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LA TRANSFORMATION TECHNOLOGIQUE DES ENTREPRISES S'ACCOMPAGNE-T-ELLE D'UNE PLUS GRANDE MAÎTRISE DU TEMPS DE TRAVAIL PAR LES SALARIÉS ? RÉSULTATS EMPIRIQUES À L'ÉCHELLE DE L'UE À PARTIR D'UN ENSEMBLE DE DONNÉES COMBINÉES

RÉSUMÉ

Dans cet article, nous examinons les liens entre la transformation technologique des entreprises et la maîtrise du temps de travail par les salariés. Nous menons cette analyse à l'échelle de l'UE au niveau méso en combinant les informations provenant de l'Enquête européenne sur les entreprises 2019 (Eurofound) et du module *ad hoc* de l'Enquête sur les forces de travail 2019 (Eurostat). Cet ensemble de données nous permet d'analyser la transformation technologique des entreprises en tant que relation entre trois types d'investissements (dans la R&D, les technologies numériques et la capacité d'apprentissage de l'organisation) qui stimulent les résultats en matière d'innovation. Nous étudions ensuite les conséquences de la transformation technologique sur la diffusion d'aménagements défavorables du temps de travail, en distinguant entre les aménagements orientés par les besoins des individus et par ceux des organisations. Notre modèle prend en compte les effets directs des investissements dans l'adoption et l'utilisation des technologies numériques et dans la capacité d'apprentissage de l'organisation, ainsi que le rôle médiateur des stratégies d'innovation des entreprises. Les résultats indiquent que la *Capacité d'apprentissage de l'organisation* est directement associée à une plus grande flexibilité du temps de travail axée sur les besoins des individus, mais entraîne également une vie privée plus exposée aux imprévus professionnels. L'effet de l'*Adoption et de l'utilisation des technologies numériques* dépend quant à elle principalement de la stratégie d'innovation des entreprises. Ainsi, l'innovation de produits conduit à une plus grande maîtrise du temps de travail par les salariés, tandis que l'innovation marketing a l'effet inverse. Les innovations de procédé et organisationnelles ont des conséquences mitigées : elles protègent les salariés contre une flexibilité du temps de travail qui répond aux besoins des organisations dans les environnements de travail où les contraintes temporelles sont plus fortes.

Mots clefs : transformation technologique, technologies numériques, capacité d'apprentissage de l'organisation, innovations, aménagement du temps de travail, flexibilité du temps de travail.

NB : Ce document fait partie des travaux menés dans le cadre du projet Beyond4.0 (https://beyond4-0.eu/the-project). BEYOND 4.0 répond aux priorités globales du programme de travail H2020 (2018-2020) " L'Europe dans un monde qui change - Des sociétés inclusives, innovantes et réfléchies " et a reçu un financement du programme de recherche et d'innovation Horizon 2020 de l'Union européenne sous la convention de subvention n° 822296.

Does the Technological Transformation of Firms Go Along with More Employee Control over Working Time? Empirical Findings from an EU-wide Combined Dataset

ABSTRACT

We investigate the links between the technological transformation of firms and employee control over working time. We conduct EU-wide analysis at the meso-level by relating information from the 2019 European Company Survey (Eurofound) with the 2019 Labour Force Survey *ad hoc* module (Eurostat). This dataset allows analysing the technological transformation of firms as a relationship between three types of investments (in R&D, digital technologies and learning capacity of the organisation) that spur innovation outputs. We then study the consequences of the technological transformation on the spread of unfavourable working time arrangements, distinguishing between individual and organisation-oriented arrangements. Our model considers the direct effects of investments in digital technologies adoption and use and learning capacity of the organisation and the mediating role of firms' innovation strategies. Results indicate that the *Learning capacity of the organisation* is directly associated with more individual-oriented working time flexibility, but entails higher organisation-oriented working time flexibility. The effect of *Digital technologies adoption and use* depends instead on firms' innovation strategy: product innovation leads to more employee control over working time, while marketing innovation has the opposite outcome. Process and organisational innovations yield mixed consequences buffering employees from organisation-oriented working time flexibility in more time-constrained work environments.

Keywords: Technological transformation, digital technologies, learning capacity of the organisation, innovations, working time arrangements, working time flexibility.

N.B : This paper is part of the work carried out in the Beyond4.0 project (https://beyond4-0.eu/the-project). BEYOND 4.0 responds to the overall priorities of the H2020 (2018-2020) work program "Europe in a Changing World - Inclusive, Innovative and Thoughtful Societies" and has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement no. 822296.

INTRODUCTION

Over the last 25 years, the dimension of quality of working time in job quality indicators has been improving in European countries, denoting a convergence towards a common standard, largely supported by the European directives on working time incorporated by national legislation (Green et al., 2013; Leschke and Watt, 2014). It is worth noting the 2002 European Directive on information, consultation and representation rights, which may also have helped to strengthen mechanisms for collective expression in the workplace (Burdín and Pérotin, 2019). On a macroscopic level, average working hours have declined, with a corresponding decrease in weekend and night-time shift work. Simultaneously, there has been a discernible increase in working hour flexibility (Messenger, 2018). This global inclination, originating in the 1990s and 2000s, gained traction as a strategy to ameliorate the employment repercussions of major economic downturns, such as the great recession or the Covid crisis (Boulin and Cette, 2013; McPhail et al., 2024). Traditional manifestations of flexible working time encompass atypical hours, shift work and part-time arrangements, while manifestations that are more contemporary include flexible schedules, on-call work, extended availability, teleworking and mobile working.

However, the significance of working time flexibility transcends cyclical utilization and quantitative adaptability. It constitutes a pivotal element in organisational policies, contributing substantially to the efficacy of the production process. In fact, the organisation of working time is closely linked to opening hours and capacity utilisation (Fernández-Macías et al., 2009), and individual-oriented working time flexibility can make a positive contribution to worker commitment and productivity (Bloom et al., 2015; Beckmann et al., 2017). Time management is also an essential dimension of the quality of life of workers, as it determines their ability to fulfil social roles other than their professional one, with a potential impact on collective well-being. Indeed, working time flexibility is likely to undermine work-life balance when employers do not grant enough working time autonomy to their employees while having high organisation-oriented working time requirements such as changing working time schedule on short notice to accommodate production needs (Wöhrmann et al., 2020; Backhaus, 2022). Thus, there are likely to be significant trade-offs between employer-friendly and employee-friendly flexibility, with large economic and social costs at stake (Kossek and Thompson, 2016; Mas and Pallais, 2020).

The current technological transformation of firms is likely to influence these trade-offs in many ways. The literature focuses mainly on the direct impact of digital technologies through teleworking, mobile working, platform working or algorithmic management. In this paper, we adopt a neo-Schumpeterian perspective on the technological transformation, viewing it not simply as the introduction of digital technologies into the production process, but as a relationship between complementary tangible and

intangible investments and innovations. Indeed, by changing the relationship to time and space, digital technologies create diverse organisational opportunities for both employers and employees. By investing in digital technologies, but also in R&D and in the learning capacity of the organisation, firms encourage creativity and innovation in their workforces, thereby completing their transformation process. The resulting innovation strategy of the organisation may in turn influence the space and working time constraints imposed on employees.

