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A comprehensive European database of tasks indices for socio-economic research

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A comprehensive European database of tasks indices for socio-economic research

Martina Bisello, Marta Fana, Enrique Fernández-Macías and Sergio Torrejón Pérez

(Eurofound and European Commission JRC, Seville)

Abstract

This paper presents a new and enriched version of the European database of tasks indices across jobs in the EU15 (minus UK) economy using most recent data from European Working Conditions Survey (EWCS 2015), a European (Italian) version of the O*NET database of occupational contents (ICP 2012) and the OECD´s PIAAC Survey. The database of tasks indicators was created based on a coherent and comprehensive taxonomy of tasks contents, methods and tools developed in Fernández-Macías and Bisello (2020), which builds on the original version published in Fernández-Macías et al., (2016a, 2016b) including several additional new concepts and indicators at different levels. After a detailed description of the construction of the database and an initial assessment of its internal consistency, the paper offers an analysis of the tasks distribution across occupations and sectors at the European level, providing useful insights of work content and organisational methods prevailing along the job structure. The possibility to dig into the complexity of work activities characterizing single jobs allow to identify patterns of correlation across task indices and to better understand how tasks are bundled across occupations by sectors pairs. The empirical analysis confirms that tasks are not isolated forms of labour inputs that just happen to be in productive processes but building blocks of coherently constructed jobs which are embedded in productive organisations. Any analysis of tasks which focuses on a particular type in isolation risks missing important connections with other types of task content and forms of work organisation. We hope that our contribution raises awareness of the importance of having good and detailed measures of tasks contents, consistently measured at the individual worker level and at different points in time, in order to understand better how technical change and other factors are continuously changing the nature of work and the associated skills demand and job quality. A future European tasks survey could precisely provide that.

Keywords: tasks, employment structure, European labour market, work organisation

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- Fernández-Macías, E., Hurley, J., Bisello, M. (2016). What do Europeans do at work? A task-based analysis: European Jobs Monitor 2016.
- Fernández-Macías, E., Bisello, M., Sarkar, S. and Torrejón, S. (2016). Methodology of the construction of task indices for the European Jobs Monitor.

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Introduction

Until not so long ago, economists paid little attention to the task content of jobs and occupations. The production process and the role played by labour on it was handled in economic theory by the convenient black box of the production function, and in the analytical models labour was at most differentiated by its potential productivity, proxied by skill level. But the empirical observation of a non-linear (polarised) evolution of employment growth across skill levels in English-speaking economies since the 1990s led some economists to search for a more nuanced understanding of how technology affected different types of labour input (Autor, Levy and Murnane 2003; Goos and Manning 2007). The hypothesis that computerisation has a "routine-biased" impact on employment (replacing routine jobs and complementing non-routine ones) provided a starting point for this more nuanced understanding: labour input could be broken down into a series of distinct "tasks", which could then be classified according to the specific types of skills they require.

Thus, a whole new literature emerged in labour economics in the last two decades, discussing how different types of task content were associated with different outcomes in terms of employment, wages or other dimensions related to job quality and working conditions, often in relation with the impact of technical change or international trade (for a review, see Fernández-Macías et al., 2016a). While this literature has without any doubt enlarged the scope of economic research and improved our understanding of recent labour market trends, it suffers from some conceptual and empirical limitations that are worth mentioning. First, it ignores very rich traditions in other fields in social sciences (in particular, sociology and social psychology, as well as other fields in economics) of research on the division of labour, work organization and occupational change which had in fact already identified decades ago some of the phenomena that this new economic literature has "discovered" in recent years. For instance, in "Labour and Monopoly Capital: The Degradation of Work in the Twentieth Century" (1974), Braverman already spoke about a tendency of polarisation in the occupational structure, with declining employment for mid-skilled working-class occupations and expanding low-skilled service jobs.[1] Even within the economics discipline, theoretical contributions like the organizational theory of the firm and the capability theory of the firm (Cetrulo et al., 2020; Dosi et al., 2001; Dosi and Marengo, 2015) discuss the implementation of organizational routines within firms as well their relationship with the creation and appropriation of knowledge over the occupational hierarchy. Secondly, most of the recent economic research on tasks was based on classifying entire occupations rather than measuring task content as such (although this is changing in most recent years, as a result of better data availability). Third, most of the task-related economic research tends to focus on specific categories of task content (most frequently, routine, manual and cognitive tasks), neglecting the fact that jobs are coherent bundles of interrelated tasks which cannot be properly understood in isolation. Fourth, the tasks approach adopted in labour economics is often grounded on a deterministic view of the process of substitution/complementarity between working activities (tasks) performed by human labour and by machines. In this framework, whether a given task is performed by humans or machines is fully determined by comparative advantage (relative costs between labour and capital inputs), disregarding values and social relations prevalent in a given historical and institutional context.[2]

In 2016, Fernández-Macías et al. (2016b) developed a comprehensive hierarchical taxonomy of task contents, methods and tools of work that tried to overcome some of these limitations. On the basis of this taxonomy, and using existing data sources that included task-relevant information as well as

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[1] It is interesting to note that Braverman also based these arguments on an analysis of long-term trends in employment across different occupational levels and discussed in detail the impact of technology on the task content of occupations. However, we should not take this argument too far: obviously, there are fundamental differences in the main arguments of the routinisation literature and Braverman´s work.

[2] Braverman (1974) also highlighted how other factors apart from technical change, such as the organisational culture and power relations in workplaces, influence to the type of technology to be used and the task content of jobs.

comparable occupational classifications, a database of task indicators for occupations was created. These indicators followed rigorously the tree structure of the taxonomy, and thus could be aggregated at different levels and simultaneously analysed. The possibility to dig into the complexity of work activities characterizing single occupations allow to identify patterns of correlation across task indices and/or to better understand how tasks are bundled across occupations (Fernández-Macías et al., 2016a; Pouliakas and Russo, 2015). Since this dataset was published, there have been several applications to specific research projects and papers, both by the authors of the present paper (or some of them) and by other researchers (see Table A1).

In this paper, we present a new version (2.0) of the tasks database, an initial assessment of its internal consistency and an analysis of the tasks distribution across occupations and sectors at the European level. It is worth emphasizing that the database presented in this paper is not a revision of the one we already made public in 2016, but a new version embedding some important novelties compared to its predecessor. First, it is based on a revised version of the underlying taxonomy, which was published in 2020 with the addition of several new concepts and components at different levels (Fernández-Macías and Bisello, 2020). Although this new version of the taxonomy remains broadly consistent with the previous one, it is sufficiently new as to require a new operationalisation, as presented in this paper. Second, since the first version of the tasks database was made public, new and better European data sources on tasks have been made available, allowing for the use of more updated and reliable data. As we will explain later in more detail, the construction of this new version of the European tasks database uses a more recent version of the European Working Conditions Survey (Eurofound, 2016) and a European (Italian) version of the O*NET database of occupational contents (rather than the US version we had to rely on five years ago because of the lack of alternatives). Only in the case of the OECD´s PIAAC Survey we use the same data source as in the first version of the database, although even in this case some indices have been updated to reflect the changes of the underlying taxonomy.

This paper unfolds as follows. Section 2 makes a review of the different measure used in recent years in different fields of social sciences and provides examples of their application based on different national and/ or international sources. Section 3 briefly presents the taxonomy used in this paper. In Section 4, a detailed presentation of sources and methodology adopted for the construction of the tasks indices is provided, together with an analysis of consistency across sources and tasks dimensions. In Section 5, we present the average distribution of tasks across European labour markets, while Section 6 presents the distribution of tasks across some of the most important jobs (occupation-sector combinations) in terms of employment size. Finally, Section 7 discusses how tasks bundle across different occupations and sectors. Section 8 concludes.

A review of existing measures and applications

In the last two decades, the increased attention paid to the role of tasks in shaping structural change in employment fostered the development of new and in many cases more granular and detailed data sources. The possibility to empirically operationalise the tasks approach to study structural changes across time and space strongly depends on data availability. As already stressed by Autor (2013) in his seminal paper, studying patterns in tasks within and across occupations is not feasible unless tasks data are collected consistently in more than one point in time. Similarly, different economies are characterized by different economic processes depending on historical and institutional factors, therefore using the mapping of tasks collected in a single country to inform on other economic structures may lead to biased estimates (Fana et al., 2020).

The rest of this section briefly reviews, although not exhaustively, the main types of data sources collected at the country and international level which have been used to operationalise the tasks approaches developed in the literature. It is worth highlighting that although the non-availability of data is detrimental for empirical applications, the theoretical grounds informing them is pivotal. For instance, the same source of data can be used in radically different tasks frameworks, depending on what researcher are looking for from a conceptual point of view.

Measures based on occupational databases

In their seminal work, Autor et al. (2003) made a systematic effort to classify occupations according to their intensity of use of some specific types of tasks, namely nonroutine analytic, nonroutine interactive, routine cognitive, routine manual and nonroutine manual. The resulting classification[3] was operationalised using the Dictionary of Occupational Titles (DOT), an occupational database that contains detailed descriptions of occupational contents made by trained job analysts based on their observations and interviews at selected job sites for the U.S. economy. More specifically, experts evaluated the importance of many different task and skill categories across different detailed occupations, assigning standardised scores to each item. By using this database, Autor et al. (2003) constructed a total of five variables measuring the extent to which occupations involve the tasks categories specified above.

