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THE IMPACT OF LABOUR MARKET TRENDS ON THE EMPLOYMENT OF R&D PERSONNEL: A LITERATURE REVIEW

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THE IMPACT OF LABOUR MARKET TRENDS ON THE EMPLOYMENT OF R&D PERSONNEL: A LITERATURE REVIEW[2]

This paper provides a literature review of the impact of labour market trends on the working arrangements and employment of R&D personnel in the business and industrial sector. Current research positively considers the effects of labour market deregulation, flexibility, and digitalisation over R&D for enhancing business growth and containing labour costs. However, lacking are perspectives that problematise their impact on R&D personnel's labour and working conditions. This paper argues that research is needed on these important dimensions, to assess their potential consequences over the R&D workforce and R&D activities.

Keywords: R&D personnel; R&D employment; digitalisation; flexibility; deregulation; non-standard work arrangements

JEL Classification: O3, O5, Z22

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Introduction

During recent years important theoretical and empirical gaps in the sociological and economic literature on employment were discovered which refer to highly-qualified R&D professionals and the increasing precarisation of their work in the science and technology business and industrial sector of the labour market. International institutions have warned about the changing division of labour and employment conditions in organisational R&D (Grundke et al./OECD 2018; CEDEFOP 2020). Increasingly, businesses are tapping into highly-skilled, temporary and external workers to scale up their workforce in an agile and effective manner, to augment their innovation and performance capacity, expand cooperation opportunities, and manage labour costs as well as peaks and troughs in demand (Cetrulo et al. 2019; Ratcheva et al./WEF 2020). This trend is increasingly leading organisations in the science and technology sector to also hire R&D personnel 'off the shelf', with implications for job stability, contract conditions, and work continuity (Ciarli et al. 2018). In addition, as a high-tech market, the rapidly evolving digitalisation of R&D work is showing criticalities for employment, as R&D professionals must keep pace with new technologies and update their skills to avoid obsolescence and replacement (Grundke et al./OECD 2018).

Nonetheless, most research has neglected these changes, and has focused instead on how labour market trends and digitalisation impact on R&D patterns and company growth (Asim & Sorooshian 2019), on R&D management (Bauer et al. 2018) on business intensity and firm performance (Falk 2006; Yeh et al. 2010). Insights stemming from these types of research are important to assess innovation and growth in R&D in ways that can favour business productivity and creativity. However, these views promote results that support firms' market competitiveness only, disregarding that the combination of labour market trends also favours cost-cutting of labour at the expenses of the workforce. Particularly, research on how these same trends act as drivers for employment conditions of the R&D workforce, is comparatively very scarce. This is remarkable, especially since R&D professionals are a highly-skilled working population, pivotal for undertaking creative work that increases the stock of knowledge, the design of applications, and more widely develops improvements for economy and society (OECD 2015). The paper looks at the following questions:

- How do labour market trends and digitalisation impact on working arrangements and conditions of the R&D workforce?
- What types of employment changes are emerging in R&D, and why?

These questions hold for understanding threats and opportunities for R&D professionals' employment, which, in contrast with extant approaches, might offer a coherent picture of effects of labour markets and organisation of work changes on R&D activities.

Against this background, this paper discusses the available literature on R&D employment, unravelling the impact of labour market trends on work arrangements and personnel in R&D. I draw upon a composite scholarship in the fields of economics, R&D management, science and technology, and the sociology of work which explores R&D in relation to labour division, skills, and work in business organisations, to develop a systematic review of changes in R&D employment that pays attention to the situation of R&D personnel. In addition, this paper bridges a gap in research, development and innovation theory by discussing the effects of changing R&D work arrangements not for the success of the firm, but for the consequences that this bears on the workforce. The value of this argument rests in the fact that existing literature exploring R&D work usually focuses on two sets of priorities: the cost-saving needs of the firm, which reflect on labour as a function of production (Coccia 2009); and labour as a function needed for enhancing R&D intensity and innovation (Dachs 2017; Hecht 2018). However, we know surprisingly little about R&D personnel beyond their 'usual' treatment as one factor in the production function which is easily exchangeable. R&D labour has evolved with the increasing complexity of R&D organisations, captured between needs for flexibility as a strategy for saving workforce-related costs and increase innovation capacity, and as a response to sustain growth and productivity. Thus, organisations have started to operate through much more flexible R&D structures, particularly in how they organise human resources (Michie & Sheehan 2003; Howells 2008) deploying 'a core group of R&D workers with stable jobs surrounded by a more fluid periphery made up of temporary workers' (Lam 2005, cited in Howells 2008: 249). In contrast with the 'traditional' orientation of R&D literature on labour as a factor in production, I explore the manifestation of changes in the employment of R&D personnel. The advantage of this perspective lies in showing that an increasingly central problem of R&D relates to resolving the complex tension between innovation objectives, firm growth, cost saving, and R&D work organisation. This focus, I argue, generates novel insights into R&D labour as shaped and constrained by a reorganisation that involves a variety of new employment forms, sprung up to meet the company's needs, but which does not necessarily favour R&D personnel.

The remainder of the paper is structured as follows. First, I introduce the underlying labour market trends of deregulation and flexibility, problematising their impact over the R&D workforce, with an emphasis on processes affecting skills, working conditions, and labour stability. Then, I discuss digitalisation and its effects over R&D employment. Thirdly, I explore

how the interrelation of deregulation, flexibility, and digitalisation creates newly-emerging forms of work in R&D. After the review, I close with a brief delineation of the implications of such dynamics.

1. The deregulation and flexibilisation of labour markets

A key driver in the current employment scenario of advanced economies has been labour market deregulation – the removal or reduction of state interventions for enhancing market adaptability against economic shocks, and to help firms to raise productivity, competitiveness, and contain labour costs. Economic analyses widely attribute these attitudes to the inability of 1970s-1980s interventionist market policies to cope with inflation and wide cyclical fluctuations (OECD 1994). In contexts such as the European Union internal market, the primacy given to the free movement of goods, services, capital and citizens as fundamental economic freedoms has favoured a deregulation reasoning to improve labour market outcomes. Large-scale deregulation of employment protection law in the EU Member States aim to stimulate job creation across sectors and countries, in turn securing human capital accumulation through the facilitation of greater labour mobility. However, deregulation of employment protection also augmented negative effects to labour standards and working conditions (Cremers 2016). At the crossroad of deregulation and labour mobility, data indicate that highly-skilled EU movers account for a significant part of the European labour market, influenced by push and pull factors such as economic motivations, quality of life and employment, and perceived quality of institutions in well-performing EU societies (ICF/European Commission 2018). Similarly, there has been a growing recognition of the link between deregulation and international labour mobility, particularly for the highly skilled. Industries and services alike rely upon the acquisition of human capital to add competitive value to their operations. If human expertise is not available to recruit locally, employers might import it from abroad. The need for global interchange of labour has been reflected in governmental changes in institutional frameworks, with the aim of supporting positive flows of international labour movement, national and company growth (Salt 1997). Increasingly, facilitation of labour movement and deregulation of state interventions appear in different measures across trans-national and bilateral partnerships such as the NAFTA (Canada, Mexico, USA), the EEA + Switzerland, the TTTA (Australia, New Zealand), and, to some extent, the TPP (including 12 trans-pacific countries such as Japan) (OECD 2012). Particularly, highly-skilled workers can move more freely, as work permit systems are reacting to an easier accommodation in the global search for expertise. Highly skilled labour migration is supported at different degree levels, according to the interdependency agreed upon by member countries and the harmonisation of selected policies. For instance, the recognition of educational

and professional qualifications, of the competitive transferability of skills, and of the need for specific categories of workers facilitates the movement of highly-skilled workers through preferential regulatory arrangements (OECD 2012).