If the socio-demographic and institutional determinants of working time arrangements have been thoroughly investigated (Berg et al., 2004; Magda and Lipowska, 2022), the empirical evidence relating the technological transformation with employee control over working time is scarce. This is also because good quality data allowing for empirical investigation usually do not cover both dimensions. Our main contribution is to bring together and analyse the best and most recent EU-wide data sources on these two topics.

We construct a combined dataset that integrates the 2019 European Company Survey (ECS, Eurofound), used to describe the firms' technological transformation, with the 2019 Labour Force Survey (LFS, Eurostat) *ad hoc* module on "work organisation and working time arrangements". Data integration occurs at the meso level of a key cell, which is a size-class in a sector in a country.

On these data, we apply the theoretical framework developed by Greenan and Napolitano (2023) and provide the latest empirical evidence about the technological transformation of firms. We then investigate how this transformation goes along with individual-oriented or organisation-oriented working time flexibility.

1. CONCEPTUAL FRAMEWORK

The empirical literature analysing socio-economic outcomes of the technological transformation from survey data often lacks a detailed organisational context description. If recent studies of employee control on working time systematically outline the potential impact of technological advances like smartphones, tablets and other connected devices, only a few include direct measures of their use at the workplace. For instance, Paek (2023) relates time varying occupational level measures of computer use with an individual-level measure of employee control on time schedule from the American Current Population and Time Use Surveys. The assumption of this study is that firms transform when they adopt and use a new technology in their production process. However, the economics of innovation describes the technological transformation process as more complex, especially in the digital age. Adopting an emerging technology creates a favourable condition, but firms must also use it creatively to depart from usual business practice and innovate.

We thus adopt a richer conceptual framework where the technological transformation is a relationship, embedded in the production process, between inputs in which firms invest to increase their stock of productive knowledge and innovation outputs. This approach generally considers investments in R&D (Crépon et al., 1998). However, Information and Communication Technologies (ICTs) and their digital advances have also been included in this relationship in a number of studies (Polder et al., 2010, Venturini, 2015; Bartelsman et al., 2017; Mohnen et al., 2019; Nicoletti et al,. 2020). This is because the four properties of general-purpose technologies make them a potential engine of growth (Bresnahan and Trajtenberg, 1995). They affect all economic sectors, improve over time, have diverse possible applications and generate complementary innovations.

We augment this approach in a neo-Schumpeterian perspective by looking for a third element that is missing in our current understanding of the technological transformation in the digital age. Following Bodrožić and Adler (2018) and Franco and Landini (2022), we argue that the more advanced innovation strategies involve revising the organisational paradigm to better align with new opportunities opened by the technological revolution.

We thus include an additional argument in the relationship, the investments into the learning capacity of the organisation. It captures the ability to adapt and compete at low cost through the adoption of management tools and organisational practices concerned with the improvement of individual and organisational learning (Greenan and Lorenz, 2010; Greenan and Napolitano, 2023). We aim to provide some new evidence about the relation between technology adoption, investment into human and organisational capital and innovativeness, assuming that the learning capacity of the organisation is a key innovation driver and that its combination with digital technologies is likely to generate synergetic effects (Corrado and Hulten, 2010).

On the output side, we consider four types of innovation. We use the traditional distinction between product and process innovations, considered in Schumpeterian approaches as technological innovations, and address marketing and organisational innovations, which are forms of non-technological innovation more often encountered in the service sector (OECD/Eurostat, 2005).

Our model of the technological transformation of firms allows considering various innovation strategies involving digital technologies among other inputs, expecting different socio-economic outcomes. Notably, we hypothesise that investing in the learning capacity of the organisation is likely to enhance innovativeness by fostering innovative work behaviour among employees (Greenan and Napolitano, 2021) while enabling a high road dynamic of improved socioeconomic outcomes (Osterman, 2018; Bailey, 2022). It overlaps with Karasek's (2004) concept of conducive economy: a production process emphasising skill development at the individual and collective levels

promotes both the quality of life at work and the quality of work by generating value that contributes to the human development of workers and consumers.

The socio-economic outcome we study in relation with the technological transformation is the employee control over working time. It relates to the social role of workers once their working day has ended. We explore whether the technological transformation has a potential to facilitate the maintenance of the workers' social bonds through the reduction of unfavourable working time arrangements. Following Wöhrmann et al. (2020), we focus on working time flexibility distinguishing between individual-oriented and organisational-oriented flexibility. Unfavourable arrangements encompass low individual-oriented flexibility and high organisational-oriented flexibility.

Our conceptual model of the technological transformation of firms allows evaluating the existence of a direct relationship between innovation inputs (digital technologies and the learning capacity of the organisation) and employee control over working time and assessing the mediating role of the different innovation strategies of firms.

2. METHODS

2.1. A EU-wide combined dataset

Our analysis builds on the construction of a dataset combining employer and employee level EU-wide surveys. It allows exploring the relations between company level decisions and characteristics of the economy, at a meso level (Greenan et al., 2022). We gather the most recent available data to cover enterprises with more than 10 employees and their employees.

At the employer level, the 2019 ECS includes questions formulated about 2018 on engagement in R&D and investments for digital tools, with a distinction between e-commerce, e-business software, data analytics and robots. It also covers a large array of work organisation aspects in 2018 - including the cognitive dimension of work, training opportunities, autonomy, motivation, teamwork, social support and direct participation - and provides data on four different types of innovation. The 2019 ECS is thus a source of data that allows describing the technological transformation as we conceptualise it (Greenan and Napolitano, 2023). We use it to approach R&D engagement, to construct a synthetic indicator of *Digital technology adoption and use*, to build a composite indicator of the *Learning capacity of the organisation* and to measure innovation outputs.

At the employee level, the 2019 LFS *ad hoc* module on "work organisation and working time arrangements" provides indicators of working time flexibility.

