develop today will be obsolete tomorrow. Most training is done by the technicians of the companies that sell the technology. Obviously, in this way, the worker only develops skills that he can use there on that machine. *Provincial Trade Union Secretary.*

Many workers describe the increasing unpredictability of market demands and the greater flexibility of production which it necessitates. These transformations are signalled by reduced production batches and the time-to-market of the product, and by the increased requests for real-time changes.

> Up to ten years ago, you had a model and built it for years, always the same. Everything changed since the crisis. The lifetime of the models has been reduced, two or three years maximum, then you change. Then there are more requests for changes that come when you are already producing. *Assembly worker, company B.*

These features of production processes – often defined as mass customisation – are typical elements of I4.0. At the same time, the Third Italy's 'flexible specialisation' is considered one of its main competitive advantages. However, according to the traditional Third Italy model, the effective management of uncertainty and variability was ensured and enabled by the availability of worker soft skills, craftsmanship skills, and cooperation. By contrast, the I4.0 project prescribes the management of flexibility through decentralising the governance process among work-teams, with the latter gaining more autonomy embodied by greater polyvalence of workers and decreased repetitiveness. While we found no evidence of either the establishment of formal or informal teams in the production departments or other instances of decentralisation, flexible production management seems to imply routines and occasional operations that do not increase worker versatility and autonomy, as one might expect.

> Things are more or less the same […] you don't get requests that make you change everything upside down, but requests that you already know. *Assembly supervisor, Company A.*

Even some middle managers are clearly aware of the gap between the rhetorical role assigned to participation, autonomy and decentralisation devices and their implementation:

> There are some important principles of this lean production method: people give their best if they are involved, if they are put in a position to be motivated. Nevertheless, this is hard because we have a culture that the important thing is to do. Who better than the one working in the assembly line can tell you what the problems are and offer you solutions, but many times the Veneto mentality expresses itself only from top to bottom. You have to do what I tell you. *Process development manager, Company A.*

Among workers, there is a widespread perception that their participation and involvement are limited to requests for partial, subordinate contributions relevant to secondary and minor aspects of organisational and production dynamics, which do not challenge vertical decision-making processes.

> Let us say that during design and organisation we do not call workers because we should discuss issues they do not know about. If I have to improve quality, I have to do things that maybe production people do not like. *Technical manager, company A.*

Trade unionists widely consider the attempts and mechanisms purporting to implement worker involvement and participation to be false, self-celebrating, and having purely rhetorical objectives, rather than policies which the companies seriously pursue.

> They start with the basic concepts of Toyotism, with training courses that concern all the workers. They are trained to use the box of ideas to be proactive about changes, start to reduce hierarchies, and ask for participation at a very theoretical level because… what happens? What happens is that managers culturally resist to these philosophies and are unable to internalise these new managerial, organisational and human relations models. So, it happens that we continue with traditional, very hierarchical methods and, at the same time, they ask the workers to get involved. Nobody understands anything, and obviously, it does not work. *Trade Unionist (metalworkers).*

6. Discussion

Our empirical observations of the north-eastern Italian experience suggest that, when companies are supported by a technology-neutral national policy and are in principle free to choose how to implement changes, their choices are influenced by the market, their position in value chains and by their socio-organizational features. Contrary to I4.0's fundamental objective of creating cyber-physical production systems, companies deploy technologies in a limited, selective and evolutionary manner (Soli, 2018), attempting to adapt the I4.0 paradigm to their unique specificities (Magone and Mazali, 2016). They invest mainly in data technologies and interpret I4.0 as a technological update to the lean production model. Simultaneously, they tend to invest only in the model's technical requirements like time-management and the implementation of the lean production flow, without addressing its organisational and social implications, like the increased participation and involvement of workers.

Although workers have high expectations of these transformations, they identify the gap between I4.0's promises of improved working conditions and their realisation. In the two companies studied, the presence of unions on the work floor does not seem to influence the dynamics of technological innovation nor foster worker participation. These findings are consistent with the firm-level capital-labour relations model that characterises the local context. Companies consider technical and organisational changes to belong exclusively to the competence of owners and managers. Trade unions have faced challenges in opening negotiating spaces large enough to curb managerial decision-making power.