Now largely favoured by neoliberalism – a policy model supporting deregulation and free trade – both globalisation and the 2008 financial crisis sped up such changes in labour markets to contrast low economic performance and high unemployment rates. Deregulation policies have thus been implemented across countries, as the benefits of tenure, state interventions and 'rigid' labour market protection have been contended as constraints against inelastic adjustment of employment to contingent economic fluctuations. In tandem, global labour market deregulation trends have caused a surge in flexibility – which refers to the ability of firms to have greater control over staffing decisions (hiring and firing, work hours, and use of nonstandard contracts) than does labour by simultaneously containing labour costs (Pulignano 2019). Facilitating labour markets' adaptability and response to change, flexibility is achieved through higher organisational turnover, subcontracting, use of external labour through agency and temporary workers, contract workers, teleworkers; through functional flexibility in work tasks, skills, and job rotation; through structural flexibility, associated with jobs availability and changes in job titles; through temporal and monetary flexibility, promoting flexible hour arrangements and wages (Standing 2002).

The consequences of flexibility are often presented in a dichotomous light. From one side, scholarship claims that flexibility helps firms to contain wage-related costs, increase productivity, as well as providing workers with opportunities for independence, self-development, and mobility (Findlay & Thompson 2017). On the other hand, critical accounts argue that much non-standard work experiences in developed economies are largely negative. The burden of risk and uncertainty falls disproportionately on workers, who face 'atypical' employment led by contractual insecurity, wage vulnerability, limited access to social security, career and training opportunities (Kalleberg 2009). Analyses of employment quality point out that flexibility is creating a gap between 'good jobs' entailing adequate earnings, sociable working times, and stability (Findlay et al. 2013) and 'bad jobs', identified with precariousness, i.e., high levels of labour insecurity created by state or capital (Kalleberg & Vallas 2018). Research also suggests that there is developing 'peripheralisation' or 'casualisation' of 'core' employment 'alongside a growing number of fixed-term, non-standard workers…blurring the boundaries between the internal and external labour markets' (Saloniemi & Zeytinoglu 2007: 124–125).

A detailed assessment of national legislations related to (de)regulation and flexibilisation of labour markets does not fall within the scope of this paper, and it would result almost impossible to take heed of the very heterogeneous character of the complex set of laws and policies that are enacted by more than 190 countries worldwide.[3] Nonetheless, a brief overview of labour regulations by a number of countries representing diverse models of neoliberal economies, helps to grasp, at least on an illustrative level, how national legislations have implemented reforms towards the deregulation of their markets and employment protection.

A study by Turrini et al. at the European Commission, DG ECFIN (2015) in cooperation with the Economic Policy Committee of the ECOFIN Council analysed EU labour regulations across Member States following the 2008 crisis. The authors show that countries with similar institutional settings tend to follow analogous deregulation patterns (Turrini et al. 2015: 20). For instance, notwithstanding their different employment and social welfare regimes, Southern Mediterranean economies as Spain and Italy, Social Democratic nations as Denmark, and coordinated market economies as Germany show consistent deregulation tendencies of market segmentation and reduction of state intervention in the employment relationship, including working time and wage setting. De Stefano (2014) also indicates that this distinct deregulatory path has widened the gap between the protections of standard and non-standard workers against unfair dismissal and decentralised collective bargaining systems, in the end weakening the traditionally inclusive nature of industrial relations in Europe and exacerbating the divide between core and marginal workforces.

Peters (2008) provides instead a critical evaluation of labour market deregulation policies across 13 OECD countries in Northern America and Western Europe, including the liberal market economies of the USA and the UK. Peters shows how recent economic and legislative changes in these two countries have weakened organised labour, eroding wage setting and social corporatism. Both present increased rates of part-time, temporary jobs, as well as self-employment led by flexibility practices. Contingently, social security protection has weakened in the USA, as non-standard employees receive lower or no benefits, including employment-sponsored health insurance. In the UK, these workers do not qualify for occupational pension (Peters 2008: 87). Kalleberg (2018) adds that deregulatory liberalisation in the USA and the UK, has shifted the risks of work to individuals, by replacing collective mechanisms of labour

[3] For a more detailed and cross-national analysis, the ILO provides information on labour market measures of 190 countries through the NATLEX database. Through the Indicators of Employment Protection, the OECD also offers yearly analyses of employment protection in OECD countries. With a focus on the EU, the FRDB-IZA Social Reforms Database informs on labour measures adopted since the 1980s by European countries.

regulation with the imposition of market processes. Both countries also boost weak levels of employment protection; thus, hiring and firing practices are easy to attain (Kalleberg 2018: 248).

Labour reforms have also facilitated deregulation tendencies in East Asian state capitalist countries such as China, as well as coordinated market economies such as Japan. Li (2019) shows that in China, under the combined principles of regulation and deregulation, stable employment has been replaced by a contract labour system, and wage is linked to performance and productivity. On the other side, as a response to the mass layoffs caused by deregulation and enterprise restructuring, the government has turned to implement regulations over atypical employment on issues such as labour relations and social security (Li 2019). Japan, which for decades has been regarded as a stronghold of lifetime employment, has implemented financial deregulation and flexibilization of labour regulation (Coe et al. 2009). These have resulted in a significant level of lifetime, standard employment guarantees; wage restraint; and the massive increase in non-regular, temporary workers.

1.2 Deregulation, flexibility, and the labour market for R&D personnel

Assessing the consequences of deregulation and flexibility for labour potential has become a crucial challenge for knowledge economies, a preoccupation covered by a vast amount of research (Enkel et al. 2009; Anzola-Román et al. 2018; Bustinza et al. 2019). One of the labour areas where the effects of these trends are deemed especially important is research and development (R&D). As in the internationally agreed standards defined by the *OECD Frascati Manual* – which sets forth the mapping and methodology of R&D at the global level – R&D is defined as 'creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society and the use of this stock of knowledge to devise new applications' (OECD 2015: 28). Already in 2003, the European Commission had noticed that, because of macro-economic trends, there was a gap in favourable prospects for R&D professionals, as most organisations commit to less sustainable R&D positions due to decreases or slow increases in public and private investments (European Commission 2003).