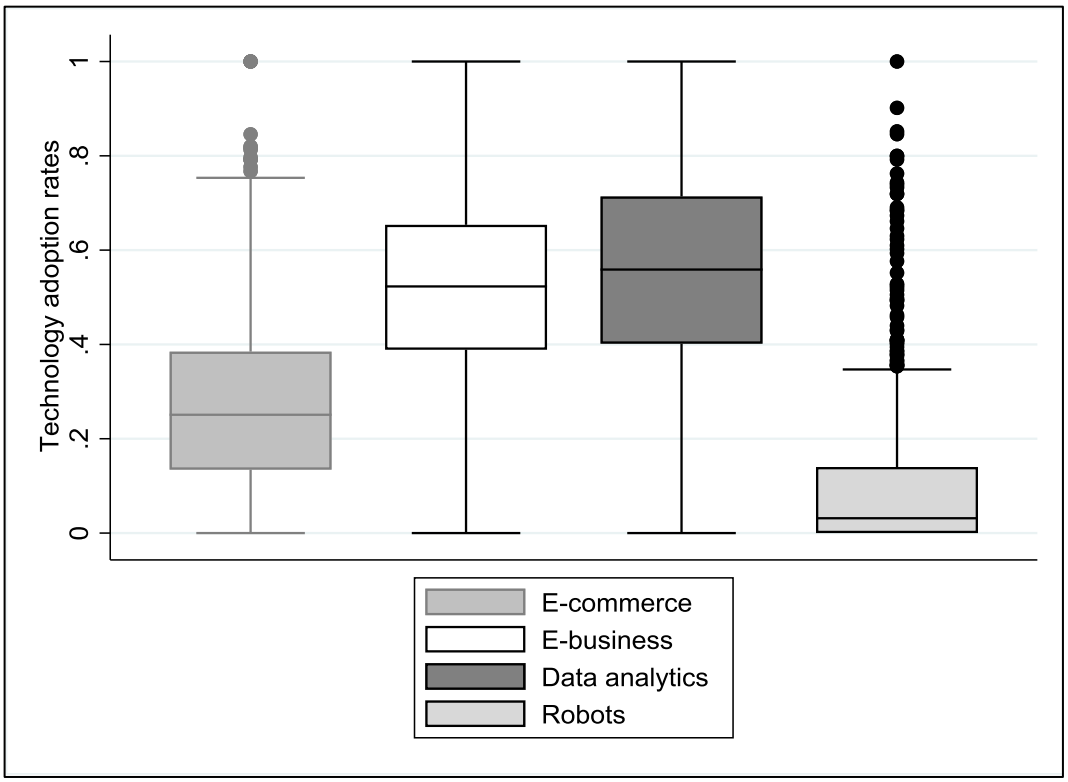
In order to combine the two data sources, we aggregate data and link them through a common cell, which identifies sectors within countries by size-class. The final dataset covers 28 countries (the 27 EU Member States plus UK), 15 sectors (sectors B to N, plus R and S of the NACE Rev. 2 at 1-digit level classification), 2 size-classes (10-50 and more than 50 employees). We have 666 cells in total. Some cells are missing because when aggregating, we dropped cells with less than three observations to comply with anonymization criteria, and because some sectors or size-classes are not covered by all countries.

2.2. Key measures to describe the technological transformation

The 2019 ECS provides direct measures of firms' adoption and use of technologies, including the latest ones. We use this information to construct a synthetic indicator of *Digital technology adoption and use* that has four sub-dimensions: e-commerce, e-business software, data analytics and robots. We weight each technology in the synthetic indicator by the inverse of its European diffusion rate, obtaining higher weights for emerging technologies and lower weights for more widespread ones. The final indicator equals the normalised sum of the weighted rates of technology diffusion at the sector-size-country level. It varies from 0 (basic technologies adoption and use) to 1 (advanced technologies adoption and use). Table A1 in appendix reports the survey questions that we used to construct the synthetic indicator. Figure 1 shows large inequalities in diffusion of different technologies across sectors, size-classes and countries. The variability is mainly explained by the fact that larger enterprises are more technologically advanced. Northern European countries have the highest levels of technologies adoption and use, while central-eastern Europe appears to have the lowest technology diffusion rates, for all types of technologies.

The 2019 ECS also provides measures of organisational practices. We use this information to construct a composite indicator of the *Learning capacity of the organisation*. We refer to the notion of "learning organisation" defined as an entity able to adapt and compete at low cost through learning. A learning organisation fosters individual worker learning through cognitive tasks, encouraging autonomy and offering training opportunities. Further, thanks to its organised setting, knowledge is shared and distributed among members, an innovative culture is promoted and the trade-offs between the competing objectives of exploration and exploitation are solved through a dynamic process of strategy renewal (Greenan and Lorenz, 2010; Lorenz, 2015; Greenan and Napolitano, 2021).

Figure 1: *Digital technology adoption and use* rates in establishments across the EU



Source: Beyond 4.0 integrated database ECS-LFS 2019
Coverage: EU27 plus UK, enterprises with more than 10 employees in NACE Rev. 2 1-digit sectors B to N plus R and S

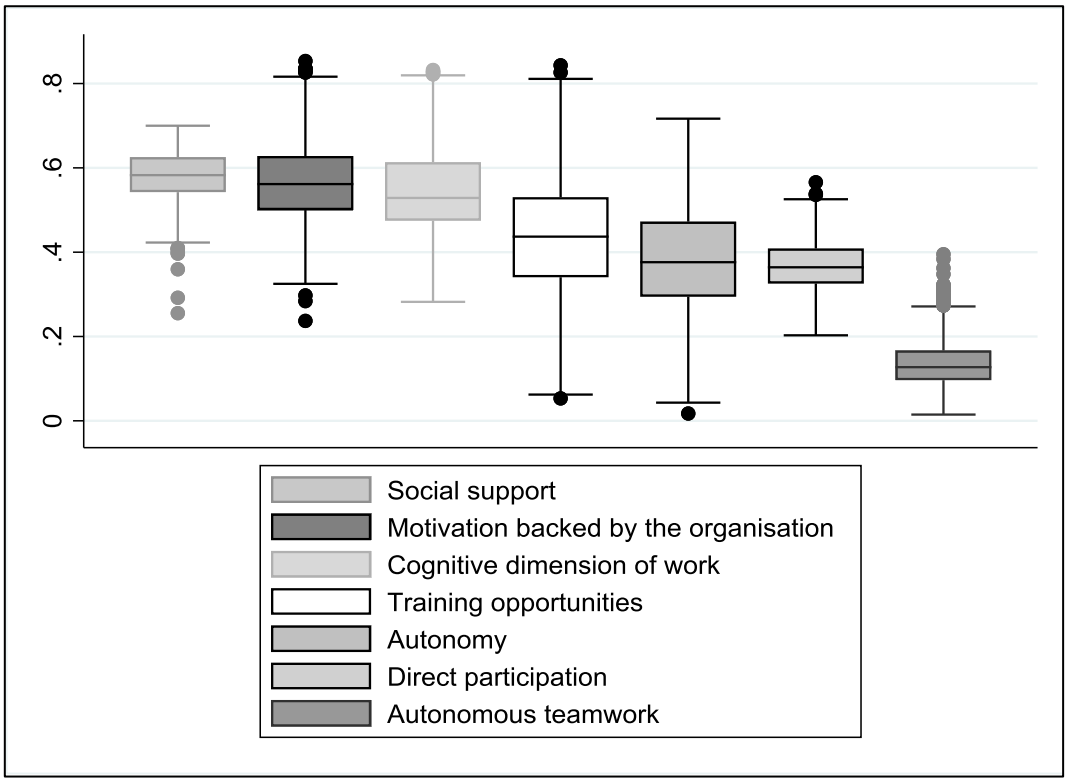
We identify seven sub-dimensions of the *Learning capacity of an organisation*: 1) the cognitive dimension of work: the average of two variables, namely the percentage of employees who are required to solve unforeseen problems and learn new things; 2) Training opportunities: the average of three variables, the percentage of employees who are in jobs that require continuous training, who participate in training sessions during paid working time and who receive on-the-job training; 3) Autonomy of workers: the average of two variables, namely the creation of an environment in which employees can autonomously carry out their tasks and independently organise their own time and schedule their own tasks; 4) Motivation backed by the organisation: the average of three variables, namely the provision to employees of opportunities for training and development, the communication of a strong vision and mission providing meaning to work and the provision of an interesting and stimulating work; 5) Autonomous teamwork: the average of two variables, namely use of teams in which members decide among themselves on how tasks are distributed; 6) Social support: calculated from one variable measuring whether helping colleagues without being asked is considered important; 7) Direct participation: the average of four variables about the importance in individual evaluation of making suggestions for improving the way things are done, the use of suggestion schemes, meetings open to all employees or between employees and their immediate manager to involve employees in how work is organised. Table A1 in

appendix reports the survey questions that we used to approach the seven sub-dimensions.