This picture reinforces the idea that lean production is insufficient to guarantee the horizontalisation of the factory and worker participation (Butollo *et al*., 2018). It indicates, also, that the I4.0 emphasis on improved working conditions and more creative and high-performance jobs does not necessarily translate into reality (Pfeiffer, 2017). Innovation processes may also take on a different form, supported by a dynamic of consensus and despotism (or despotic paternalism), which does not promote worker involvement and participation (see also Steward *et al*., 2009). Training, flexibility management, subjective involvement and proactivity are at the core of I4.0 because they are deemed to be indispensable for addressing production fluctuations and ensuring that workers are concerned with the quality of products and processes. Yet, in the companies studied, workers and unionists saw these participation tools as being used in a rather superficial and hypocritical (Cushen and Thompson, 2012) manner for purely rhetorical purposes. In this regard, they pointed to weakened participatory devices and, above all, the fact that they were tools 'without explicit counterparts' (Coriat, 1993).

Managers depict so-called flexible specialisation as consistent with the mass customisation, flexibility and versatility of I4.0. Yet, their respective underlying mechanisms are different and, to some extent, contrasting. Ideally, the I4.0 project promotes flexibility in the form of decentralised decision making. By contrast, the key to managing uncertainty and variability in the Third Italy have traditionally been worker flexibility and craftsmanship skill within a hierarchical framework. Paradoxically, by underlining the consistency between the two paradigms and by denying the disruptive features of I4.0, entrepreneurs and managers are implicitly discarding participation, decentralisation and autonomy as relevant issues. By doing so, they contribute to 'rewriting' the road to I4.0.

7. Conclusion

This article has explored how social and production contexts are shaping the policy and techno-organisational project of I4.0. It has done so by studying the adaptation of small and medium manufacturing companies in the so-called Third Italy, particularly in the Veneto region. Our analysis suggests that the concrete deployment of the I4.0 model follows two processes. First, the I4.0 policy is reinterpreted and implemented, as described in policy transfer studies (De Jong, 2013; Dolowitz and Marsh, 1996; Prince, 2010; Stone, 2017). Second, technological innovation encounters institutional conditions and actor positions, consistently with the traditional critique of technological determinism (Nye, 2007; Noble, 1979).

The analysis corroborates the thesis that policies are redefined and techno-organisational changes are implemented under the influence of a number of factors, and their interplay: the specific features of the economic system, the set of (non)involved actors and their relationships, and the social norms regulating employment, production and management. In our case, the dominant position of SMEs that act as suppliers in global value chains appears to have influenced the policy goals and instruments. Policies support technological upgrades without differentiating between various ways that this can be achieved, leaving the realisation of these upgrades to the strategies of individual firms (which are sensitive to their market position and specific histories). The weak influence of trade unions in both the definition of the I4.0 plan and firm-level decisions concerning the adoption of technology – that, in turn, reflects a weak system of industrial relations – seems to reinforce a rather technocratic, top-down version of I4.0. In this version, attention is paid almost exclusively to its organisational aspects (e.g., training, participation, and worker involvement). The specific local employment regime, consisting of the norms regulating employment, management and the organisation of work, appear to contribute to setting aside the 'social' agenda of I4.0.

These mechanisms have the effect that SMEs in the Veneto region are far from adhering to a preordained model of '4.0 enterprise'. Likewise, there is minimal evidence of the transformation of work in the direction of greater autonomy, proactivity, and polyvalence for workers. The growth in technical and organisational complexity does not, on its own, require or produce an improvement in skills and increased autonomy for all workers. The modified technological infrastructure also works within traditional organisational methods.

Without denying the power of policy or technology to intervene in social and organisational realms and dynamics (Boyd and Holton, 2018:339), these results point to the need to embed the analysis of their influence in specific socio-historical contexts. In the diffusion of the I4.0 paradigm, ignoring the context runs the risk of leading to failed policies, wasted resources and unmet technological and social promises. This exploratory contribution paves the way to systematic comparative inquiries into transfers and translations of I4.0 as a policy programme and a technological framework, along with their meanings and outcomes.

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