Notwithstanding institutional arguments about R&D's capability to break traditional working arrangements between professionals and organisations, there is a dearth of studies on key issues such as new forms of work, employment patterns, and work experiences of R&D personnel as driven by labour market trends. This lack of theoretical and empirical discussions available for the R&D workforce is surprising. Indeed, if we consider the crucial role of R&D professionals in the creation of knowledge – whether improving or developing concepts, theories, models,

techniques, instrumentation, software or operational methods (OECD 2015) – the silence over their employment situation shows a lack of recognition for their labour value, if not directly considered as a determinant of business performance and innovation. Over the years, research has explored the effects of labour market policies over R&D labour in terms of R&D productivity (Cardamone 2017; Kwon & Kwon 2019), R&D innovation (Baum et al. 2017; Coluccia et al. 2019), and R&D management (Farrington & Alizadeh 2017). These studies have oriented their efforts towards the examination of business opportunities that exploiting R&D human capital and labour can generate, but ignored to assess whether these same opportunities threaten R&D professionals' working conditions. For instance, Miyamoto (2010) shows that labour market policies that protect workers have an important role in determining the level of R&D activities. However, the author does not problematise the important link between labour market policies and their effects over R&D personnel, ignoring that R&D activities can be influenced by working conditions. Similarly, Hazak et al. (2017) recognise the ties between trends of labour flexibility and R&D professionals' preferences over working times as an indicator of performance. Yet, they fail to theorise the implications that changing working arrangements have for a distinct workforce who 'often require[s] more freedom (of mind) for their intellectual work', and might be particularly 'interested in taking advantage of flexible working options' (Hazak et al. 2017: 3). In order to redress these shortcomings, this paper explores here the link between structural labour market trends of deregulation and flexibility over R&D employment, emphasising their effects for R&D personnel.

To this extent, a first research strand has investigated the impact that deregulation and flexibility trends present for R&D employment. Growing evidence of the international mobility of skilled talent, following the liberalisation of cross-border movements of people and the deregulation of employment, arguably yields far more benefits than disadvantages (Thorn & Holm-Nielsen 2008). Specifically, research on R&D workers has widely shown that these skilled individuals, due to trends such as deregulation, general economic integration of product markets and the increased globalisation of corporations, comprise a large part of those globally mobile professionals who participate in the development of high-tech, knowledge-based industries (Gera et al. 2004). Evidence shows that firms exploiting 'mobile' skills increase transfers of knowledge and inter-firm relationships (Rosenkopf & Almeida 2003), firm productivity (Balsvik 2011; Görg & Strobl 2005), R&D output (Ejsing et al. 2013), and total innovative activity (Kaiser et al. 2015). A number of corresponding studies also shows that international R&D mobility, in turn, can facilitate career advancement of R&D workers. This occurs through the creation of personal networks and enhanced understanding of R&D organisation and management (Béret et al. 2003; Criscuolo 2005) as well as through the upgrade in their expertise

in international assignments (Sapouna et al. 2016). In contrast, recent views more attuned to the labour side of the matter, suggest that deregulation-led trends cause a negative impact on dimensions such as labour-driven innovation in R&D. For instance, Hoxha and Kleinknecht (2020) show that more labour market regulation (such as rigidity in labour turnover through less easier hiring and firing) positively affects R&D innovation. Employment stability of R&D personnel would secure loyalty, trust and commitment and greater efforts in the mobilisation of knowledge, in contrast with the climate of fear, control, and overwork experienced by less stable workers vis-à-vis the management in a high-risk employment scenario (ibid.).

In turn, recent studies of labour market trends, demonstrate a negative impact of flexibility policies on labour productivity growth (Vergeer et al. 2015) and on innovation (Wachsen & Blind 2016) in those industries that rely on accumulation of knowledge – as in the case of R&D (Hoxha & Kleinknecht 2020). Cetrulo et al. (2019) state that flexibility, intended as an intense labour turnover associated with temporary contracts, negatively affects the accumulation of 'within-firm' knowledge and discourages R&D personnel's competence and efforts. This is evinced in a longitudinal study (1998-2021) of the five major European economies (France, Germany, Italy, Spain and the Netherlands), where it was observed that temporary employment (proxying labour flexibility) has a negative effect on R&D employment. Temporary employment was also negatively associated with the development of new products in knowledge intensive sectors and to the penalisation of 'those industries structurally characterized by a stronger propensity towards product innovation' (Cetrulo et al. 2019: 6368). Similarly, in their study of human resources flexibility in R&D of 1,666 Spanish industrial firms from the *Survey of Business Strategies Questionnaire*, Martinez-Sanchez et al. (2019) find that there is good flexibility when 'employees with high functional flexibility…are able to remain in the firm for a long time in order to exploit their knowledge'. Instead, there is negative flexibility when temporary employees are not able to develop key competences for transforming and integrating knowledge for firm innovation, because of the short-term and unsteady contractual conditions they face (Martinez-Sanchez et al. 2019: 18-19).

Similarly, a second research strand assesses how external contracting is a new form of firm-driven employment in R&D. This form is associated with deregulation and flexibility, used to augment innovation performance and competitive advantage (Bertrand & Mol, 2013; Rodríguez & Nieto, 2016). To this extent, Ciarli et al. (2018) capture, in a study of the effects of R&D investments over employment in local labour markets in the UK, that 'the traditional idea that R&D might trigger a positive effect on employment, based on the potential for compensation mechanisms via new products, productivity growth, lower prices and increased demand seems to be challenged' (2018: 2). The study shows that the impact of changes in the R&D labour market

goes beyond 'the job enhancing effect of product innovation and the job-displacing effect of process innovation' (Ciarli et al. 2018: 16) and suggests that R&D labour is at risk of becoming more precarious. On this line, in a case study of a German R&D centre division, Benassi and Kornelakis (2020) explore how employers often choose between four types of contingent work arrangements: fixed-term, agency, subcontracting, and freelancing along the dimensions of costs and control. They propose that employers' choice is influenced by 'institutional toying', or misclassification of employment status; misapplication of wage levels and working condition standards; and twisting work organisation. The authors suggest that institutional toying makes itself explicit as managers pay agency workers according to lower salary levels, hiring them on fixed-term contracts to extend the permitted tenure. In response to pressures to reduce headcount costs instead, managers misclassify the employment status of directly employed R&D workers as either freelancers or subcontractors. Finally, managers twist the work organisation, so that subcontracted workers remain under their directive control (Benassi & Kornelakis 2020: 19). Indeed, in a report on R&D systems in the UK and the USA, British think-tank Common Wealth (Hanna et al. 2020) argues that R&D work performed by large tech companies is facing lowering employment regulations at the detriment of workers, so that R&D professionals are increasingly becoming 'independent contractors', exempt from various labour protections. This allows firms to avoid significant employment costs, while capitalising on intangible assets produced by them, such as intellectual property. Additionally, recent evidence shows a dramatic surge in self-employment in R&D over the past decade. Ciarli et al. (2020) argue that this might be a structural phenomenon linked to firms' innovation strategies, which create incentives for harvesting external skills not available in the internal workforce. They argue that R&D investment can create more stable career opportunities for high-skilled workers, whilst workers with mismatched, obsolete skills might be forced to resort to self-employment as a buffer strategy (see also Åstebro et al. 2011; Vona & Consoli 2015). Furthermore, R&D investment might create low-skilled roles outsourced by the more R&D-intensive firms, forcing R&D personnel to resort to self-employment to top up income and avoid becoming trapped in unwanted work arrangements.