The final indicator for the *Learning capacity of the organisation* at the individual level is the average of the seven sub-dimensions. The composite indicator on aggregated data equals the average *Learning capacity* in a specific sector-size-country level cell. Values vary from 0 (no *Learning capacity*) to 1 (maximum *Learning capacity*). The Cronbach's alpha coefficient among sub-dimensions equals 0.83, suggesting that the items have relatively high internal consistency.

Figure 2 shows significant variation between different sector-size-country observations, particularly in training opportunities and workers' autonomy. The variability is mainly explained by differences between northern and western European countries that have slightly higher average levels of *Learning capacity* than central-eastern and southern countries, while on average it does not depend on the enterprise size.

Figure 2: Dimensions of the Learning capacity of the organisation in establishments across the EU



Source: Beyond 4.0 integrated database ECS-LFS 2019
Coverage: EU27 plus UK, enterprises with more than 10 employees in NACE Rev. 2 1-digit sectors B to N plus R and S

The 2019 ECS provides information on innovations introduced by the firm since 2016 (table A1 in appendix). The questions on product, process and marketing innovations

are in line with the definitions provided by the Oslo Manual (OECD/Eurostat, 2005) and usually applied in the Community Innovation Survey (CIS). This is not the case however for organisational innovation. According to the Oslo Manual, an organisational innovation refers to "the implementation of new organisational methods in the firms' business practices, workplace organisation or external relations". In the ECS, establishments are asked about how employees have directly influenced management decisions implemented in the area of organisation and efficiency of the work process. The response item includes an option to indicate that there has been no decision made in this area. We quote as an organisational innovation a situation where some decisions have been made in this area that have been influenced to a great extent by employees. The underlying concept of organisational innovation is thus more specific than the CIS one, and close to the concept of employee-driven organisational innovation or workplace innovation (Oeij et al., 2015). The variables of innovation we use equals the sector level share of enterprises in a given country and of a specific size-class that introduced an innovation of a given type.

2.3. Employee control over working time as an outcome

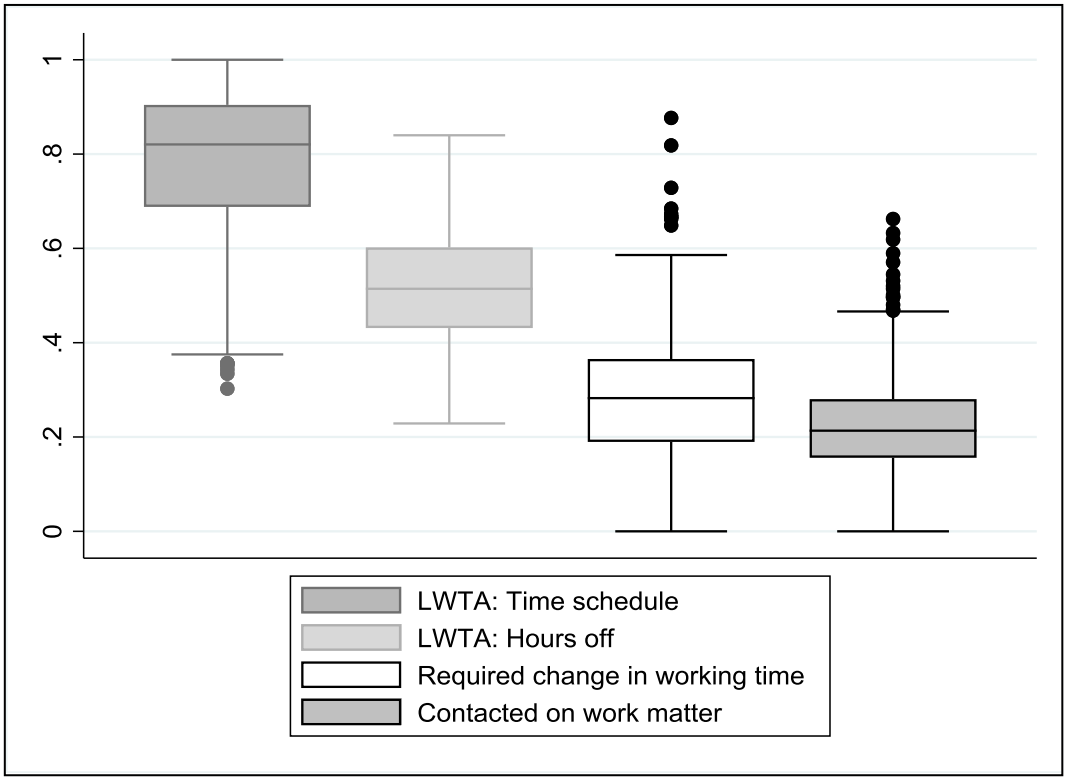
The 2019 LFS *ad hoc* module on "work organisation and working time arrangements" allows us approaching employee control over working time through different indicators. Greater control over working time facilitates more harmonious organisation of different social times, which probably contributes to a feeling of better work-life balance (Wörhman et al., 2020) and better health outcomes (Shifrin and Michel, 2022).

This approach considers that employed workers have additional social roles to fulfil beyond their professional activity. In the following, we identify unfavourable working time arrangements for employees denoting a lack of employee control over working time. Table A2 in appendix presents the list of indicators that we have constructed and the corresponding survey questions.

First, we consider two indicators of individual-oriented working time flexibility, which reflect the level of autonomy in setting working time. The first indicates whether employees can decide themselves on the start and end time of the working day and the second whether they can easily take one or two hours off within a working day for family or personal matters. These indicators identify situations of Low Working Time Autonomy (LWTA) in deciding on time schedule or on taking hours off. We then address working situations where employees' personal life is exposed to professional contingencies through organisation-oriented working time flexibility. We consider another pair of indicators indicating whether employees have to make frequent changes to their working time and whether they are frequently contacted on work matters during their leisure time.

Figure 3 shows the variation of the selected outcome indicators between different sector-size-country observations. LWTA is the most widespread situation followed by exposures of personal life to professional life.