Other researchers replicated the ALM model or produced reformulations introducing adjustments to adapt their data to their particular interests, while still using DOT or its successor: the Occupational Information Network Database, known as O*NET. Cunningham and Mohr (2019) use a taxonomy that includes together with ALM indices the type of tools used at work and, more generally, the tasks that are associated to a higher and a lower pay (job specific tools and general tools). Blinder (2009), with the aim of evaluating the potential number of jobs at risk of displacement because of international trade, created an index of offshorability based on requirement of physical location and proximity to the work unit. More recently, direct contact and physical proximity has been used by Dingel and Neiman (2020) to study the potential for telework during the COVID-19 pandemic. More in line with the original proposal, the ALM taxonomy (with refinements in some cases) built using DOT/O*NET occupational content data has been matched with EU-LFS data to illustrate changes in the work composition of several European countries (Acemoglu and Autor, 2011; Arias et al., 2014; Goos et al., 2014; Goos and Manning, 2007; Górka et al., 2017; Hardy et al., 2018). Similarly, Arias et al. (2014) use measures of skill requirements, defined following the ALM model, and extrapolate these measures to the occupational structure of countries in Central and Eastern Europe and Central Asia.

While DOT and O*NET contain U.S. data, the Indagine Campionaria sulle Professioni (ICP), developed by the National Institute for Public Policy Analysis (INAPP) and the Italian National Statistical Institute (ISTAT), constitutes the only European data source closely replicating O*NET for the Italian occupational structure, although with some methodological differences that will be discussed later. This Italian version of the O*NET has been extensively used in recent years. For example, Cirillo et al. (2020) adopt the standard task approach (Autor et al., 2003; Goos et al., 2014) to investigate the Routine Biased Technical Change (RBTC) hypothesis in the Italian context, finding supporting evidence. Another recent contribution, (Cetrulo et al., 2020) uses ICP data to characterise the Italian occupational structure in terms of knowledge and learning, work organization (including degrees of autonomy, routinariety, automation, control, and social interactions) and ICT skills. In their study, departing from the standard approach, the authors put human agency and organizations at the centre of the stage, highlighting the importance of power relations, hierarchies and knowledge as the most relevant attributes characterizing the division of labour.

The main advantage of occupational databases such as DOT, O*NET and the ICP is that they cover the entire spectrum of the occupational structure at a high level of detail. These sources are the most comprehensive databases reporting qualitative and quantitative information on tasks, skills, work

[3] Other indices to measure the intensity of routine tasks at work have been developed and used by Autor and Dorn (2013), Autor, Dorn and Hanson (2015), Goos et al. (2014), etc.

contexts, and organizational characteristics. But they have important limitations too. First, they provide information at the level of occupations rather than individual workers, and therefore they do not allow to capture the variability of tasks within the same occupation. For the same reason, task differences between economic sectors are not captured, so that the horizontal dimension of the division of labour is entirely missing. Second, in the case of O*NET, it also gathers data from professional job analysts on the Abilities and Skills questionnaires, and from "occupational experts" on small occupations that are difficult to reach through samples (Freeman et al., 2020, page 3). Such information, which is updated on a rolling basis, supplement data from job incumbent collected through ongoing surveys of workers in each occupation. The ICP instead is based on survey evidence collected at the worker's level, which is then validated ex-post by experts. Third, these sources were not originally constructed to measure changes in the task content over time, but rather to have a very detailed measure of occupational content at a specific point in time. To our knowledge, prior research has used O*NET data only cross-sectionally, with only a couple of exceptions (see Freeman et al., 2020; Ross, 2017). For a detailed discussion of strength and limitations of O*NET database see Handel (2016).

Measures based on survey data

A second empirical approach to task measurement is based on survey data in which respondents indicate the type of activities they perform on their job. This procedure offers some advantages. First, provided each occupation by sector pair has enough observations, the resulting databases allow to analyse the variability of tasks indices within and between jobs. Second, these sources are more suitable to capture changes in task contents (as long as they actually occur). Third, they allow to create new task measures that can be used for testing specific hypotheses. Furthermore, surveys usually include additional information which complement activities performed at work with workers' individual characteristics, such as education and experience, or other attributes of their jobs such as wages or the type of contract. In summary, the potential applications of the task approach to labour market analysis are increased exponentially by making use of survey data.

A widely used data source is the Qualification and Career Survey, a survey of employees carried out by the German Federal Institute for Vocational Training (BIBB) and the Research Institute of the Federal Employment Service (IAB), that offers detailed self-reported data on workers' primary activities at their jobs. The survey is carried out every six years, being the last one (the seventh) 2018. Occupational skill requirements are measured by workers' job duties, represented by the activities that employees actually perform at the workplace. The dataset also includes detailed information on the tools and machines used at the workplace, with a focus on computers, terminals, and electronic data-processing machines. Based on these variables, Spitz-Oener (2006) elaborated indicators that reproduced the categories of the ALM model, adding information on computer use to enrich the analysis. Many other researchers have used the job activity questions in the IAB/BIBB data for the same purpose and the aim of explore links between technological change, the composition of employment and shifts in wage structure (Antonczyk et al., 2010; Dustmann et al., 2009; Senftleben-König and Wielandt, 2014).

In 2014, a new survey was developed by IAB to operationalize five major types of tasks: analytic, interactive, manual, routine, and autonomy-demanding ones. The resulting questionnaire was administered in the fourth panel wave of the German National Educational Panel Study's (NEPS) adult stage. Matthes et al. (2014) use this database to operationalise an extended version of the ALM taxonomy in which routine tasks are defined over two main dimensions, with the peculiarity that it is measured in reverse (that is, by variables that imply the opposite of routine). The first one relates to task complexity (in reverse), measured by variables such as having to react to unforeseen situations, learning new things, or dealing with problems. The second one operates a shift in the conceptual understanding of routine from the standard technical aspect to the organisational one, in line with social psychology school (Breaugh, 1985; Morgeson and Humphrey, 2006). More precisely, the second dimension of routine is measured as (lack of) autonomy, defined as the capacity for the employees to make autonomous decisions, defining goals and organizing the work necessary to achieve these goals.

Michael J. Handel, another pioneer scholar in the field, created the Skills, Technology, and Management Practices (STAMP) survey, explicitly designed to overcome the limitations of the O*NET by capturing tasks at the worker level. STAMP is a U.S. nationally representative two-waves panel survey of employed adults, although the number of observations (2,304) is rather low to map the occupational structure at a detailed level. The survey contains approximately 166 unique items on job characteristics, covering skills and task requirements in terms of a detailed list of intellectual activities (reading, mathematics, problem-solving, visuals) and a broader category for physical tasks required at work. It also includes ICT and non-ICT technology; employee involvement practices; autonomy, supervision and authority (Handel, 2008, 2016).

The STAMP questions were subsequently revised, leading to the Princeton Data Improvement Initiative (PDII) led by Alan Krueger, Ed Freeland and Bill Barron, and conducted only in 2008, reducing the scope for dynamic analysis. Also, this survey has been used to refine the ALM by including physical tasks, repetitive tasks, managing/supervising, problem solving, and maths (Autor and Handel, 2013). Blinder and Krueger (2013) and Goos et al. (2014) have also used the PDII to generate an index to measure the offshorability of jobs.

The OECD Survey of Adult Skills (PIAAC) measures adults' proficiency in key information-processing skills (literacy, numeracy and problem solving), and gathers information on how adults use their skills at work and in the wider community. This survey is conducted in over 40 countries. For that reason, it has been widely used to produce indices aimed to measure the skill and the task content of work (De La Rica et al., 2020; Górka et al., 2017; Martínez-Matute and Villanueva, 2020; Nedelkoska and Quintini, 2018; OECD, 2016; Vignoles and Cherry, 2020).

Last but not least, there is an important European survey that is worth considering: the European Working Conditions Survey (EWCS). Developed by Eurofound, it was launched in 1990, aimed to provide an overview of working conditions in Europe. This survey is conducted every five years[4] and contains information about the everyday reality and the activities of men and women at work. Joling and Kraan (2008) and Salvatori et al. (2018) propose an indicator of machine use at work based on the EWCS survey to study the association between technology use and job quality. Sebastian-Lago (2018) investigates the main determinants behind job polarisation in Spain between 1994 and 2014. Using this database, the author analyses employment changes of different jobs, classified on the basis of their task content as abstract, routine, and manual (similar to the standard ALM model). Finally, Bisello et al. (2019) also rely on this source to analyse changes in the task content, methods and tools of European jobs from 1995 to 2015, drawing on the taxonomy of tasks proposed by Fernández-Macías et al. (2016a; 2016b). From the complete list of indices of the original proposal, only a restricted number could be investigated due to changes in the survey questionnaire across different waves (these were indices capturing physical strength, social interaction, autonomy, routine, machines and computers use).

As we have illustrated above, the use of task indices in social sciences research has considerably increased in the last two decades. Although the task approach is still very popular, and there are more and more databases available which include information about what workers do, most studies still focus on just one or a few types of job task, depending on the specific research interests of the authors. Therefore, we think that a comprehensive and well-structured database of task indicators which is freely available for any interested researcher can be a useful contribution to this field. Following the framework and taxonomy presented in Fernández-Macías and Bisello (2020), not only we include indicators that have been widely used in task research in recent years (routine, manual,

[4] The fieldwork for the last wave, due to take place in 2020, was postponed due to the COVID-19 crisis.

cognitive, etc), but also others less frequently used such as problem-solving tasks, several specific types of social interaction tasks, several work organisation measures as well as indicators of technology used. This should allow researchers to expand the focus beyond traditional explanations of recent changes in the labour market, allowing them to consider other factors and dynamics.