Additionally, a sizeable stream of non-mainstream economic literature shows that flexibility and deregulation trends affect not only R&D personnel's working conditions, but also more widely R&D-intensive industries' labour productivity. For instance, questioning why many advanced economies witness unsatisfactory R&D performance when it comes to labour productivity growth, Pariboni and Tridico (2020) advance that this is due to the challenge for mainstream economics to recognize why:

> ‘a generalized application of all the ingredients that, according to most “supply-side” economists and international institutions, should have modernized and enhanced the competitiveness of dynamic and growing economies: labor market flexibilization and, more generally, structural labor market reforms, downsizing of the welfare state, market deregulation, privatizations and so on’ equal to productivity slowdown (Pariboni & Tridico 2020: 1290).

Exploring the reasons behind the dynamics of labour productivity in R&D as driven by institutional and structural changes, Pariboni and Tridico (2020) thus propose a theoretical and empirical econometric analysis of 25 European countries for the period 1995-2016. The authors argue that the deregulation of the labour market and the increase of temporary employment and stagnant wages, encourage low productivity gains and low added value in firms’ R&D-intensive strategies. This is explained by the share of temporary employees in total R&D employment, which acts as a drag on labour productivity, training, and wellbeing, and is negatively associated with the creation of low-productivity, low-wage jobs in return.

To meet customers’ needs and maintain a competitive profile, organisations can also resort to external R&D service suppliers to improve their in-house R&D, or to expand their portfolios (Kohtamäki et al. 2013). External R&D service supply yields several benefits, including higher profit margins, more stable revenues, and resistance to recessions (Gebauer & Fleisch 2007). Additionally, these types of services do not require significant relational or customer investment as for other more intensive knowledge services (Kohtamäki et al. 2013). Koschatzky and Stahlecker (2008) show that companies providing R&D services are part of knowledge-intensive business services (KIBS), which transform heterogeneous stocks of knowledge with high intellectual value into problem-solving activities and products. For instance, R&D service suppliers such as engineering companies are taking over significant shares of companies’ internal R&D, through the provision of body leasing, product tailoring, feasibility studies, manufacturability analysis, and prototype design (Homburg et al. 2003). As a matter of example, Altran (part of Capgemini),[4] an engineering multinational, provides consulting, digital analytics, and manufacturing 4.0 for R&D in several industrial domains, from space, defence and naval to life sciences. Their global network of personnel, equipped with technical and intellectual assets, work on specific solutions, projects and partnerships to deliver tailored R&D solutions to customers, offering a strategy that optimises in-house and externally available R&D human resources. Schlumberger and Halliburton,[5] two of the world’s largest service and product providers in the oil field industry, provide R&D production enhancement, project management, and consulting throughout the lifecycle of customers’ reservoir, from construction and

[4] See Altran https://www.altran.com/ (accessed January 5th, 2020).
[5] See Halliburton https://www.halliburton.com/en-US/default.html and Schlumberger https://www.slb.com/ (accessed January 5th, 2020).

completion to optimisation of production and asset duration. In doing so, they also offer customised intervention solutions, deploying specialised engineers and consultants. Cambridge Consultants[6] – a global product development and technology consultancy firm specialised in outsourced R&D services – work with customers by identifying, creating and launching original R&D services and products which foresee long-term, sustainable competitive advantage. Furthermore, they support R&D by providing digital services, integrating high-tech solutions in AI & analytics, connectivity and the Internet of Things, robotics and digital security. Cambridge Consultants operate on a business model that combines technical, commercial and market expertise on a global scale, offering to clients, among the others, outsourced personnel. Arguably, these type of large corporations act as suppliers by offering, together with their services, an accompanying 'body leasing'. This expression refers to the temporary outsourcing of professionals in highly-specialised and technical domains, such as R&D and information and communication technology. Leased professionals are available to a company for a specific time, and work at the customer's premises for the design, development, implementation, and management of one or multiple projects.

Although in the knowledge-intensive services literature, several contributions deal with R&D service providers (see Kohtamäki et al. 2013), the impact that these have on R&D personnel is neglected. The growing resort to external R&D service suppliers and the fixed-term contracting of their specialists, implies potential issues for the labour market of R&D personnel. Consistently with previous studies, external R&D services might increasingly substitute for internal R&D (and thus for in-house personnel) (Hess & Rothaermel 2011; Hagedoorn & Wang 2012), as companies rely on the input of the R&D external labour market, with implications for the latter's employment stability and career development. Thus, companies can capitalise on external sources of R&D personnel according to their own needs and funding, avoiding expensive recruitment and labour costs for internal staff. This might also point to an increasing segmentation of the labour market for R&D personnel through contractual arrangements (segmentation along permanent/temporary or 'leasing' nature of employment contracts),[7] with consequences for employment equity and efficiency of labour market outcomes. As already suggested by Jones' s (2002) study of R&D in the UK pharmaceutical industry, increasingly companies might consider 'R&D as a 'make or buy' decision rather than as a core activity', with

[6] See Cambridge Consultants https://www.cambridgeconsultants.com/(accessed January 5th, 2020).
[7] Of course, the future scenario of the labour market for R&D personnel is also tied to employment regulations and contractual agreements that apply in different countries.

consequent reductions in the number of personnel directly employed by leading firms (Jones 2000: 352).

Overall, these views suggest the development of 'boundaryless careers' in R&D. This definition emphasises independence from traditional, organisational working arrangements towards mobile careers, as R&D professionals increasingly work on projects at different stages of the innovation process, through short contracts (Inkson et al. 2012). The review of available literature conducted so far points to the need of re-assessing R&D employment developments, as the field moves towards multidimensional – but potentially precarious – job options.

2. Digitalisation and its effects over R&D work

Research shows that digitalisation is another macro trend affecting economic growth, wealth creation and distribution, as well as employment dynamics towards more flexible working arrangements (Kässi & Lehdonvirta 2018). Defined as the pervasive synergy of digital innovations in economy and society (Perez 2015), digitalisation refers to enabling or improving work processes by leveraging the techno-economic paradigm of the information society: digital technologies and digitised data (Valenduc & Vendramin 2017). Digitalisation is variously applied to all aspects of business, from growth strategy to performance, models, and worker enablement. Labour markets – particularly across OECD countries – have undergone structural transformation as a result of technology developments, which are now a matter of intense scholarly debate, particularly for their impact on employment.

A growing literature demonstrates that digitalisation improves business processes and productivity, for instance by automating routine tasks and reducing interaction costs with customers and suppliers (Bartel et al. 2007; Brynjolfsson et al. 2017). Other scholars suggest instead that there is no link between digital intensity and firm productivity (Bartelsman et al. 2017), or that digitalisation supports productivity only in combination with other factors, such as management skills and organisational capital (Aral et al. 2012), human capital (Bugamelli & Pagano 2004) and a favouring regulatory environment (Bartelsman 2013). Research also shows that digitalisation is linked to a decreasing share of income that accrue to workers, with the main explanatory factor relating to the substitution of capital for labour, driven by competitive technology use and costs (Comin & Mestieri 2018).