Figure 3: Unfavourable working time arrangements across the EU



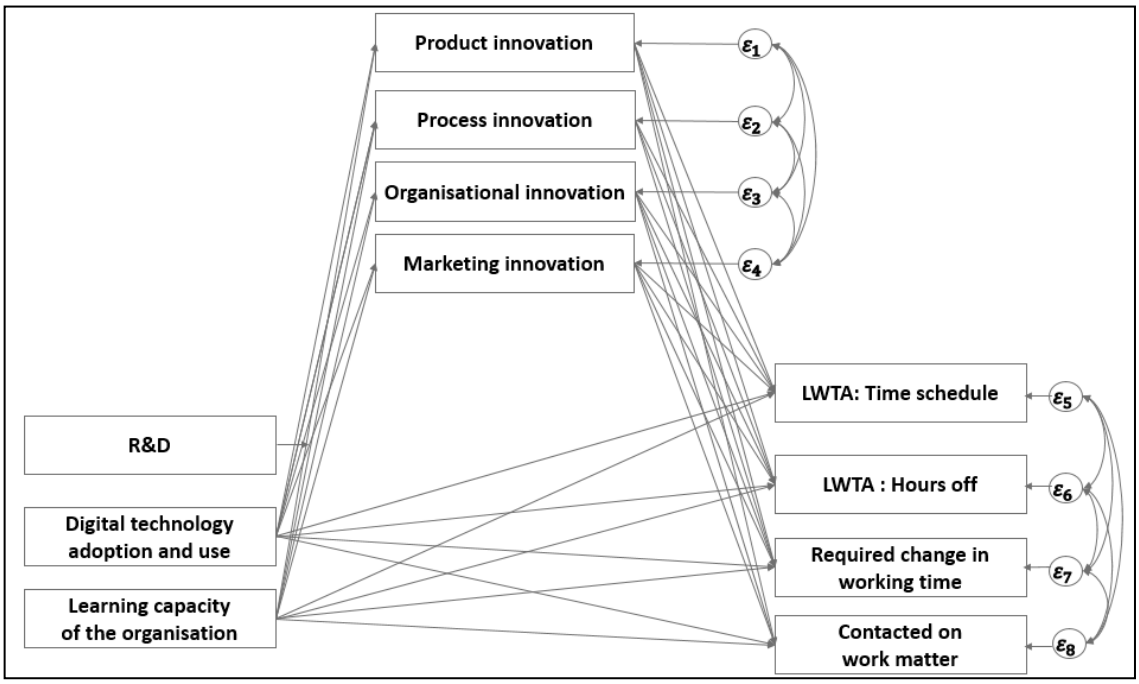
Source: Beyond 4.0 integrated database ECS-LFS 2019
Coverage: EU27 plus UK, enterprises with more than 10 employees in NACE Rev. 2 1-digit sectors B to N plus R and S

2.4. Econometric model

We analyse econometrically the relationship between the technological transformation of firms and employee control over working time at the sector-size-country level by implementing a Structural Equation Model (SEM), represented in Figure 4. It allows estimating simultaneously the multiple relations between investments and innovation outputs and between this transformative relationship and employee control over working time. It also allows assessing whether the relationship between the selected inputs of the technological transformation and employee control over working time is mediated by the innovation strategies of firms. The approach developed by Baron and Kenny (1986) and adjusted by Iacobucci et al. (2007) suggests that complete mediation occurs when the size of the effect of an independent variable (e.g. *Learning capacity of the organisation*) on the dependent variable (e.g. LWTA) is no longer significant once the effect of the mediator (e.g. product innovation) is considered. Partial mediation occurs instead when the size of the effect is reduced but not nullified. In this case, the Ratio of the Indirect effect to the Total effect (RIT) provides the effect size, interpretable as the

percentage of the effect of an independent variable on the dependent variable mediated by the innovation output variable (MacKinnon et al., 2007).

Figure 4: SEM diagram



Our system includes the following equations:

$$\begin{cases} Product\_Inno_{ijs} = \beta_{01} + \beta_{11}R\&D_{ijs} + \beta_{21}Tech_{ijs} + \beta_{31}Learn_{ijs} + Y_{1ijs} + \varepsilon_{1ijs} \\ Process\_Inno_{ijs} = \beta_{02} + \beta_{12}R\&D_{ijs} + \beta_{22}Tech_{ijs} + \beta_{32}Learn_{ijs} + Y_{2ijs} + \varepsilon_{2ijs} \\ Organisation\_Inno_{ijs} = \beta_{03} + \beta_{13}R\&D_{ijs} + \beta_{23}Tech_{ijs} + \beta_{33}Learn_{ijs} + Y_{3ijs} + \varepsilon_{3ijs} \\ Marketing\_Inno_{ijs} = \beta_{04} + \beta_{14}R\&D_{ijs} + \beta_{24}Tech_{ijs} + \beta_{34}Learn_{ijs} + Y_{4ijs} + \varepsilon_{4ijs} \\ \\ LWTA: time\_schedule_{ijs} = \beta_{05} + \beta_{15}Tech_{ijs} + \beta_{25}Learn_{ijs} + X_5(Inno-type)_{ijs} + Y_{5ijs} + \varepsilon_{5ijs} \\ LWTA: hours\_off_{ijs} = \beta_{06} + \beta_{16}Tech_{ijs} + \beta_{26}Learn_{ijs} + X_6(Inno-type)_{ijs} + Y_{6ijs} + \varepsilon_{6ijs} \\ Required\_change\_WT_{ijs} = \beta_{07} + \beta_{17}Tech_{ijs} + \beta_{27}Learn_{ijs} + X_7(Inno-type)_{ijs} + Y_{7ijs} + \varepsilon_{7ijs} \\ Contacted\_work\_matter_{ijs} = \beta_{08} + \beta_{18}Tech_{ijs} + \beta_{28}Learn_{ijs} + X_8(Inno-type)_{ijs} + Y_{8ijs} + \varepsilon_{8ijs} \end{cases}$$

Where *i* are sectors according to the NACE Rev. 2 classification at 1-digit level, *j* are countries and *s* are the size-classes.

The first set of four regressions describes the technological transformation of firms. We include R&D engagement measured by the share of establishments that engage in the design of new products or services, the *Digital technology adoption and use* indicator $Tech_{ijs}$ and the *Learning capacity of the organisation* indicator $Learn_{ijs}$ as firms' investments. The variables $Inno_{ijs}$ represent the sector level share of firms in a given size-class and country that introduced new or significantly improved products or

services, production processes, organisational methods influenced by employees, marketing concepts or strategies.

The second set of four regressions analyse the relationship between the technological transformation and our four indicators of lack of employee control over working time. In these regressions, we include the *Digital technology adoption and use* and the *Learning capacity of the organisation* indicators, which we expect to interact directly with working time outcomes, as well as the four innovation types that are the dependent variables in the first set of regressions $X(Inno\text{-}type)_{ijs}$.

All specifications include a set of organisational, socio-demographic and geographical controls (Y_{ijs}). Organisational controls are small firms (10 to 50 employees) and tertiary sectors (G to N plus R and S) dummies characterising the sector-size-country cell. Socio-demographic controls are the share of females and the share of employees with tertiary education within each cell, computed from the LFS. Geographical controls indicate whether the cell belongs to the northern, western or central-eastern geographical areas[1].

Table 1 provides the summary statistics for inputs, outputs, working time outcomes and socio-demographic controls on the overall country-sector-size cells.