The JRC-Eurofound taxonomy of tasks: an overview

The taxonomy which underlies our database, presented in Table 1 below and discussed in detail in Fernández-Macías and Bisello (2020), was constructed in two steps. First, a detailed review of the recent empirical social sciences literature that referred to the concept of tasks was made to create an inventory of the types of tasks discussed. For instance, the literature on the impact of technology on employment tends to focus on two main types of tasks (cognitive and routine), although other types are sometimes mentioned (interactive, service and manual, for instance); while the literature on trade often focuses on social interaction tasks to capture the offshorability character of them, etc. Secondly, a material and organisational model of work was developed to provide a conceptual structure to the mentioned inventory of tasks, and to identify and fill gaps where necessary. The result is the hierarchical taxonomy of tasks presented in Table 1.

The first dimension of the taxonomy refers the contents of tasks. This dimension looks at work from a material perspective, as a transformative activity upon an object, tasks being discrete units of that work. Hence, on the basis of the type of object being transformed, there is a first threefold differentiation between physical tasks (operated upon objects), intellectual tasks (operated upon ideas or information) and social tasks (operated upon social relations). Within each of those upper-level categories of task contents, there are additional nested classifications based on the type of transformation and the skills typically required to perform them. For instance, intellectual tasks are first differentiated into information processing and problem solving. Information processing is then further differentiated into the processing of uncodified (visual or auditory) information, and the processing of codified information. Then, the processing of codified information is further differentiated into literacy (processing of textual information) and numeracy (processing of numeric information). And finally, literacy is further subdivided into business, technical and humanities. Therefore, this particular branch of the taxonomy has 6 levels (from task contents to the processing of technical textual information). The taxonomy is therefore hierarchical although not symmetric in its depth (some branches are more differentiated than others), and the different branches can be compared at equivalent levels (so “strength” in physical tasks has a similar level of generality as “information processing” in intellectual tasks or “caring” in social tasks).

The second dimension refers to the methods and tools of work. Whereas the task contents dimension reflects directly the material properties of the work process (the type of object being transformed and the type of transformation operated upon it), the methods and tools dimension reflects the socially determined forms of work organisation and the technologies used in production. In terms of work methods (or forms of work organisation), three main categories are identified: autonomy, teamwork and routine. In terms of tools (or technologies used at work), a differentiation between analog and digital machinery is made. As in the case of task content, most of the upper-level branches of the taxonomy are further distinguished at different levels.

Whereas the overall logic and structure of our taxonomy of tasks remains fully consistent with the previous (2016) version, there have been some changes that are worth specifying. These changes were introduced mostly as a result of subsequent work done with this database (see for instance Bisello et al., 2019; Tolan et al., 2020), which uncovered some gaps for the analysis of the impact of recent technological developments on work. Within physical tasks, a new indicator was added for “navigation”, referring to tasks involving moving oneself or objects within changing or unstructured spaces, and within intellectual tasks an indicator for the processing of uncodified (visual or auditory) information was included.[5] Within problem solving, each of the two sub-components were further differentiated into two more in order to gain specificity, and within social tasks a new category for “caring” was included. Within methods of work, autonomy was differentiated into the two sub-components of “latitude” (ability to decide) and “control” (mechanisms restraining the workers´ decisions), and a third component (uncertainty, in reverse) was added to routine. Finally, robotic technology and specialised ICT were added to the classification of tools used at work. For more details of this version of the taxonomy of tasks, see Fernández-Macías and Bisello (2020).

Table 1: A taxonomy of tasks according to the content of work, methods and tools

A. In terms of the content:

1. **Physical tasks:** aimed at the physical manipulation and transformation of material things:
   - a. *Strength:* lifting people and heavy loads, exercising strength.
   - b. *Dexterity:* precisely coordinated movements with hands or fingers.
   - c. *Navigation:* moving objects or oneself in unstructured or changing spaces
2. **Intellectual tasks:** aimed at the manipulation and transformation of information and the active resolution of problems:
   - a. *Information processing:*
     - I. Visual and/or auditory processing of uncodified/unstructured information
     - II. Processing of codified information
       - i. Literacy:
         - a. Business: read or write letters, memos, invoices, …
         - b. Technical: read or write manuals, instructions, reports, forms, …
         - c. Humanities: read or write articles or books.
       - ii. Numeracy*:*
         - a. Accounting: calculate prices, fractions, use calculators, …
         - b. Analytic: prepare charts, use formulas or advanced maths
   - b. *Problem solving:*
     - I. Information gathering and evaluation.
       - i. Information search and retrieval
       - ii. Conceptualization, learning and abstraction
     - II. Creativity and resolution
       - i. Creativity
       - ii. Planning/implementation
3. **Social tasks:** whose primary aim is the interaction with other people:
   - a. *Serving/attending:* responding directly to demands from public or customers
   - b. *Teaching/training/coaching:* impart knowledge or instruct others
   - c. *Selling/influencing:* induce others to do or buy something, negotiate
   - d. *Managing/coordinating:* coordinate or supervise the behaviour of colleagues
   - e. *Caring:* provide for the welfare needs of others.

B. In terms of the methods and tools of work:

1. **Methods:** forms of work organisation used in performing the tasks:
   - a. *Autonomy*
     - I. Latitude: ability to decide working time, task order, methods and speed.
     - II. Control (in reverse): direct control by boss or clients, monitoring of work.
   - b. *Teamwork:* extent to which the worker has to collaborate and coordinate her actions with other workers
   - c. *Routine*
     - I. Repetitiveness*:* extent to which the worker has to repeat the same procedures
     - II. Standardisation: extent to which work procedures and outputs are predefined and encoded in a formalised system
     - III. Uncertainty (in reverse): extent to which the worker needs to respond to unforeseen situations
2. **Tools:** type of technology used at work:
   - a. *Non-digital machinery (analog)*
   - b. *Digitally-enabled machinery*
     - I. Autonomous (robots)
     - II. Non-autonomous
       - 1. Computing devices
         - a. Basic ICT (generic office applications)
         - b. Advanced ICT (programming, admin)
         - c. Specialised ICT
       - *2.* Others

***Source**: Fernández-Macías and Bisello (2020)*

The construction of the European tasks database

Sources

Despite the interest in tasks performed by workers and the development of a rich strand of interdisciplinary literature using the tasks approach to explain structural change in labour markets, data availability remains poor, with some exceptions. At present there is no data covering all items included in the JRC-EF framework at the European level, nor national sources. However, there exist international, European and national surveys providing a partial coverage of the framework which

[5] It is worth mentioning that “processing of uncodified (visual or auditory)” has an ambiguous position within the taxonomy of tasks. Although in strict terms, it is information processing and thus fits within the “intellectual” dimension of our index, in fact it is a very physical type of information processing (because it is mostly done unconsciously) and it could also fit in that dimension. As we will see later, this indicator correlates better with the physical task indices than with the intellectual ones. Although for consistency reasons we kept this indicator within the “intellectual” branch of the taxonomy, we have not included it in the upper-level aggregated index of “intellectual tasks”.

have been recently used to build a cross country comparable database (Fana et al. 2020). In this paper, in order to operationalise the broad spectrum of items included in the JRC-EF framework, different indicators from three different surveys, whose characteristics are described in this section, are combined.

EWCS

The European Working Conditions Survey (EWCS) is provided by The European Foundation for the Improvement of Living and Working Conditions (Eurofound). Launched in 1990, this survey has become an important source of information about working conditions and the quality of work and employment since it enables monitoring long-term trends in these topics in Europe. The scope of the questionnaire has widened substantially since the first edition, aiming to provide a comprehensive picture of the everyday reality of men and women at work. In each wave a random sample of workers (employees and self-employed) has been interviewed face to face. In 2015, Eurofound carried out the last wave (its sixth survey) in the series until the moment, which is used in this paper. This sixth survey interviewed nearly 44,000 workers in 35 countries. Its findings provide detailed information on a broad range of issues, including exposure to physical and psychosocial risks, work organisation, work–life balance, and health and well-being.

ICP 2012

The Italian Indagine Campionaria sulle Professioni (ICP) is provided by INAPP-ISTAT. Launched in 2007, the ICP is an occupational database that replicates extensively the American O*NET database over all building blocks: skill, work contents, attitudes, tasks, technological and organizational characteristics of productive processes and many other subjective and objective indicators on occupations. Both the American O*NET and the Italian ICP use occupations as unit of analysis rather than workers (i.e. occupation-level variables are built relying on both survey-based worker-level information as well as on post-survey validation by experts' focus groups) covering the whole spectrum of the Italian 5-digit occupations excluding armed forces (i.e. 797 occupational codes). The interviews are administered to 16,000 Italian workers ensuring representativeness with respect to sector, occupation, firm size and geographical domain (macro-regions). The sampling strategy is articulated as follows. Relying on a matrix – built using the Italian Labour Force Survey (ILFS) carried out by ISTAT – providing information on the distribution of occupations (in terms of number of employees) across 5-digit sectors, 797 independent samples are generated. Each sample refers to a specific 5-digit occupation and is populated by firms (stratified by region and size class) belonging to the cluster of sectors (circumscribed using the just mentioned occupation-sector matrix) where the probability of finding such specific occupation is above a pre-established threshold. Firms are randomly extracted from the ISTAT-ASIA register (Registro delle imprese attive). Given that the unit of analysis is the occupation at five-digit instead of the individual worker, standard deviations for the tasks indicators are not created as they would reflect variability between occupations belonging to the same broad three-digit group, in contrast with the other two sources using individual data. In the present paper, information from the ICP is drawn from the 2012 wave and the intensity scale (ranging between 0 and 100) is used for all variables.