Equally, digitalisation is at an inflection point for disruption in R&D, as organisations and R&D personnel's behaviours and expectations are perpetually evolving as new devices emerge to help

achieve business imperatives (Accenture 2016). In R&D, digitalisation processes cover a wide range of applications, including virtual experimentation and simulation; the use of digitalisation as a tool for internal and external collaboration; robotisation of experiments; big data analytics; artificial intelligence, and other technologies, all expected to generate significant impact in highly knowledge-intensive industries and professional functions (Li et al. 2019). Part of the scholarship assessing the link between such digitalisation initiatives and R&D suggests that the former has significant benefits on the latter in terms of increased consumer and customer intimacy; accelerated speed to market; growth in open innovation and crowdsourcing; more playing field for market stakeholders; and the development of cradle-to-grave product lifecycles (Farrington & Alizadeh 2017). This is particularly evident in R&D management literature exploring decentralisation of R&D and digitalisation. Since the 1980s, R&D activities have been characterised by decentralisation as a core element of an organisation's design, in contrast with the classic unitary organisation, where R&D activity was centralised along with other functions (Ecker et al. 2011). Furthermore, R&D is now often decentralised internationally, as companies seek to keep pace with the demands of global markets by leveraging upon a concentration and specialisation of resources, local know-how and human capital, networks of innovation and knowledge flows (Gassman & von Zedtwitz 2003). Such decentralization is also associated with efficiency advantages, stemming from reduced managerial opportunism, combined with improved information processing (Argyres & Silverman 2004). Other pros include the utilisation of differences in local personnel costs (Boutellier et al. 1998). Multinational companies particularly drive this trend, dominating international, decentralised R&D: 70-80% of worldwide R&D investment is led by the 150 largest technology-intensive companies (von Zedtwitz 2020).

Thus, R&D management in knowledge intensive companies has been increasingly confronted with supervising projects involving teams and members from different R&D laboratories, centres, and business units. These teams operate in multiple countries and across time zones to carry out R&D projects, global product development projects, and transnational innovation projects (von Zedtwitz 2020; Gassmann & von Zedtwitz 2003). There are obvious disadvantages in these decentralised set up: issues of communication, management and synchronisation; varying working cultures and practices; geographical distance (Boutellier et al. 1998). These challenges drove the development of R&D management models and coordination mechanisms, supported by intensive use of technology as useful solutions (Mendez 2003).

One of these solutions is knowledge management. Regarded as the process of organising corporate collective knowledge to increase innovation and competitive advantage, knowledge management is increasingly employed as an indispensable managerial tool (Park & Kim 2005).

Owing to the massive development in information technology, companies are developing and using knowledge management systems software (KMS), designed specifically to facilitate the creation, sharing and storage of knowledge in R&D functions. Both knowledge management and information system's literature shows that KMS are essentially based on digital ecosystems built on information and communication technology tools, which can be used to systematise knowledge (Santoro et al. 2018). In R&D, they vary from databases to algorithms, intranets and internet, e-mails and online interfaces (Soto-Acosta & Cegarra-Navarro 2016). Equally, digital ecosystems have enabled decentralised R&D activities, allowing project management across space and time zones (Zedtwidtz et al. 2004). R&D project management defines work packages and supervises overall integration, including the respect of costs, deadlines, and quality of results (Mendez 2003). Project management systems are now aligned through digital technologies to best fit R&D imperatives. For instance, artificial intelligence (AI) technologies, such as deep learning or machine learning, are radically changing the way R&D projects are managed (Schuhmacher et al. 2020). AI is used to streamline and automate standardised project tasks, e.g. planning and monitoring, resource allocation, and risk management through functions such as predictive analysis and deep neural networks (ibid.). 3D virtual reality spaces also commonly support decentralised R&D, for example by offering smart tables and digital layout of tools for multi-project management (Vér 2018). Decentralised cyber-physical systems (CPS) also enable researchers to use a cloud-based approach to create an intelligent collaborative environment for project management (Zhang et al. 2017).

Adequate knowledge and project management in decentralised R&D units also make use of digital simulation. For instance, Block et al. (2018)'s study on cyber physical production systems, shows how this approach to decentralised manufacturing execution allows, through optimization algorithms, to simulate the whole production process. By automatically gathering data on manufacturing models, digital simulation helps R&D processes in planning and intervening in the operation time of a machine, as well as on the assembly line and its logistical process, even without human support. Another significant digital development that supports R&D decentralised personnel's participation to shared projects, despite time and space constraints, is blockchain. As opposed to centralised databases maintained by a single R&D unit, a blockchain involves 'an infrastructure of different parties (nodes), each maintaining an identical copy of a distributed ledger' working through cryptographic, time-stamped data-structuring which offers 'a common and inviolable source of records that can be verified by (permitted) network entities, removing the necessity of having a mutually trusted, centralized intermediary for verification and record-keeping of exchanges' (van der Waal et al. 2020: 719). On the other hand, cloud computing – a model for on-demand and ubiquitous networks access to shared computing

resources, such as servers, applications, and networks – supports R&D decentralised units, efficiently transmitting real time information and scaling up project capabilities (Huang & Hsu 2017). Research also shows that data analytics – the processing, analysis, and transformation of data to detect insights, patterns, and support decision making – accelerates the pace at which innovation can be applied in business and industrial research (Wu et al. 2019). This is particularly true for companies with decentralised R&D units, which greater demand for data analytics across remote teams sustains collaborative relationships, allowing to combine existing insights, linking knowledge and results across domains (Wu et al. 2019).

Therefore, digitalisation is variously and positively associated with technology-enabled decentralisation of R&D organisation. In this context, R&D personnel are facilitated in their communication and collaboration with professionals from other industrial sectors or markets, as digital technologies help knowledge management and production. However, this relation does not necessarily hold true for R&D personnel's career. Lam (2005) describes how the decentralisation of R&D, has also prompted industries to pursue more market-focused R&D strategies, establishing a market relationship between R&D as a supplier, and business divisions as customers based on the commercialisation results, and strict corporate expectations in terms of relevance and accountability (Lam 2005: 245). These reorganisations altered R&D personnel's career structures and work roles, as they are increasingly expected to operate within science and business management, using digital technologies for both purposes. However in this frame, well-defined, stable R&D careers have been substituted by project-to-project, cross-functional, and mixed technical/managerial roles – a change which generated career insecurity among R&D personnel (Lam 2005).

These dimensions are particularly evident in (sociological) labour research. Although there is limited research examining the organisational and behavioural effects arising from the adoption of digital technology by R&D professionals, a few studies show that R&D professionals could be affected in terms of acceptance of standardisation and routinisation processes, and in terms of professional identity (Susskind 2017). Equally, there are views warning about digitalisation in R&D as giving rise to potential tensions 'between the corporate strategic need to make full use of the benefits of the new technologies associated with automation and digitalisation, and the occupational autonomy that R&D staff expect and have traditionally been given within the R&D function' (Li et al. 2019: 552). In their study of digitalisation of R&D processes at Unilever, Li et al. (2019) find that, amongst R&D professionals, there are mixed attitudes towards the adoption of digital technologies; respondents are concerned about losing control on their work content, habits, time and data as generated from new digital approaches.