Table 1: Summary statistics of selected variables

Variable	Obs	Mean	Std. Dev.	Min	Max
R&D engagement	666	0.41	0.26	0.00	1.00
Digital technology adoption and use	666	0.45	0.16	0.00	1.00
Learning capacity of the organisation	666	0.54	0.09	0.26	0.78
Share of product innovative enterprises	666	0.31	0.20	0.00	1.00
Share of process innovative enterprises	666	0.32	0.20	0.00	1.00
Share of marketing innovative enterprises	666	0.28	0.19	0.00	1.00
Share of organisation innovative enterprises	666	0.20	0.15	0.00	1.00
LWTA: Time schedule	662	0.78	0.15	0.30	1.00
LWTA: Hours off	662	0.51	0.12	0.23	0.84
Required change in working time	662	0.29	0.13	0.00	0.88
Contacted on work matter	662	0.23	0.10	0.00	0.66
Share of female employees	662	0.40	0.18	0.00	1.00
Share of employees with tertiary education	662	0.38	0.22	0.00	1.00

Source: Beyond 4.0 integrated database ECS-LFS 2019

Coverage: EU27 plus UK, enterprises with more than 10 employees in NACE Rev. 2 1-digit sectors B to N plus R and S

[1] Northern countries are Denmark, Estonia, Finland, Lithuania, Latvia and Sweden.
Western countries are Austria, Belgium, Germany, France, Ireland, Luxembourg, Netherlands and the UK.
Central-Eastern countries are Bulgaria, Czech Republic, Hungary, Poland, Romania, Serbia and Slovakia.
Southern Countries are Cyprus, Greece, Spain, Italy, Malta and Portugal.

3. RESULTS

The results of the SEM model are presented in table 2. The Chi-squared test indicates a p-value higher than 10% (it equals 0.40), indicating a good model fit. As our approach targets the role of organisational factors, we do not discuss the influence of sociodemographic and geographical controls. They are however in line with the results of Magda and Katarzyna (2022) based on the same LFS *ad hoc* module[2].

The first set of regressions that describe the technological transformation shows that the three knowledge inputs that we consider are significantly associated with the technological and non-technological innovation outputs, with two expected exceptions. In particular, in line with the literature in economics of innovation, the share of firms engaged in R&D activities is positively and significantly correlated with the share of innovative enterprises, of all types except for organisation innovative enterprises. This is probably because it is an employee-driven concept that underpins our measure. A 1 percentage point (pp) rise in the share of enterprises engaged in R&D increases by around 0.3 pp the share of product and process innovative enterprises and of 0.1 pp the share of marketing innovative enterprises.

Digital technologies strongly drive innovation. A 1 pp rise in the *Digital technologies adoption and use* synthetic indicator is associated to higher shares of product and process innovative enterprises (0.3 pp), marketing innovative enterprises (0.4 pp) and organisation innovative enterprises (0.1 pp).

The *Learning capacity of the organisation* captures a strong driving factor of innovation that is missing in usual models. It proves central in the technological transformation, showing that innovation also depends on having forms of work organisation favouring innovative work behaviour and creativity throughout the whole workforce. The *Learning capacity of the organisation* is highly significant for all types of innovative enterprises except for process, but it is especially relevant for the share of organisation innovative enterprises. A 1 pp rise in the *Learning capacity of the organisation* composite indicator is associated with higher shares of product innovative enterprises (0.3 pp), marketing innovative enterprises (0.3 pp) and, in particular, organisation innovative enterprises (0.4 pp).

The results concerning R&D, *Digital technology adoption and use* and the *Learning capacity of the organisation* are consistent with what Greenan and Napolitano (2023) found on a different dataset, the Beyond 4.0 integrated CIS-CICT-ECWS database (2010, 2012 and 2014), confirming the robustness of our model of the technological transformation of firms.

[2] The authors can make the extensive results available upon request.

The second set of regressions analyse the relationship between the technological transformation of firms and indicators of employee control over working time.

A first outstanding result is that there are no direct relationships between *Digital technology adoption and use* and the selected outcomes. This is clear evidence that there is no deterministic relationship between the use of digital technologies and working time flexibility arrangements.

By contrast, the *Learning capacity of the organisation* shows direct effects on our four working time outcomes. It is associated with a lower incidence of low working time autonomy and with more exposure of personal life to professional life. The result in terms of the organisation of working time is therefore more ambiguous than expected. While employees benefit from greater working time autonomy, this comes at the price of more organisation-oriented working time flexibility. The right balance has to be found at the organisational level, but we can assume that employees in firms with a greater learning capacity have greater bargaining power when it comes to crafting "flexibility I-deals" (Kossek and Kelliher, 2023).

Coefficients associated with the shares of the different innovation types in table 2 give a first idea of how innovation outputs influence the working time outcomes. Product innovations positively affects employee control over working time. A 1 pp rise in the share of product innovative enterprises is associated with lower risks of low working time autonomy (-0.07 pp for time schedule and -0.09 pp for hours off). Results for process and employee-driven organisational innovation are mixed, indicating lower working time autonomy (+0.05 for both indicators for process innovation, and +0.7 and +0.08 for organisational innovation) and lower interferences between professional and personal life (for process innovation, -0.07 for required changes in working time and -0.06 for contacted on work matters; for organisational innovation, -0.09 for the first indicator). These types of innovations seem to buffer employees for the work overflow into personal life in more time-constrained work environments. Finally, marketing innovations clearly have a negative impact on employee control over working time. Time scheduling appears unaffected in its individual and organisation-oriented dimensions but employees have less leeway to have additional flexibility to reconcile work and family life (+0.05 for hours off) and they are more exposed to concrete requests from their employers or clients during their free time (+0.06 for contacted on work matter).

Table 2: Structural Equation Model on total population

	Share of product innovative enterprises	Share of process innovative enterprises	Share of marketing innovative enterprises	Share of organisation innovative enterprises	LWTA: Time Schedule	LWTA: Hours off	Required change in working time	Contacted on work matter
R&D engagement	0.363***	0.275***	0.118***	-0.008				
	(11.91)	(9.11)	(3.75)	(-0.24)				
Digital technology adoption and use	0.323***	0.354***	0.437***	0.094**	-0.013	-0.016	-0.035	-0.031
	(6.37)	(6.73)	(7.69)	(2.04)	(-0.39)	(-0.56)	(-1.01)	(-1.01)
Learning capacity of the organisation	0.271***	0.107	0.296***	0.378***	-0.779***	-0.691***	0.440***	0.505***
	(2.97)	(1.21)	(3.07)	(4.32)	(-14.50)	(-14.62)	(6.96)	(9.53)
Share of Product Innovative enterprises					-0.068***	-0.086***	0.047	-0.020
					(-2.58)	(-3.78)	(1.57)	(-0.85)
Share of Process Innovative enterprises					0.053**	0.051**	-0.072**	-0.055**
					(2.08)	(2.20)	(-2.32)	(-2.17)
Share of Marketing Innovative enterprises					0.036	0.052**	0.008	0.059***
					(1.45)	(2.56)	(0.31)	(2.65)
Share of Organisation Innovative enterprises					0.067**	0.079***	-0.087***	-0.031
					(2.46)	(3.32)	(-3.03)	(-1.21)
Small enterprises	0.012	-0.015	0.006	0.037***	0.002	0.007	-0.008	-0.007
	(0.92)	(-1.18)	(0.40)	(2.99)	(0.22)	(1.00)	(-0.82)	(-1.05)
Tertiary sector	0.012	0.004	0.057***	0.018	-0.017*	0.020**	0.057***	0.024***
	(0.74)	(0.24)	(3.43)	(1.24)	(-1.75)	(2.07)	(4.87)	(2.60)
Socio-demographic and geographical controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-0.105**	0.033	-0.164***	-0.083*	1.303***	0.893***	0.053*	-0.026
	(-2.18)	(0.69)	(-3.43)	(-1.91)	(49.81)	(40.86)	(1.84)	(-1.02)

*t statistics in parentheses; * p < 0.10. ** p < 0.05. *** p < 0.01. Number of observations: 662; Overall R2=0.89. Additional controls include shares of females and employees with tertiary education, groups of countries.*

Source: Beyond 4.0 integrated database ECS-LFS 2019.