PIAAC

The OECD Survey of Adult Skills assesses the proficiency of adults aged 15-65 in key information-processing skills -literacy, numeracy and problem solving- and gathers information and data on how adults use their skills at home, at work and in the wider community. The survey is conducted in over 40 countries as part of the ongoing Programme for the International Assessment of Adult Competencies (PIAAC). The Survey is administered every 10 years and has had two cycles so far. In the First Cycle, there were three rounds of data collection, between 2011-2018. In 2018, the Second Cycle of the Survey has begun, with results for this cycle to be published in 2024. Apart from measuring the key cognitive and workplace skills, the survey also collects information on demographic characteristics, qualification, work experience, training and use of the skills at work, at home and in the community.

Advantages and limitations of the sources used

As explained above, our database combines information from a workers' survey (EWCS), an individuals' survey (PIAAC) and a mix between a workers' survey and an occupational database (ICP). In the latter case, while the questionnaire is administered to a representative sample of the working population, information is also complemented by experts. From a methodological point of view, using workers' and individuals' surveys allows to dig into tasks profiles within the same job or occupation. In principle, workers employed in the same specific jobs should perform the same or at least a similar bundle of tasks, a hypothesis that can be tested empirically by analysing heterogeneity within jobs.

A common drawback of workers' and individuals' surveys relates to the possibility of introducing subjective elements into the answers, leading to some forms of bias. Other types of problems emerge for the ICP. First, it does not provide any breakdown in terms of economic sectors, and therefore it is not possible to create the tasks indicators at the job level (occupation-by-sector pairs) using only this source of information. Second, although the survey is quite rich in terms of dimensions, it only refers to Italy and therefore using it for other countries might remove differences in tasks profiles emerging from country-specific historical and institutional factors (for an alternative tasks database with the same underlying taxonomy but country-specific variables, see Fana et al., 2020).

Although these limitations cannot be ignored, the availability of larger sample sizes and the possibility of combining multiple questions and sources for the construction of single items mitigates the risk of biased or inconsistent outcomes. Additionally, none of the databases available allows for a full coverage of all the items in our taxonomy, so combining data from different sources is unavoidable in order to construct a comprehensive task database.

It is important to highlight that although the three sources refer to the same employed population (since in the case of PIAAC we filter out those not in employment), they refer to different geographic areas. The EWCS is a European survey, PIAAC covers different OECD countries (many but not all in Europe), and the ICP bases its measurement on Italian workers only. In combining the three sources, and to keep a certain degree of consistency, the sample has been restricted to the EU-15 (minus UK) countries, therefore using both EWCS and PIAAC[6] information only for those countries. This choice leads to the creation of the task measures which primarily refer to European Western countries.

Mapping of the sources to the taxonomy of tasks

Table 2 shows the sources used for the construction of indices for each category of tasks in the proposed taxonomy. As can be seen, the ICP can provide a more exhaustive coverage of all the elements in the model presented here, while EWCS is very detailed in terms of work organization. PIAAC has very good coverage of intellectual tasks, as well as social and computer use at different levels of proficiency.

Some elements are only covered by one of the sources, while in most cases the indices have been constructed by combining information from two or three sources. Even for the elements that are only covered by one source we have constructed the corresponding indices by using several variables from the same source, except for the case of uncertainty (in reverse), the only index in our framework that has been constructed with one single variable. As most of the variables used are just partial proxies of the concepts of the proposed framework, this redundancy can increase the

[6] The sample of EU-15 countries that is available in PIAAC 1st round is formed by Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Spain and Sweden.

consistency and robustness of the measure. Having different measures of the same concept is also very useful for testing the validity of this framework, as will be shown later. The only index which could not be operationalised due to lack of suitable data is the one on specialised ICT. Annex 2 contains the full list of variables used across the three sources, including labels and exact wording.

Table 2: Mapping of variables from the different sources into the elements of the JRC-EF taxonomy of tasks

	ICP 2012	**EWCS 2015**	**PIAAC 1st Cycle**
A. In terms of the content:			
1. **Physical tasks:** aimed at the physical manipulation and transformation of material things:			
a. *Strength:* lifting people and heavy loads, exercising strength.	x	x	
b. *Dexterity:* precisely coordinated movements with hands or fingers.	x		x
c. *Navigation:* moving objects or oneself in unstructured or changing spaces	x		
2. **Intellectual tasks:** aimed at the manipulation and transformation of information and the active resolution of problems:			
a. *Information processing:*			
I. Visual and/or auditory processing of uncodified/unstructured information	x		
II. Processing of codified information			
i. Literacy:			
a. Business: read or write letters, memos, invoices,…	x		x
b. Technical: read or write manuals, instructions, reports, forms,…	x		x
c. Humanities: read or write articles or books.	x		x
ii. Numeracy:			
a. Accounting: calculate prices, fractions, use calculators,…	x		x
b. Analytic: prepare charts, use formulas or advanced maths	x		x
b. *Problem solving:*			x
I. Information gathering and evaluation.			
i. Information search and retrieval	x		
ii. Conceptualization, learning and abstraction	x	x	x
II. Creativity and resolution			
i. Creativity	x	x	
ii. Planning/implementation	x		
3. **Social tasks:** whose primary aim is the interaction with other people:			
a. *Serving/attending:* responding directly to demands from public or customers	x		
b. *Teaching/training/coaching:* impart knowledge or instruct others	x		x
c. *Selling/influencing:* induce others to do or buy something, negotiate	x		x
d. *Managing/coordinating:* coordinate or supervise the behaviour of colleagues	x		x
e. *Caring:* provide for the welfare needs of others.	x		
B. In terms of the methods and tools of work:			
1. **Methods:** forms of work organisation used in performing the tasks:			
a. *Autonomy*			
I. Latitude: ability to decide working time, task order, methods and speed.	x	x	x
II. Control (in reverse): direct control by boss or clients, monitoring of work.	x		
b. *Teamwork:* extent to which the worker has to collaborate and coordinate her actions with other workers	x	x	x
c. *Routine*			
I. Repetitiveness: extent to which the worker has to repeat the same procedures	x	x	
II. Standardisation: extent to which work procedures and outputs are predefined and encoded in a formalised system		x	
III. Uncertainty (in reverse): extent to which the worker needs to respond to unforeseen situations		x	
2. **Tools:** type of technology used at work:			
a. *Non-digital machinery (analog)*	x	x	
b. *Digitally-enabled machinery*			
I. Autonomous (robots)			
II. Non-autonomous			
1. Computing devices		x	x
a. Basic ICT (generic office applications)			x
b. Advanced ICT (programming, admin)	x		x
c. Specialised ICT			
2. Others			

Construction of the indices

In order to construct the tasks indices from each source, and following the same approach as Fernández-Macías et al. (2016b) the following procedure is adopted:

- For each index, all the potential variables that could match the elements of the framework are identified.
- Given the variable or set of variables related to a specific indicator that have been selected, three main statistical tests have been performed to analyse the correlation and consistency among them. Pairwise correlations and the Cronbach's Alpha tests are run to check the overall correlation of all the items used to measure each single indicator, as well as a Principal Component Factor Analysis to evaluate the consistency of the variables and identify those that did not fit the relevant concept well. It's important to note that in principle variables aimed at measuring the same concept should be highly correlated, although this may not be the case if two variables capture complementary aspects of the same concept or if those variables, while capturing the same concept, are occupation-specific. This means that low correlations should not be necessarily considered a failure of the statistical test, and this has to be specifically considered case by case.
- Once the variables to be combined into a single index (linked to a particular element in our framework) have been selected, they have been rescaled into a 0-1 scale when not already in this format. Then, the selected variables are combined by simply averaging them at each relevant level.
- Forth, the construction of the indices from each source is followed by the computation of their average scores for all the occupation-by-sector combinations (in other words, for each "job" in our terminology) at the two-digit level, using ISCO08 for occupations and NACE Rev. 2 for sector[7]. In the case of the ICP starting from the three digits of the original database tasks indicators are computed at 2-digit occupations (ISCO08). When the data source included the information at the individual worker level (as for the EWCS and PIAAC), also the standard deviation and number of workers in the sample are computed, for later analysis.

As previously shown in Table 1, the tasks framework has a nested structure which has been replicated in the construction of the indices from each source. In practice, while the aggregation of individual variables has been performed using the highest level of detail, the construction of indices at higher levels was carried out by simply averaging the indices below as indicated by the nested structure. This ensures that the values of the indices at higher levels are consistent with the lower levels and will allow later to break down any high-level score into its lower-level components in order to understand it better.

Once the set of possible indices from each source has been created, information from the three sources is combined by appending the three databases; next, employment weighted average tasks scores for all jobs are computed merging the complete database with employment data from an ad-hoc extraction of European Labour Force Survey (EU-LFS) 2019 at the EU-15 (minus UK) level provided at ISCO08 two digit and NACE REv.2 at the same level of detail.

Consistency across sources and variables

Before averaging scores across the three sources, a new round of consistency tests by means of correlation, principal component factor analysis and Cronbach's Alpha test - reported in Table 3 - has been performed to check whether, within and between sources, variables consistently capture the same concept and tasks dimension.

[7] Sampling weights at the individual level were used to compute weighted averages at the job level for EWCS and PIAAC.

Physical tasks

Each index belonging to physical tasks is measured using several variables from one or more sources. Strength is constructed with indicators from the EWCS and the ICP, Dexterity is constructed with indicators from the ICP and PIAAC and Navigation is constructed with two indicators from the ICP. From the pairwise correlations performed, we can observe a positive and significant association between sources for both Strength and Dexterity (0.7). Pooling together all indicators (from different sources) into a principal component factor analysis results into a single factor, indicating a strong coherence in capturing one single main dimension: physical tasks.