In labour market research, forecasts indeed suggest a link between digitalisation and the division of labour. One strand points to the deskilling hypothesis originally proposed by Braverman ([1974]1998). This view suggests that the division of labour into routine, standardised tasks, aided by digital technology has deskilled work in most occupations. This view has been often criticised as applicable only to contexts with a high level of routine and automatable tasks (Martinaitis et al. 2020). However, it remains influential, because it presupposes a relatively advanced division of labour into highly differentiated tasks implemented by digitalisation (Frey & Osborne 2017; Acemoglu & Restrepo 2018). However, more nuanced models understand that these shifts tend to substitute workers in some routine tasks, while they complement workers performing more complex abstract tasks, such as problem-solving (Acemoglu & Autor 2011). Other studies advance that digitalisation can even cause 'job destruction' when occupations present highest probabilities of their tasks becoming completely automated, leading to workers' displacement and unemployment (Berger & Frey 2016). Notwithstanding this dire scenario however, since all jobs are bundles of tasks, a certain fraction of a job tasks can be automated, but the job need not be automated as a whole (Brynjolfsson & Mitchell 2017). Therefore, most jobs are unlikely to be sufficiently well defined into automated, routine tasks to be fully substitutable by digital technology, and workers might instead specialise in non-automatable niches within their field (Arnzt et al. 2020). Indeed, overall adjustments within the economy tend to take place within occupations, so that workers can shift to tasks that complement digitalisation, some of which may be newly created tasks (Acemoglu & Restrepo 2018). At the same time, following Schumpeter's highly influential concept of creative destruction, it is not controversial to argue that new jobs are also created through digital developments. Thus, digitalisation has also contributed to the emergence of whole new industries that employ millions of individuals, performing jobs that formerly did not exist (Balsmeier & Woerter 2019). However, the complex relationship between the increase in digitalisation and the decrease in human capacity cautions that changes which lead to job creation, also typically begin with efficiency and productivity gains that tend to save on labour costs (Comyn 2018).

The debate appears more challenging if one considers that digitalisation does not necessarily translate into human labour and skills obsolescence. Indeed, another strand of literature advances the skill-biased technological change hypothesis (Acemoglu 2002). Digital progress results in higher demand for specialised skills; since investment costs are needed to implement digital technologies and make them profitable, the acquisition of specific skills via new hires or further training is often needed to complement available skills (Brynjolfsson et al. 2017). Secondly, the adoption of digital technologies is likely to differently affect workers depending on their abilities. Janssen and Mohrenweiser (2018) for instance show that only those workers who are forced to

switch their occupations experience negative labour market effects, suggesting that those who remain employed learn to handle digitalisation effects on the job, gaining opportunities for switching to higher-paid jobs. Hence, workers' fate in phases of digital turmoil might depend on their ability to learn or upgrade the skills required in their work environment – which is not a given. Overall, these studies suggest that digitalisation is unlikely to fully automate workplaces on a large scale, but rather change the tasks involved in certain occupations. However, if the tasks that complement machines become increasingly demanding, the employment prospects for workers lacking certain skills may deteriorate (Janssen & Mohrenweiser 2018).

A third view, the polarisation hypothesis, sees digital technology as complementary to higher skills (Acemoglu & Autor 2011). Several empirical studies of skills polarisation show that digitalisation is positively associated with employment of high-skilled workers and negatively associated with employment of low-skilled workers (Autor et al. 2003; Bogliacino et al. 2015; Breemersch et al. 2019). These findings are in line with longitudinal reviews of skill polarisation, so for instance there has been an increase in jobs for either low-skilled and high-skilled workers, who more easily can complement machines or replace their skill set, whilst medium-skilled jobs have declined (Goos et al. 2009).

Turning to R&D, the OECD argues that there is a need for professionals who have a 'common set of foundational digital skills coupled with domain-specific specialised skills' (OECD 2020: 8). This is particularly evinced in the relationship between R&D digitalisation and the 'reskilling revolution', projected to bring new opportunities for as many as one billion people globally by 2030 (Ratcheva et al./WEF 2020: 6). This revolution shows the extent to which different skills related to R&D are rewarded. The OECD, in a study of skills needed for the science and technology labour market, assessed 31 countries through the *Programme for Assessment of Adult Competencies* and through the *OECD Index on the Digital Penetration of Industries*. The report shows that as the nature and content of jobs change because of digitalisation, so do the skills required to perform them, which in turn shapes labour supply and demand (Grundke et al./OECD 2018). Echoing these results, Shmatko et al. (2020) show, in a study of two high-tech areas of R&D – robotics and biotechnology – that due to the rapid spread of digitalisation, R&D professionals need to update competencies, as organisations increasingly hire personnel with a combination of hard and soft skills which can be leveraged according to projects. The study suggests that the employment model of R&D professionals is changing into a 'portfolio model' of competencies, facilitating more mobile, cumulative careers replacing the model of a rigid occupation structure.

As evinced in the review so far, employment effects attributed to digital change across skills and occupations seem to be more heterogeneous than generally predicted. Clearly, much is at stake and our current understanding is limited, otherwise there would not be so many diverging viewpoints. This gap calls for extensive research in labour economics, the economics of knowledge and innovation, and for macro and micro studies of digitally-driven changes in business models and the accompanying societal employment effects. Furthermore, empirical insights on specific sectors and national contexts are required to increase understanding of which business models, jobs, tasks or skills will be at risk of being disrupted due to digitalisation. Although the underlying economic mechanisms are well understood, their magnitude on labour substitution effects are still unclear or, worse, unnecessarily polarised. It is a truism that digitalisation is a human-led process, leading to often unexplored ways of use in economic production. However, we should pay more attention to the recursive relationship between digitalisation and the experiences, outcomes, and conditions of work. A profound review of national labour legislations is also pivotal for implementing and rethinking labour law in the digitalisation era. As employment evolves constantly due to digitalisation, there is a corresponding need for labour laws to be subject to regular assessment and reforms, which more adequately capture the changing (but also the disruptive) economic and work patterns that digitalisation brings. Governments and regulators play a major role in encouraging and incentivising digital innovation for the benefit of the society and the economy. Therefore, it is timely to engage in such re-assessment, particularly as digitalisation is an ongoing process that challenges existing regulations, and creates the need for new ones. It is important, in this respect, to where necessary reorganise and update the framework regulating employment relationships, with a view to adapting to a country's current needs and challenges of digitalisation, in turn informing good standards and practices.

3. Labour market trends and new forms of employment in R&D

Research has argued that macro trends of deregulation, flexibility and digitalisation, have spurred also 'alternative work arrangements' and forms of 'non-standard work' diverging from stereotypical stable agreements (Spreitzer et al. 2017). An extensive body of literature has approached these transformations, focusing on how they have materialised into new ways of conducting business through digital technologies and online markets, allowing connections between people and organisations. Studies exploring these changes at firm level have captured the emergence of the 'digital ecosystem', where businesses can exploit digital technologies for the promotion of employee performance and satisfaction, as well as for the optimisation of space

use and employer branding. Kane's (2019) study in collaboration with the MIT Sloan Management Review and Deloitte on how traditional companies can adapt in today's digital world, shows that the most successful transformations entail digitalisation at the employee and leadership levels. This in turn facilitates the company in becoming more agile, risk tolerant, experimental, and collaborative. However, these trends had already been vastly criticised on different grounds, for instance in the extent to which digitally-driven forms of employment hinder organisational collaboration (Pearlson & Saunders 2001) affect knowledge sharing (Sarker et al. 2012) or lead to work intensification and reduction in work satisfaction (Kelliher & Anderson 2010). Furthermore, several studies have shown that precariousness has expanded considerably over the last decade, because of the absence of legal and institutional imbalance in counteracting exploitative economic trends aided by the massive use of digital technologies in industrial and employment activities (Aroles et al. 2019). At the global level, there are in fact new forms of employment that are emerging, transforming work organisation and patterns; but they all involve an extensive use of digitalisation (Fernández-Macías 2018). Scholars agree that, regardless of positive or negative outcomes, digitalisation has unhinged the expectation of work 'performed on a fixed schedule, at the firm's place of business under the firm's control and with mutual expectation of continued employment' (Kalleberg et al. 2000: 257) enhancing flexibility of workers and tasks not physically bound to a particular place or time (Tremblay & Thomsin 2012). According to Eurofound, such new forms of employment are characterised by:

- 'Relationships between employers and employees that are different from the established 1:1 employment relationships;
- Provision of work on a discontinuous/intermittent basis or for very limited periods of time rather than on a continuous or regular basis;
- Networking and cooperation arrangements between the self-employed…going beyond 'standard' relationships along the supply chain, sharing premises or traditional conducting of project work;
- Strong and widespread support of ICT, where this technology changes the nature of work relations or patterns' (Mandl and Biletta/Eurofound 2018: 1).

Generally, these manifestations revolve around pervasive arrangements of platform work, which organises tasks outsourcing to a pool of 'virtual workers', enabling both organisations and individuals to access services or products upon payment, all taking take place outside the boundaries of formal work organisation. Platform workers' profiles vary from skilled professionals to unskilled amateurs. Platforms act as intermediaries, creating the conditions for the transaction to take place, matching client and worker, task and worker, task fulfilment and

submission, as well as assisting with dispute resolutions, payment deposits, and workers' ratings (Valenduc 2019). On the surface, platform work positively favours both sides of the working relationship. From a firm and consumer's perspective, it allows expanded choice, convenience and value, reducing competition-dampening monopolies (Scully-Russ & Torraco 2020). It also provides firms with the resources to perform certain tasks, speeding up hiring processes, increasing workforce flexibility (Kuek et al. 2015). Other observers argue that platform work matches workers with jobs, reducing underemployment, particularly offering income and social mobility opportunities in stagnant economies, whilst mitigating the challenges connected to lack of skilled workers in specific geographical areas (Schmidt 2017). Nonetheless, the pay associated with platform work is generally low and insecure (Valenduc 2019). In addition, the majority of tasks is of repetitive and trivial nature, which might negatively affect workers' upskilling and job satisfaction (Mandl & Curtarelli 2017). Others warn that platform work creates uncertainty, as jobs are broken down into smaller tasks commissioned online, with the greater risk that secure dependent employment could be transformed into more precarious forms of employment (Kittur et al. 2013).

It is unrealistic to distil here an analysis of labour legislation concerning the fuzzy boundaries of platform work, given that each country regulates the employment status of platforms workers according to different legal, national parameters. Existing analyses of specific national legislations, however, suggest that platform workers' status in much of regulatory frameworks worldwide remains unclear. If we consider, for instance, the EU, De Stefano and Aloisi (2018) and PwC Legal (2019) point out that this same category of workers is classified as quasi-subordinate workers in Italy; as zero-hours contract workers in the UK; as intermittent workers in Belgium; as either employees or self-employed in Germany, France, and the Netherlands according to contractual arrangements; and as largely self-employed in Spain. The USA, under the Fair Labor Standards Act (FLSA) debate on whether platform workers should be considered as independent contractors or employees (Malos et al. 2018). East Asian countries, for instance Japan, consider platform workers as freelance contractors (Shibata 2019), and similarly China frames them as self-employed (Zhou 2020). In Russia, discussions of the legal status and rights of individuals performing platform work are still in a grey zone, and proposals are issued to variedly frame them as either self-employed, employees, or dependent contractors (Lyutov 2020). Although I do not suggest that any of these countries might be representative for a fair regulation of platform workers' employment status, yet a core issue in contemporary debates seems to point to whether such individuals should be considered employees or independent contractors (Aloisi, 2015; De Stefano, 2015; Prassl, 2018). In most legislations however, as evinced above, they largely fall into the category of self-employed (widely conceived), so they do not receive

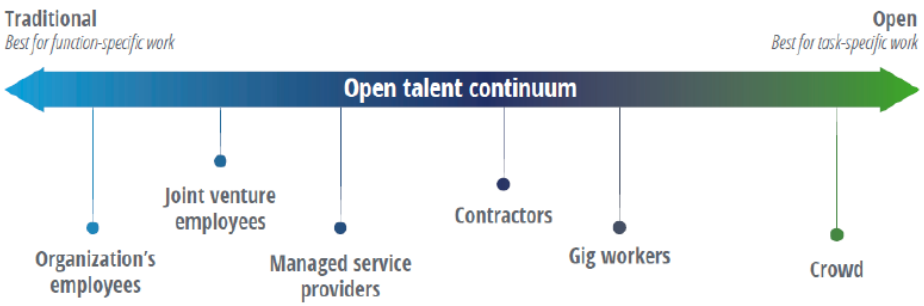
company benefits and social protection, with implications for precariousness (Pulignano 2019). Therefore, there are wide concerns related to platform work as a model of 'digital Taylorism', where companies can access a flexible workforce without management responsibilities, suppressing costs in low-demand periods as a key profitability driver, but where working standards and jobs are fragmented, workers' output is measured, pay is linked to performance, all without the employment safety nets traditionally afforded to workers (Healy et al. 2017).

Nonetheless, a strand of scholarship advances a positive correlation between the digital economy and employment opportunities in R&D. Recently, a report by the World Economic Forum, *Jobs of Tomorrow: Mapping Opportunity in the New Economy*, has raised that the science and technology sector is increasingly shifting from traditional employment arrangements to the digitally-underpinned roles of the future (Ratcheva et al./WEF 2020). Such changing arrangements would promote remote and flexible work options, positively leading to a better utilisation of R&D professionals' creative potential for improved output and individual wellbeing. Nonetheless, studies exploring the emergence of digital work arrangements and platform markets for R&D are close to non-existent. Only a few scholars show that organisations are starting to exploit digital economy opportunities for R&D employment. Aloisi (2016) suggests that organisations increasingly resort to the services of skilled workers to complete multi-hour tasks on professional online marketplaces such as *InnoCentive*, to solve R&D challenges linked to open innovation. Aloisi's analysis of *InnoCentive* for instance shows that this platform connects companies with external R&D brainpower across industries – from engineering to medical sciences. This method is called 'Challenge Driven Innovation', as R&D 'solvers' can select any challenge posted on digital platforms and submit solutions to companies. If the company selects the solution provided, it repays the R&D solver with an award in exchange for the acquisition of intellectual property rights. In this sense, platforms allow business arrangements where the organisation comes into contact with a virtual board of R&D professionals, pulling down labour costs. Accordingly, this business arrangement can be conducted from anywhere, as R&D professionals can bid and work in a global, online labour market. Similarly, Cooke (2020) discusses the case study of Chinese multinational Haier and of its 10 R&D centres. In adopting a platform interface structure, Haier taps into more than 50,000 R&D professionals worldwide, who are not employees registered at the company but rather as 'micro-entrepreneurial independent workers', who share 'risks and profits' with the company (Cook 2020: 242). The study argues that though it remains unclear whether Haier's platform reorganisation of R&D work is successful, this model 'practically brings to an end the corporate career design' of R&D workers, dismantling the bureaucratic and cost structure but also its 'related job security' (ibid.) As in the case of platform work however, this raises serious