Coverage: EU27 plus UK, enterprises with more than 10 employees in NACE Rev. 2 1-digit sectors B to N plus R and S.

The mediation analysis tests the indirect influences of *Digital technologies adoption and use* and of the *Learning capacity of the organisation* on employee control over working time, i.e. via firms' innovation strategies. Results from the RIT test presented in table 3 indicate that the *Digital technology adoption and use* indicator is almost completely mediated by innovation outputs in its relationship with working time outcomes. The only exception involves organisational innovation and required change in working time where mediation is clearly partial (19%).

The *Learning capacity of the organisation* is either not mediated by innovation outputs or it is partially mediated at a very low level, between 2% and 8% according to the considered relationship. Hence, unlike for *Digital technologies adoption and use*, the innovation strategy of firms has a marginal impact on the relationship between the *Learning capacity of the organisation* and employee control over working time. We note however, that employee-driven organisational innovation is likely to curb the positive influence of the *Learning capacity of the organisation* on required change in working time. First, the partial mediation is highest on this relationship (8%). Second, it is on the share of employee-driven organisational innovation that the *Learning capacity of the organisation* has the strongest impact (0.4 pp). Third, when the direct effect of the *Learning capacity of the organisation* on required change in working time is positive (+0.4), that of employee-driven organisational innovation is negative (-0.09).

Table 3. RIT test from SEM model at t+3

	Share of product innovative enterprises	**Share of process innovative enterprises**	**Share of marketing innovative enterprises**	**Share of organisation innovative enterprises**
LWTA: time schedule				
Digital technology adoption and use	Complete mediation	Complete mediation	-	99%
Learning capacity of the organisation	2%	-	-	3%
LWTA: hours off				
Digital technology adoption and use	Complete mediation	Complete mediation	Complete mediation	91%
Learning capacity of the organisation	3%	-	2%	5%
Required change in working time				
Digital technology adoption and use	-	Complete mediation	-	19%
Learning capacity of the organisation	-	-	-	8%
Contacted on work matter				
Digital technology adoption and use	-	Complete mediation	Complete mediation	-
Learning capacity of the organisation	-	-	3%	-

4. DISCUSSION AND CONCLUSIONS

This paper investigates the relationships between the technological transformation of firms and employee control over working time. We conduct EU-wide analysis at the meso-level by relating information from an employer level survey – the 2019 ECS - describing the technological transformation, with information from a household survey - the 2019 LFS *ad hoc* module on "work organisation and working time arrangements" - capturing working time flexibility arrangements from the viewpoint of employees. This methodology has the advantage of combining the responses from the most informed sources on both technological transformation of firms and quality of working time, although this causes a loss of information due to data aggregation.

The approach used views the technological transformation as a relationship between three investments - R&D activities, *Digital technologies adoption and use* and the *Learning capacity of the organisation* - and four innovation types: two technological forms, product and process innovations, and two non-technological ones, marketing and employee-driven organisational innovations. By changing the way production takes place in time and space, the technological transformation of firms is then likely to interact with the employee control over working time. This model implies that investments in *Digital technologies adoption and use* and in the *Learning capacity of the organisation* impact the quality of working time either directly or indirectly, through the mediation role of the different innovation types.

Estimating this model with Structural Equation Modelling, we find that investments into the *Learning capacity of the organisation* is a win-win strategy leading to more innovativeness and to a high road of better quality of working time. Indeed, a higher *Learning capacity* favours all forms of innovations except process innovations. In higher *Learning capacity* sectors, employees are also less exposed to low working time autonomy. There are however two points of attention. First, the *Learning capacity of the organisation* induces more interferences of professional life with personal life, this negative effect being partially attenuated by employee-driven organisational innovation and, to a lesser extent, process innovation. The higher working time flexibility at the initiative of employees granted in firms that invest into the *Learning capacity* of their organisation comes with a blurring of the frontier between personal and professional life. We may assume however, that employees in high *Learning capacity* firms have stronger bargaining power to negotiate the right balance between individual-oriented and organisation-oriented working time flexibility. Second, in most sectors, the level of the *Learning capacity of the organisation* has been stagnating over the last decade (Greenan and Napolitano, 2023). Hence, barriers to its development need to be addressed.

Investments in digital technologies, meanwhile, have grown rapidly everywhere until 2019, with countries in southern and central-eastern Europe catching up with the rest of the EU. *Digital technology adoption and use* by sectors, as R&D and the *Learning capacity of the organisation,* favours innovativeness. Higher digital intensity drives all forms of innovation except employee-driven organisational innovation. Contrary to investments in the *Learning capacity of the organisation* that generate direct impacts on employee control over working time, the impact of *Digital technology adoption and use* on working time flexibility arrangements is completely mediated by the innovation strategy of organisations.

Product innovation mediates positively the relationship between *Digital technology adoption and use* and working time autonomy when the mediation effect of marketing innovation is opposite: it induces in digitally intensive sectors less leeway to take hours off to reconcile work and personal life and more work-related contacts imposed by employers during leisure time. This effect can be explained by the higher concentration of product and labour markets in sectors with higher shares of marketing innovators. Indeed, this type of innovation is likely to have a stronger business stealing than job creation impact. As a result, employees would have less bargaining power to gain more control over their working time. We also note that marketing innovation is the most strongly connected with *Digital technologies adoption and use* (0.4 pp). Faced with less competitors, employers in marketing innovative firms may choose to use digital technologies to increase their control over the workforce. Finally, the influence of process and employee-driven organisational innovations is mixed with similar profiles: these types of innovation protect employees from organisation-oriented working time flexibility while being associated with less working time autonomy. It is likely that they develop in work environments that are more time constrained, because of issues of capacity utilisation or strong productive interdependencies in work activities.