Intellectual tasks

The different indices referring to intellectual tasks are constructed with variables from the EWCS, the ICP and PIAAC. Also, in this case, the correlations among sources are always high. The pairwise correlations between indices from different sources are always above 0.70 with only three exceptions: technical literacy (0.53), creativity (0.59) and in the case of Conceptualization, learning and abstraction (for this index we use variables from three sources, and in two cases the correlations are lower than 0.7: the index from PIAAC and the one from the EWCS have a coefficient of 0.55, while the index from PIAAC and the one from the ICP have a coefficient of 0.56).

Using a principal component factor analysis, five factors (82% of variance explained) emerge, confirming the multifaceted character of intellectual tasks. More than sorting indicators according to the conceptual framework, factor analysis bundles indices built within the same source, although not perfectly. Therefore, Factor 1 includes all ICP indices but Visual/auditory and Analytical numeracy; Factor 2 and 3, include PIAAC indices differentiating between all components for Numeracy and Business literacy on the one hand and literacy and conceptualization on the other. Factor 4 accounts for visual/auditory processing of uncodified information, as well as technical literacy and analytical numeracy from the ICP. It is worth noticing that the correlation between visual and auditory processing of uncodified information and all five factors is rather low compared to all other indices, confirming its peculiarity within the Intellectual bundle of tasks. Finally, Factor 5 includes both creativity and conceptualization built using the EWCS.

Social tasks

Social tasks are measured both in PIAAC and the ICP, apart from serving/attending and caring which are only available in the ICP database. The indicators are all positively and significantly correlated with each other although with different degrees. Between sources, each pair of indicators is highly correlated (0.6 or more), for example the correlation between the ICP and PIAAC indicator for managing/coordinating is 0.68 while for training/coaching it reaches 0.8. Using a principal component factor analysis, two factors emerge: the first capturing teaching/training, managing/coordinating and selling/influencing from both sources; the second capturing serving/attending and caring activities only present in the ICP.

Methods of work

Autonomy is consistently measured across the three sources and the indicators are highly correlated with each other. At the same time, latitude is negatively correlated with routine and teamwork at least using the indicator from PIAAC. The same holds for routine and its sub-indicator repetitiveness positively and significantly correlated across sources. In line with expectations, repetitiveness and uncertainty are negatively correlated with all variables measuring latitude and control but also teamwork in most of the cases.

The factor analysis returns quite consistent results. Three factors emerge. The first groups indicators for latitude and control, the second captures routine and the third teamwork. The indicator for uncertainty negatively correlates with all the three factors, as could be expected. It is worth highlighting that the relative lower level of the Alpha Cronbach's test for methods of work compared to the other dimensions is a reasonable result. In fact, the three indicators (routine, teamwork and autonomy) relate to three qualitative different aspects of work organisation (whereas the sub-components of the other indices are related to the same underlying factors/concepts).

Tools

Use of non-digital machines is measured in the EWCS and the ICP, and the correlation analysis shows a positive and significant association between the two sources (0.72). As expected, the two measures are instead negatively correlated with all other indicators capturing the use of digital tools at work. High consistency is also found for the ICT indicator for which the correlation among three sources is above 0.7. A similar conclusion applies to the sub-indicator for advanced ICT tool measured both in the ICP and PIAAC. Lastly, the principal component factor analysis is coherent with outcomes of the pairwise correlation, grouping indicators into two main factors: the first factor groups non-digital machines for both the ICP and PIAAC; while the second factor bundles all the indicators related to digital tools across sources.

Table 3: Cronbach's Alpha test across sources and task macro-dimension

	Physical	Intellectual	Social	Methods	Tools
Alpha Test	0.77	0.96	0.87	0.71	0.86

Source: *ICP 2012, EWCS 2015 and PIAAC (1st cycle)*

After showing consistency within indicators belonging to each dimension, a factor analysis has been performed on the entire framework to capture how indicators sort together exhibiting conceptual coherence. According to the analysis (see Table A2), most of intellectual tasks measuring literacy and numeracy get grouped together with the use of basic ICT tools, while the majority of intellectual tasks measuring problem solving, latitude and control, as well as social tasks for teaching, selling/influencing and managing are grouped into a second factor. A third factor includes business literacy, information search and retrieval and advanced ICT use. Then, the fourth factor captures physical tasks together with use of non-digital machines. Finally, caring and serving/attending are grouped together, as well as all indicators forming the routine measure. In sum, this factor analysis of all the low-level indicators overlaps with the structure of the taxonomy to a significant extent (confirming the validity of the underlying model of task contents, methods and tools), but also reveals interesting patterns of correlation between different branches of the taxonomy that reflect how different types of task contents, methods and tools are bundled in real-life jobs and workplaces. In a later section, we discuss this bundling issue in more detail.

Describing the distribution of employment from a task perspective

The methodology adopted in the previous section allows to transform our tasks taxonomy into a comprehensive tasks database at the EU-15 (minus UK) level, using jobs (defined as two-digit occupation by two-digit sector pairs) as unit of analysis.

To start from the aggregate picture, Figure 1 shows summary statistics, including the average task scores for all workers in all jobs in the EU-15 and information about the dispersion of values around the mean. This figure has been constructed averaging each task score across all jobs weighted by their employment level in the EU-15 (minus UK) in 2019. This way we can get an approximation to the task profile of the average worker in Europe. In terms of the content of work, it can be noted that the most frequent type of tasks in European employment is intellectual (in particular, problem-solving tasks), whereas physical tasks have a much lower prevalence and social tasks are somewhere in between. The dispersion of values around the mean and their distribution also vary significantly across task categories. Some problem-solving tasks (conceptualization, learning and abstraction and creativity), autonomy, teamwork and standardisation have high scores and a low dispersion and are thus very widespread task types (all jobs have those types of tasks contents). On the other hand, business and humanities literacy and information search and retrieval have high scores but high dispersion, suggesting a more polarised distribution (some jobs have a lot of task content of those types, other jobs very little).

Among the three subdimensions of physical tasks, dexterity has the highest prevalence and strength the lowest one. When we explore the distribution of physical dexterity by occupation, as expected it emerges that highest scores are found for market-oriented foresters, fishers and hunting workers, as well as metal, machinery and related trades workers, but also health (associated) professionals.

Intellectual tasks exhibit overall high average values, compared to physical and social ones, suggesting that most of European workers perform some intellectual tasks in the execution of their duties at work. However, it is more likely that a worker is engaged in problem solving activities than in the processing of codified information (whether literacy or numeracy related). This finding should not come as a surprise if information processing is interpreted as the use of explicit knowledge for specific work activities, while problem solving involves both explicit and tacit knowledge. According to this interpretation, the processing of codified information, like reading/writing whether for general and/or specialised purposes, characterises the job of fewer workers who belong more likely to the middle and top of the occupational distribution (from managers to clerks). On the contrary, activities involving conceptualisation/learning and creativity (even if they are not embedded into formalised activities) are more widespread across occupations. This interpretation finds preliminary confirmation in the summary statistics reported in Figure 1, according to which information gathering and evaluation, and creativity and resolution, show high average values but low dispersion, while the relative dispersion for literacy and numeracy is higher. The distribution of intellectual tasks by occupational breakdown reported in Table A3 also supports these arguments. High levels of information gathering, and creativity and resolution characterize not only managers, professionals and clerks but also protective service workers, handicraft and printing workers electrical and electronic trades workers and subsistence farmers, fishers, hunters and gatherers. The same does not hold with respect to (codified) information processing, whose score is high only for the former group.

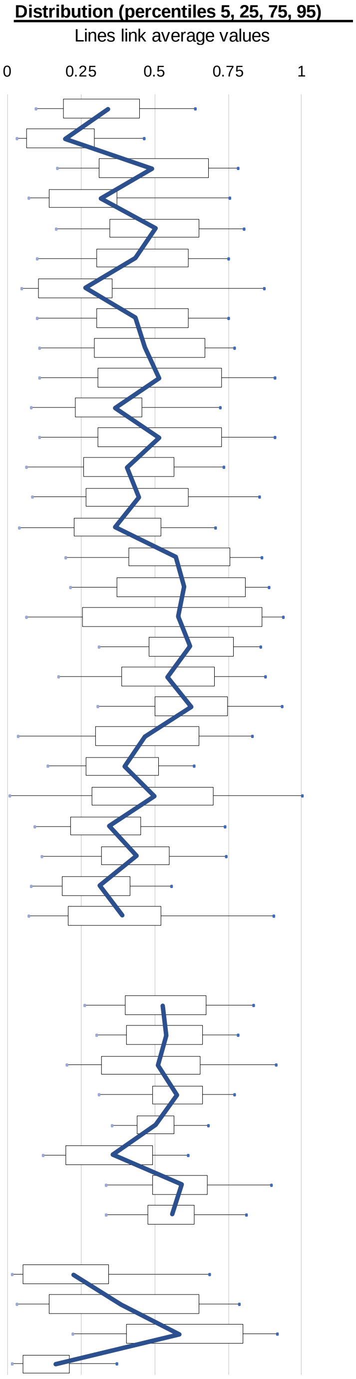
Serving/attending is the type of social task that is more common in European employment, while managing/coordinating is the least frequent. The structural shift from manufacturing to service activities partly explains the relatively high frequency of social tasks in European employment. This historical shift, even considering the wide heterogeneities across European countries, results into a high share of employment occupied in activities requiring contact with the public. An extreme example is provided by sales workers (the occupation with highest values for serving/attending), counting 10,5 million workers in 2019. But hospitality, retail and other services managers, health professionals, customer services clerks, personal service workers and street and related sales and service workers also require an intense use of these tasks. In line with expectations, managing and coordinating activities are on average less frequent, reflecting the concentration of hierarchical power within organisations.