questions regarding labour protection, social security, and social arbitrage (Aloisi 2016: 661). In reporting the results of a foresight project over industrial R&D, Ayers et al. (2016) similarly advance the advantages of the 'Hollywood model', or contracting talent, in which R&D professionals 'no longer work for a single firm but rather contract out their services to individual projects and then move on to other projects and companies' (Ayers et al. 2016: 27). The authors identify the model as a paradigm for freelance R&D, arguing that, if significant infrastructure and legal impediments get overcome, both firms and professionals might achieve higher-level knowledge for competitive advantage. Such arrangement would help R&D professionals to bring new ideas and hard skills to firm projects, avoiding the 'internal indoctrination' and the 'just can't be done' syndrome which would often characterise internal personnel and limits innovation capacity (Ayers et al. 2016).

These dimensions are advanced also by a recent report by Deloitte (2019). Drawing upon surveys and interviews with R&D leaders in the science and technology sector, the report argues that, in relation to the R&D workforce, the 'traditional talent management focused on attracting, developing, and retaining needed talent…may have run its course' (2019: 23). Because of the complexity of converging labour market trends, the report recognises that roles, jobs, and talents are evolving together with the organisational structure of R&D work, so that evolving strategic imperatives are shifting the way corporations operate. With the aim to strive for innovation, productivity, and growth, Deloitte's report suggests for organisations to rethink the dimensions of work in the field in a more flexible way, accessing talent on an 'open continuum', that is, an approach where talent is externally hired. In fact, on the demand side, firms have been increasingly aware that hiring independent workers such as freelancers can help them to handle business uncertainties. These needs and changes in demand, have fuelled the emergence of a dynamic model, used also in R&D, dubbed the 'open talent economy': 'a collaborative, transparent, technology-enabled, rapid-cycle way of doing business' (Liakopoulos et al. 2013), which allows companies to be more agile and flexible by searching for 'on-demand skills' along the open talent continuum, mostly through platforms. On the closed end of the continuum, a company uses a full-time internal workforce; moving towards the open end, the company takes on independent workers. As in the image below, it is proposed a positive correlation between 'open employment' which is best for task-specific, platform-mediated work, and flexible work arrangements, suggesting that the barrier of traditional employment will 'need to be overcome' for business innovation (Deloitte 2019: 16).

Figure 1: The open talent continuum.



Source: *The future of work in technology*. Deloitte analysis (2019: 17).

Similarly, the *LifeSciHub Independent Workforce Survey Report 2020*, which explores self-employment in the life sciences R&D in the USA, argues that R&D industries have 'long and heavily relied on non-employees' to deal with the 'permanent unpredictability' of R&D workflows (LifeSciHub 2020: 2). The survey captures both independent, 'talent' consultants and the hiring companies that engage them, assessing from internal perspectives issues related, from one side, to the use of independent workers, corporate procurement and human capital. From the other side, the survey ascertains preferences, motivations, and circumstances of R&D 'talent' work that appeals to independent consultants. From the side of companies, results show that they deem temporary on-boarding of expertise as vital for R&D, and that the vast majority of independent consultants is useful to support projects at specific stages, managing costs uncertainty by 'increasing flexibility without increasing headcount' (LifeSciHub 2020: 12). The least valuable aspects of working with independent consultants are located in maintaining performance and in strategically aligning them with organisational thinking. Instead, independent consultants praised opportunities for work-life balance (48%) and freedom (70%), but only around 30% mentioned remuneration as a positive factor. Respondents identified instead disadvantages in finding work (48%), business administration tasks (46%), managing workflow peaks and troughs (41%). Overall, the survey shows that talent contracting is unbalanced in favour of companies, and that R&D independent workers seem to be affected by precariousness, pay instability, and uncertain legal status. However, it is worth noting that the survey shows no explicit concern about the risks associated with using independent consultants, such as workers' classification issues.

These studies bear the merit of paving the way for a discussion of emerging work arrangements in R&D. Yet, they fail to fully acknowledge the negative trends led by labour market deregulation, flexibility, and rapid digitalisation over R&D personnel's employment stability and conditions. In advancing that businesses should harvest talent through talent and open continuum models, these studies implicitly support and exacerbate a rise in the use of contingent work

arrangements in R&D, turning a blind eye to the precariousness and lack of workers' protection that these employment practices generate.

Conclusion

Extant research shows transformations of R&D employment and working conditions of R&D personnel. Flexible and on-standard work arrangements have proliferated in R&D as a corporate response for responding to demand fluctuations, contributing to innovation, and reducing headcount labour costs (Benassi & Kornelakis 2020). Equally, the volume of new evidence about the impact of digitalisation, presents R&D with significant challenges. These dynamics have to be disentangled if we are to fully grasp the impact of digitalisation as a driver of contingent forms of work in R&D. The suggestion is to input a consideration of employment conditions at the heart of the analysis of the R&D workforce, at a moment when mainstream discourse on digitalisation and R&D is dominated by determinist claims about the transformative capacities of these technologies over R&D work, workers, and processes.

In other words, the issue here is not about identifying which amalgamation of flexible arrangements enhances firms' market competitiveness, but recognising that the combination of deregulation and flexibilisation for corporate value, innovation, and productivity creation is favouring cost-cutting of labour and short-term employment in R&D. The overall tendency of available research fails to address that these developments are symptoms of a more deep-seated change in competition, which is not only serving to undermine job opportunities across industries, but is increasingly jeopardising stable employment and human capital retention. This is increasingly paired with difficulties in managing qualified labour, particularly across practices of international R&D decentralisation, and the increasing use of R&D service companies. In this sense, on the one hand, companies are challenged with managing external relations and more complex projects, by also resorting to external R&D providers, to maintain a competitive outlook. On the other hand, the composite literature analysed in this paper clearly shows that R&D labour is not immune from wider labour market developments, and is at risk of transitioning into what Styhre (2017) dubs 'precarious professional work' – professional expertise extremely subject to market flexibilisation – as historically seated specialized functions and divisions within firms are being locked within highly unstable forms of employment. My argument is nor that R&D professionals are necessarily and voluntarily participating in emerging forms of precarious (or 'flexible', 'autonomous', 'independent' 'leasing') employment, neither that precarious employment is affecting them indiscriminately. Rather, it is that what was once regarded as a safe labour market for R&D personnel, might become increasingly associated with

faltering employment conditions because of galloping labour trends. Although this might be treated as a polemical approach, it is also true that theoretical and empirical studies examined in this paper have demonstrated significant trends of instability that are starting to penetrate R&D work, in all cases accompanied by 'entrepreneurship ideologies, serving to normalize or even romanticize…the volatility of the financialized competitive capitalism and being unable to provide many of the benefits that historically have accrued to professional workers' (Styhre 2017: 10).

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