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10.APPENDIX

Table A1 – Construction of key indicators to describe the technological transformation with the European Company Survey 2019

Indicator	Sub-dimensions	Questions	Recodification criteria
Digital technology adoption and use	**E-commerce**	Does this establishment buy or sell goods or services on the internet? For instance, by using business-to-business portals. e-commerce etc.	Yes =1 No=0
	E-business	Since the beginning of 2016, did this establishment purchase any software that was specifically developed or customised to meet the needs of the establishment?	Yes =1 No=0
	Data analytics	Does this establishment use data analytics (DA)? ITPERFMON: DA to monitor employee performance? ITPRODIMP: DA to improve the processes of production or service delivery?	DA=1 If ITPERFMON=yes or ITPRODIMP =yes; 0. otherwise
	Robots	Robots are programmable machines that are capable of carrying out a complex series of actions automatically. Which may include the interaction with people. Does this establishment use robots?	Yes =1 No=0
Learning capacity of the organisation	**Cognitive dimension of work**	For how many employees in this establishment does their job include finding solutions to unfamiliar problems they are confronted with? Your best estimate is good enough.	None at all => 0 Less than 20% => 0.1 20% to 39% => 0.3 40% to 59% => 0.5 60% to 79% => 0.7 80% to 99% => 0.9 All => 1
		How many employees in this establishment are in jobs that offer limited opportunities to learn new things? Your best estimate is good enough.	None at all => 0 Less than 20% => 0.1 20% to 39% => 0.3 40% to 59% => 0.5 60% to 79% => 0.7 80% to 99% => 0.9 All => 1
	Training opportunities	How many employees in this establishment are in jobs that require continuous training? Your best estimate is good enough.	None at all => 0 Less than 20% => 0.1 20% to 39% => 0.3 40% to 59% => 0.5 60% to 79% => 0.7 80% to 99% => 0.9 All => 1
		In 2018, how many employees in this establishment participated in training sessions on the establishment premises or at other locations during paid working time? Your best estimate is good enough.	None at all => 1 Less than 20% => 0.9 20% to 39% => 0.7 40% to 59% => 0.5 60% to 79% => 0.3 80% to 99% => 0.1 All => 0
		In 2018, how many employees in this establishment have received on-the-job training or other forms of direct instruction in the workplace from more experienced colleagues? Your best estimate is good enough.	None at all => 0 Less than 20% => 0.1 20% to 39% => 0.3 40% to 59% => 0.5 60% to 79% => 0.7 80% to 99% => 0.9 All => 1

Table A1(continued)

Indicator	Sub-dimensions	Questions	Recodification criteria
Learning capacity of the organisation	**Autonomy**	For how many employees in this establishment does their job include independently organising their own time and scheduling their own tasks? Your best estimate is good enough.	None at all => 0 Less than 20% => 0.1 20% to 39% => 0.3 40% to 59% => 0.5 60% to 79% => 0.7 80% to 99% => 0.9 All => 1
		Different establishments use different approaches to manage the way employees carry out their tasks. Which of these two statements best describes the general approach to management at this establishment? Please think about the approach that is used the most by managers. 1. Managers control whether employees follow the tasks assigned to them 2. Managers create an environment in which employees can autonomously carry out their task	1 => 0 2 => 0.5
	Motivation backed by the organisation	How often are the following practices used to motivate and retain employees at this establishment? **- Providing interesting and stimulating work**	Very often => 1 Fairly often => 0.6 Not very often =>0.3 Never => 0
		How often are the following practices used to motivate and retain employees at this establishment? **- Communicating a strong mission and vision, providing meaning to our work**	Very often => 1 Fairly often => 0.6 Not very often =>0.3 Never => 0
		How often are the following practices used to motivate and retain employees at this establishment? **- Providing opportunities for training and development**	Very often => 1 Fairly often => 0.6 Not very often =>0.3 Never => 0
	Autonomous teamwork	A team is a group of people working together with a shared responsibility for the execution of allocated tasks. Team members can come from the same unit or from different units across the establishment. - Do you have any teams fitting this definition in this establishment?	Yes => 1 No => 0
		Please think about the tasks to be performed by these teams. Who usually decides how the tasks are distributed within the team 1. Team members decide among themselves 2. Tasks are distributed by a superior	No team work => 0 2 => 0.2 1 => 1

Table A1(continued)

Indicator	Sub-dimensions	Questions	Recodification criteria
Learning capacity of the organisation	**Social support**	To be evaluated positively, how important is it that employees at this establishment show the following behaviour? **- Helping colleagues without being asked?**	Very important => 0.7 Fairly important => 0.5 Not very important => 0.3 Not at all important => 0
	Direct participation	To be evaluated positively, how important is it that employees at this establishment show the following behaviour? **- Making suggestions for improving the way things are done in the company?**	Very important => 0.7 Fairly important => 0.5 Not very important => 0.3 Not at all important => 0
		Which of the following practices are used to involve employees in this establishment in how work is organised ? **- Meetings between employees and their immediate manager**	Yes. on a regular basis => 0.4 Yes. on an irregular basis => 0.2 No => 0
		Which of the following practices are used to involve employees in this establishment in how work is organised ? **- Meetings open to all employees at the establishment**	Yes. on a regular basis => 0.8 Yes. on an irregular basis => 0.2 No => 0
		Does this establishment make use of **suggestion schemes**? ***Suggestion scheme**: The collection of ideas and suggestions from the employees. voluntary and at any time. often by means of a physical or virtual 'suggestion box'.*	Yes=> 0.5 No => 0
Share of innovative enterprises	**Product innovation**	Since the beginning of 2016, has this establishment introduced any new or significantly changed products or services? Answer yes. whether new to the market or to the establishment	Yes. New to the market OR Yes. new to the establishment. but not new to the market =1 No=0
	Process innovation	Since the beginning of 2016, has this establishment introduced any new or significantly changed processes either for producing goods or supplying services? Answer yes, whether new to the market or to the establishment	Yes. New to the market OR Yes. new to the establishment. but not new to the market =1 No=0
	Marketing innovation	Since the beginning of 2016. has this establishment introduced any new or significantly changed marketing methods? Answer yes,whether new to the market or to the establishment	Yes. New to the market OR Yes. new to the establishment. but not new to the market =1 No=0
	Organisation innovation	Since the beginning of 2016 have employees directly influenced management decisions in the area of organisation and efficiency of work processes?	To a great extent = 1. 0 otherwise

Table A2 – Measurement of unfavourable working time arrangements using the Labour Force Survey 2019 and its ad hoc module

Indicator	Variable in LFS	Recoded indicators
Low Working Time Autonomy : Time schedule	How is determined the start and end of the working time in the main job? 1 Worker can fully decide working time 2 Worker can decide working time with certain restrictions 3 Employer or organisation mainly decides working time	It varies from 0 (high working time autonomy: worker can fully decide on the start and end of working time) to 1 (low working time autonomy: employer or organisation mainly decides)
Low Working Time Autonomy : Hours off	Possibility to take one or two hours off in the main job for personal or family matters within one working day? 1 Very easy 2 Quite easy 3 Quite difficult 4 Very difficult	It varies between 0 (high working time autonomy: worker can very easily decide to take one or two hours off for family or personal matters within one working day) and 1 (low working time autonomy; very difficult to take one or two hours off for family or personal matters within one working day).
Required change in working time	Frequency to which the worker has to face unforeseen demands for changed working time in the main job? 1 At least once a week 2 Less than every week but at least every month 3 Less than every month or never	It varies between 0 (low frequency of change in working time required) to 1 (frequent required change in working time)
Contacted on work matter	Worker was contacted during leisure time in the last two months to take action before the next working day for the main job? 1 Was not contacted in the last 2 months 2 Was contacted on a few occasions 3 Was contacted several times and expected to act before the next working day 4 Was contacted several times and not expected to act before the next working day	It varies between 0 (not contacted in the last 2 months) and 1 (contacted several times and expected to act before the next working day).

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