In terms of the methods of work, aggregate figures feature relatively high levels of autonomy and teamwork, but also some routine (in particular, with respect to work standardisation). Teamwork and, more markedly, autonomy display higher dispersion compared to routine indicators, suggesting a more polarised distribution for the first two tasks. High scores of autonomy mostly characterise managerial and professional occupations, and to a lower extent electrical and electronic trades workers, but also handicraft and printing workers and market-oriented agricultural workers. From a qualitative point of view, autonomy for managers is different than for electricians: indeed, the latter are relatively more often self-employed or micro-entrepreneurs bearing mainly external control, from clients or customers. Managers or chief executives, instead, enjoy great autonomy within a more complex organisation. On the other hand, our evidence is in line with evidence presented in the European Jobs Monitor 2016 (EJM 2016), according to which tasks are generally highly standardised along the entire occupational distribution, although less repetitive. This is a quite interesting result being routine the most debated job attribute in tasks-analysis. According to our data, only very few but relevant occupations, such as personal care workers and sales workers, show levels of standardisation more than one standard deviation below the average score. Yet, being standardised does not necessarily imply high levels of repetitiveness, as it is the case for different professional occupations. In short, while repetitive activities usually imply high levels of standardisation (as in the case of stationary plant and machine operators), the opposite is not necessarily true (see for instance science and engineering associate professionals). This peculiar distribution of indicators measuring routine across occupations (see Figure 5 in the appendix) result in an overall indicator with low variability. As already discussed, this outcome is not a weakness of our measure but rather the consequence of the different ways in which standardisation and repetitiveness behave across different occupations.

Finally, in terms of the tools used at work, computing devices and in particular basic ICT are much more frequent than analog machines but also than advanced ICT tools, which is not surprising. High scores in the use of basic ICT mostly characterise managerial and professional occupations and clerks, and to a lower extent protective service workers and electrical and electronic trades workers. The way ICT Tools distribute across occupations and its association with other task indicators is of paramount importance to understand how tasks bundle together within occupations. From this perspective, our results are in line with the recent literature pointing to a positive association between standardisation and ICT (Bisello et al., 2019). This is the case for different categories within the Technical and Associate professionals group, as well as for Numerical and material recording clerks. At the same time, these are occupations showing higher levels of different types of intellectual tasks. According to this evidence, the relationship between basic ICT deployment, content and methods of work is less straightforward. Relatively high complex intellectual tasks can be simultaneously complementary to information technologies and standardised practices, and therefore routine. Another interesting result, also coherent to some extent with Bisello et al. (2019), refers to the relationship between the use of ICT tools and social tasks. While high levels of managing and coordinating are associated with high level of ICT use, the opposite does not hold, suggesting that the concentration of managerial power is unrelated to technological complementarities. Furthermore, while in general selling and influencing activities are positively correlated with ICT use, serving and attending ones do not, especially in the case of clerical workers.

Figure 1: Average task scores for EU-15, 2019

Task indices	Summary statistics		
In terms of the content of work:	**Mean**	**Std dev**	**CV**
1. Physical	0.34	0.17	0.51
a. Strength	0.20	0.14	0.70
b. Dexterity	0.49	0.21	0.43
c. Navigation	0.32	0.20	0.64
2. Intellectual	0.50	0.19	0.39
a. Information processing	0.44	0.20	0.45
I. Visual and/or auditory processing of uncodified/unstructured ir	0.26	0.21	0.82
II. Processing of codified information	0.44	0.20	0.45
i. Literacy	0.47	0.21	0.45
a. Business	0.52	0.25	0.49
b. Technical	0.37	0.17	0.47
c. Humanities	0.52	0.25	0.49
ii. Numeracy	0.41	0.20	0.49
a. Accounting	0.45	0.23	0.52
b. Analytic	0.36	0.20	0.54
b. Problem solving	0.57	0.21	0.37
I. Information gathering & evaluation	0.60	0.24	0.39
i. Information search and retrieval	0.58	0.31	0.54
ii.Conceptualization, learning and abstraction	0.62	0.18	0.29
II. Creativity and resolution	0.54	0.21	0.39
i. Creativity	0.62	0.18	0.29
ii. Planning	0.47	0.25	0.54
3. Social	0.40	0.15	0.39
a. Serving/ attending	0.50	0.27	0.53
b. Teaching/ trainin/ coachig	0.35	0.19	0.56
c. Selling/ influencing	0.44	0.19	0.42
d. Managing/ coordinating	0.31	0.16	0.50
e. Caring	0.39	0.25	0.63
In terms of the methods and the tools of work			
1. Methods			
a. Autonomy	0.53	0.19	0.35
I. Latitude	0.54	0.16	0.29
II. Control (in reverse)	0.51	0.23	0.45
b. Teamwork	0.57	0.14	0.25
c. Routine	0.50	0.10	0.20
I. Repetitiveness	0.36	0.16	0.46
II. Standardization	0.59	0.17	0.28
III. Uncertainty (in reverse)	0.56	0.15	0.26
2. Tools			
a. Non-digital machinery (analog)	0.22	0.22	0.99
1. Computing devices	0.39	0.26	0.67
a. Basic ICT	0.59	0.23	0.39
b. Advanced ICT	0.16	0.15	0.88



Note: *Employment shares in each job derived from the EULFS 2019 data were used for weighting the indices.*

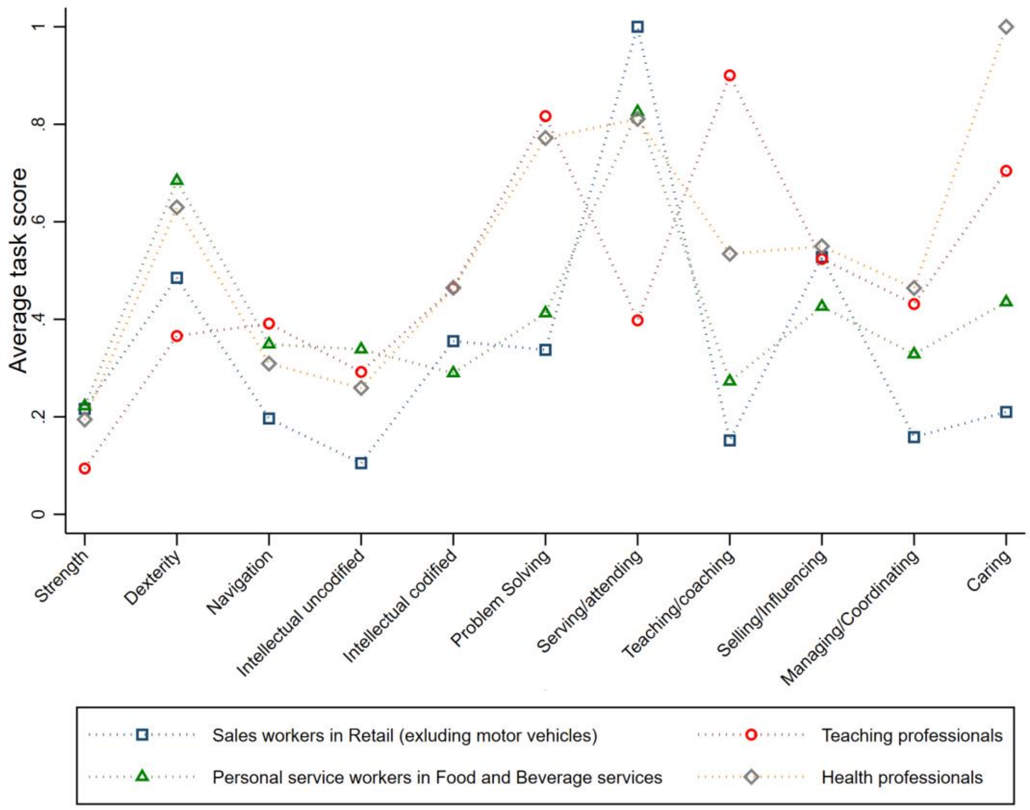
Source: *JRC – Eurofound European database of tasks indices.*

An inspection of the task profile of 4 significant jobs

Sorting jobs according to their employment size, the four biggest jobs, i.e., those employing the highest number of workers at the EU-15 level, are sales workers in retail trade (except motor vehicles); teaching professionals in education, personal service workers in food and beverage service activities, and health professionals in human health sector. Because of their importance in terms of employment, the comparison of tasks profiles among these jobs is very illustrative (see Figure 2 and Figure 3), although not representative of the overall employment structure. For instance, these jobs all refer to the service sector but very different economic activities; while looking at the vertical division of labour it can be appreciated that the occupational component varies considerably among them.

The distribution of social and intellectual tasks varies more than physical ones across the four jobs. In terms of the latter, there is relative similarity in terms of strength and navigation, while more heterogeneity is found for dexterity, being higher for health professionals and personal service workers. As for intellectual tasks, sales workers show on average less intensity across all indices, while health and teaching professionals are characterized by very high levels of problem solving. Figure 2 also shows average distributions for social tasks which are highly heterogeneous across jobs. First, each job is characterised by a very high (above 0.8) intensity in at least one of the social tasks included in the framework. Second, apart from sales workers, most social activities are carried with medium or high intensity pointing to a multifaced profile among big jobs. Exceptions refer to selling/influencing and managing/coordinating, the former being similar across the four illustrated jobs, while the latter being significantly lower for sales worker with respect to the other jobs.

Figure 2: Tasks profile in terms of content across big jobs



***Source**: JRC – Eurofound European database of tasks indices*

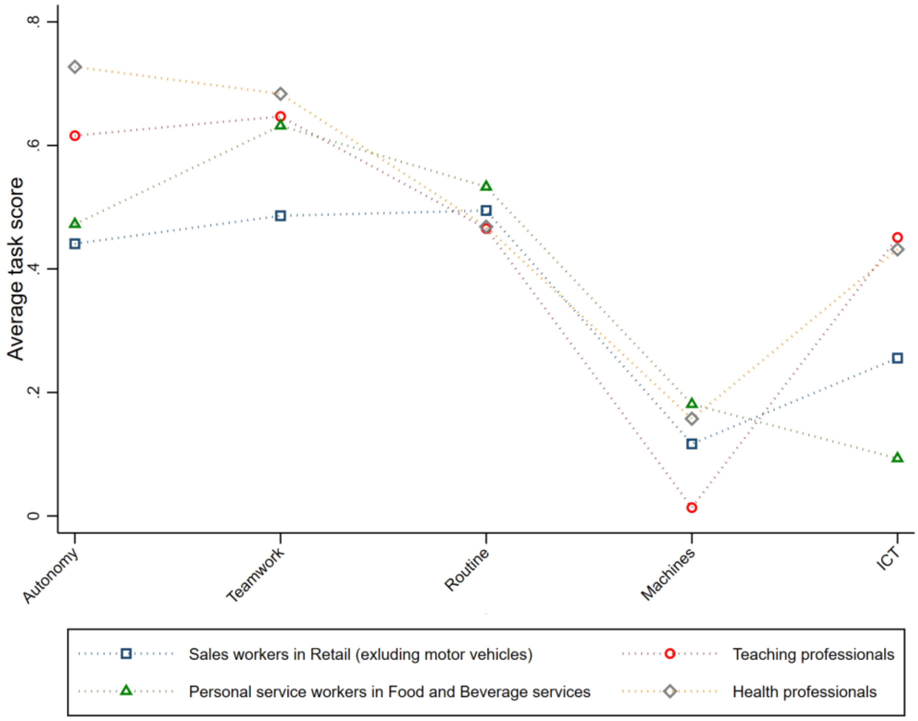
Looking at methods of work, while average scores for autonomy and teamwork differ, the level of routine is quite similar and above 0.6 across the four big jobs. The lower dispersion of routine among these jobs results from the construction of the index as the average of repetitiveness, standardisation and uncertainty (in reverse).[8] More specifically, while for Sales and Personal service workers the levels of repetitiveness and standardisation are similar, for Professionals it is not,

[8] See Figure 5 in Appendix for detailed scores across Occupations.

therefore averaging them reduces the overall dispersion. Still, similar average scores of routine tasks across occupations is an interesting result challenging the idea that workers performing more complex intellectual tasks, like problem solving, would be characterized by less routine. Once routine is measured as a multi-dimensional concept, this claim holds only for the case of repetitiveness, but not for standardization or uncertainty. Furthermore, Sales and Personal care workers are endowed with less autonomy, while only Sales workers also show low levels of teamwork compared to the others. In any case, while task contents are very strongly associated to occupational demarcations and thus the differences in task content indicators across occupations are very significant, task methods are determined by different forms of work organization which are not so occupation-specific, but instead determined by issues such as establishment size, cultural norms or industrial relations systems. The indicators of task methods, in other words, do not vary so much across occupations but across countries, sectors or different types of establishments.

Finally, figure 3 reports average scores for tools used at work. Overall, machinery is less used than ICT, which is not surprising as the use of machines characterize manufacturing and agricultural activities more than the service sector. However, even the use of ICT is quite heterogeneous across jobs, with teaching and health professionals characterized by substantial higher levels of use compared to sales and personal care workers.

Figure 3: Tasks profile in terms of methods of work and tools use across big jobs



***Source**: JRC – Eurofound European database of tasks indices*

This analysis of the tasks profile across relevant jobs at the European level is quite consistent with similar analysis performed in the European Job Monitor 2016. While evidence presented in this paper is qualitatively in line with the abovementioned work, with relevant jobs preserving their ordinal position for each indicator, our data show different cardinality within this rank. For example, Sales workers are endowed with lower autonomy levels than Teaching and Health Professionals in both studies; however, the differences in absolute score is higher in our data than in EJM 2016. Similar considerations apply to other indicators as ICT tools used at work as well as problem solving. This comparison shows that the new tasks database reflects higher dispersion levels in the distribution of task indicators, suggesting an improvement in overall quality of the data.

Bundling of tasks across European jobs

One of the key advantages of using a detailed and comprehensive framework rather than a general and fragmentary approach to task analysis is that it allows to evaluate thoroughly how different types of task content, methods and tools interact with each other. An initial assessment of the distribution of the task scores for individual jobs showed that the different task categories seemed to be associated in particular ways: such task interactions can be as important for characterising jobs as the individual task scores themselves, so they merit specific analysis.

Table 4 shows the bivariate correlations between all the indices in the framework, at all levels. This allows to evaluate associations among indices after the aggregation of all the three sources into final indicators. Correlations between indices at the highest level of aggregation are reported in bold, while some interesting combinations of tasks are highlighted in blue.

Correlations within domains of task content

The table shows that physical and intellectual tasks are quite consistent internally. In the case of physical tasks, which have three components, the highest correlation is between tasks that require high levels of physical exertion and stamina (referred to in the index as 'strength') and manual dexterity (0.81). Somewhat lower positive correlations, but still above 0.6, are found instead for the index of navigation, that captures tasks of a slightly different nature, such as moving objects or oneself in unstructured or changing spaces.

The much more detailed set of indicators of intellectual tasks also show quite high levels of consistency, with most bivariate correlations above 0.6. The notable exception is visual and/or auditory processing of uncodified/unstructured information, which consistently displays negative correlations with all the other indices in the intellectual domain. In strict terms it is information processing, yet it is of a fundamentally different nature from the processing of codified information (and problem solving). In light of the peculiar nature of such index, which is somewhat between physical and intellectual, it was decided not to include it neither in the index of information processing nor in the overall index on intellectual tasks. By keeping it separate (at least empirically) one can still analyse it on its own, without generating meaningless average values.

Social task content, on the other hand, is less internally consistent, except in the categories of managing/coordinating and teaching/coaching or selling/influencing, which often coexist in the same jobs (correlations above 0.7 in the case of both combinations). The tasks of serving and attending are meaningfully related only with selling/influencing, while they display much lower correlations with other social tasks. Finally, caring is certainly the most unique type of social work activity: indeed, providing for the welfare needs of others is a stand-alone task that is not often combined with others. Consequently, even though all the categories of tasks included within the social domain are conceptually related, they are generally not all bundled together in the same jobs.

Correlation between indices of task content

In terms of task content, and in line with expectations, physical tasks are negatively correlated with intellectual tasks (-0.64) and to a lesser extent to social tasks (-0.52). This means that jobs that involve a significant amount of physical tasks tend to involve less intellectual or social tasks, and vice versa. This is particularly the case for physical strength, while less so for navigation. The notable exception is clearly visual/auditory processing of uncodified information, as already anticipated above. This intellectual index is indeed strongly linked to physical tasks (especially navigation, 0.95) because it refers to the physical act of perceiving the environment, and therefore is a crucial component of "hand-eye coordination". Finally, it is interesting to note there are some interesting distinctions: for instance, technical literacy tasks are not so negatively correlated with physical dexterity or navigation tasks. This brings the overall correlation down to only -0.33, suggesting that some physically intensive jobs require technical literacy as well.

On the other hand, social tasks tend to show positive correlations with intellectual tasks (0.66), although again with some important distinctions at a higher level of disaggregation. Overall, managing/coordinating and selling/influencing display more consistently high positive correlations with almost all intellectual tasks (notably in terms of problem-solving), with the partial exceptions of technical literacy and to a lesser extent analytic numeracy. On the contrary, serving/attending and caring show the weakest positive correlations with intellectual tasks indices, and at times even negative (there is for instance a clear negative association between numeracy tasks and caring). It is no surprise that serving and caring are also showing much milder negative correlations with physical tasks.

The remaining category of social tasks, teaching, is somewhere in the middle: it is positively and strongly associated with problem solving tasks, but much less with information processing. Finally, all social tasks correlate negatively with visual/auditory processing of uncodified information, although to a less extent compared to intellectual tasks (the correlation is almost 0 for caring tasks).

Correlation between the task content and the task methods and tools

The correlation between the task content and the task methods and tools domains also reveals some interesting patterns. Physical tasks tend to be associated with less autonomy (both in terms of latitude and control), more routine (particularly in terms of repetitiveness), high use of non-digital machinery and less use of computing devices. The opposite happens to all intellectual tasks, again with the notable exception of visual/auditory processing of uncodified information. Figure 1 displays graphically the correlations between the tree main dimensions of task content and two key indices of work methods and tools, that is routine tasks and ICT use.

In terms of methods of work, problem solving tasks are those which are more correlated with teamwork (ranging from 0.44 of creativity to 0.56 of abstraction), a dimension which is otherwise less strongly related to all other indices of task content. Technical literacy presents milder correlations with all indices of methods and tools, apart from the use of advanced ICT which stands at 0.72. Technical and numeracy (analytic) tasks are those which are less negatively correlated with routine work methods and the use of non-digital machinery, suggesting that there are several industrial-type jobs which require intellectual tasks of such kind.

Social tasks tend to be similar to intellectual tasks when it comes to correlations with tasks methods and tools, with the exception of caring and serving, which lie somewhere between physical and intellectual (less autonomy and slightly more repetitiveness, and less use computer use compared to other categories of social tasks).[9]

[9] Some of the correlations between the indices for methods and tools (not shown here) are also interesting. Autonomy is negatively correlated with routine and machinery, but positively with ICT. The relationship between routine and tools is different for the three routine components: repetitiveness is positively correlated with machinery (0.62) and negatively with ICT (-0.75); standardization and uncertainty (in reverse) display a much weaker positive correlation with machinery (0.37 and 0.28) respectively, and relates quite differently to computer use, with correlations close to zero in the former case, and around -0.41 in the latter.

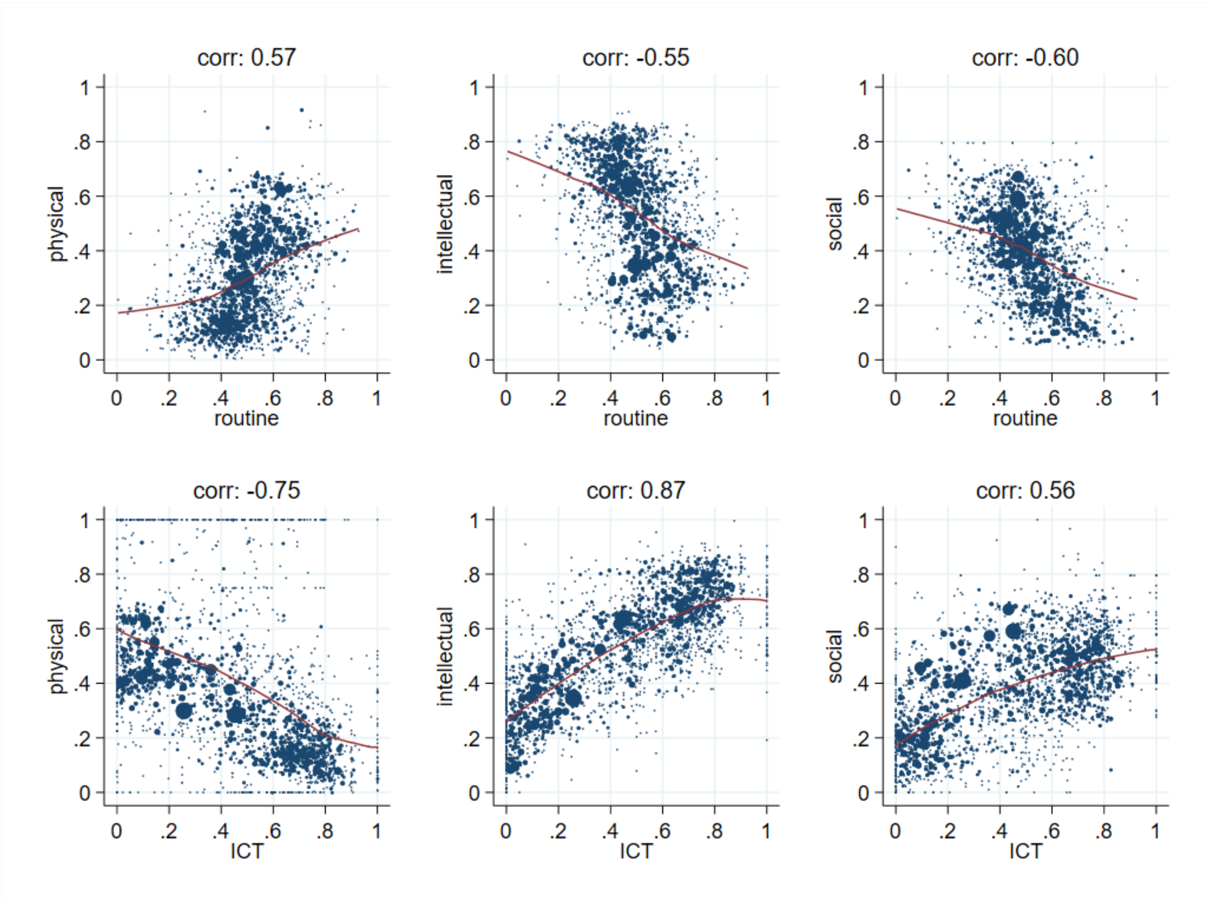
Table 4: Bivariate correlations between different task indices. [Click to enlarge it]

	1. Physical	a. Strength	b. Dexterity	c. Navigation	2. Intellectual	a. Info processing	I. Visual/auditory	II. Codified info	i. Literacy	a. Business	b. Technical	c. Humanities	ii. Numeracy	a. Accounting	b. Analytic	b. Problem solving	I. Evaluation	i. Info search	ii. Abstraction	II. Resolution	i. Creativity	ii. Planning	3. Social	a. Serving	b. Teaching	c. Selling	d. Managing	e. Caring
A. In terms of the content:																												
1. **Physical tasks:** aimed at the physical manipulation and transformation of material things:																												
a. *Strength:* lifting people and heavy loads, exercising strength.	0.89																											
b. *Dexterity:* precisely coordinated movements with hands or fingers.	0.91	0.81																										
c. *Navigation:* moving objects or oneself in unstructured or changing spaces	0.86	0.64	0.62																									
2. **Intellectual tasks:** aimed at the manipulation and transformation of information and the active resolution of problems:	**-0.64**	-0.75	-0.65	-0.48																								
a. *Information processing:*	-0.67	-0.76	-0.67	-0.52	0.95																							
I. Visual and/or auditory processing of uncodified/unstructured information*	0.84	0.63	0.63	0.95	-0.50	-0.55																						
II. Processing of codified information	-0.67	-0.76	-0.67	-0.52	0.95	1.00	-0.55																					
i. Literacy:	-0.66	-0.77	-0.68	-0.51	0.95	0.96	-0.51	0.96																				
a. Business: read or write letters, memos, invoices,…	-0.71	-0.79	-0.73	-0.57	0.91	0.94	-0.56	0.94	0.98																			
b. Technical: read or write manuals, instructions, reports, forms,…	-0.33	-0.51	-0.35	-0.20	0.77	0.75	-0.20	0.75	0.78	0.63																		
c. Humanities: read or write articles or books.	-0.71	-0.79	-0.73	-0.57	0.91	0.94	-0.56	0.94	0.98	1.00	0.63																	
ii. Numeracy:	-0.62	-0.68	-0.60	-0.48	0.87	0.95	-0.55	0.95	0.83	0.81	0.64	0.81																
a. Accounting: calculate prices, fractions, use calculators,…	-0.62	-0.66	-0.60	-0.55	0.78	0.90	-0.59	0.90	0.79	0.82	0.47	0.82	0.94															
b. Analytic: prepare charts, use formulas or advanced maths	-0.52	-0.61	-0.52	-0.34	0.86	0.87	-0.42	0.87	0.76	0.68	0.75	0.68	0.92	0.74														
b. *Problem solving:*	-0.56	-0.69	-0.57	-0.40	0.96	0.83	-0.41	0.83	0.85	0.81	0.73	0.81	0.72	0.59	0.77													
I. Information gathering and evaluation.	-0.59	-0.71	-0.61	-0.43	0.93	0.82	-0.41	0.82	0.88	0.85	0.74	0.85	0.68	0.57	0.72	0.96												
i. Information search and retrieval	-0.68	-0.74	-0.67	-0.44	0.91	0.83	-0.43	0.83	0.90	0.87	0.72	0.87	0.68	0.58	0.70	0.92	0.98											
ii. Conceptualization, learning and abstraction	-0.50	-0.60	-0.51	-0.37	0.90	0.77	-0.35	0.77	0.82	0.77	0.73	0.77	0.65	0.52	0.71	0.95	0.95	0.88										
II. Creativity and resolution	-0.51	-0.59	-0.49	-0.33	0.89	0.76	-0.36	0.76	0.74	0.70	0.65	0.70	0.71	0.57	0.77	0.94	0.81	0.75	0.85									
i. Creativity	-0.42	-0.51	-0.41	-0.24	0.77	0.62	-0.27	0.62	0.61	0.58	0.54	0.58	0.57	0.44	0.65	0.85	0.69	0.62	0.77	0.95								
ii. Planning/implementation	-0.55	-0.61	-0.52	-0.37	0.92	0.81	-0.40	0.81	0.79	0.75	0.68	0.75	0.76	0.63	0.81	0.95	0.84	0.80	0.85	0.97	0.85							
3. **Social tasks:** whose primary aim is the interaction with other people:	**-0.52**	-0.56	-0.48	-0.40	**0.66**	0.55	-0.37	0.55	0.59	0.63	0.31	0.63	0.46	0.44	0.40	0.71	0.63	0.61	0.64	0.74	0.70	0.73						
a. *Serving/attending:* responding directly to demands from public or customers	-0.35	-0.32	-0.26	-0.35	0.22	0.23	-0.30	0.23	0.24	0.33	-0.06	0.33	0.20	0.34	0.00	0.18	0.11	0.10	0.12	0.24	0.24	0.23	0.69					
b. *Teaching/training/coaching:* impart knowledge or instruct others	-0.41	-0.53	-0.43	-0.21	0.73	0.57	-0.24	0.57	0.56	0.53	0.48	0.53	0.53	0.36	0.65	0.82	0.73	0.70	0.75	0.85	0.81	0.83	0.74	0.13				
c. *Selling/influencing:* induce others to do or buy something, negotiate	-0.61	-0.64	-0.60	-0.51	0.75	0.73	-0.48	0.73	0.74	0.78	0.40	0.78	0.66	0.71	0.51	0.71	0.64	0.62	0.65	0.72	0.65	0.73	0.86	0.65	0.59			
d. *Managing/coordinating:* coordinate or supervise the behaviour of colleagues	-0.46	-0.55	-0.44	-0.31	0.82	0.74	-0.34	0.74	0.72	0.70	0.57	0.70	0.70	0.61	0.70	0.81	0.71	0.69	0.73	0.87	0.78	0.88	0.73	0.22	0.77	0.71		
e. *Caring:* provide for the welfare needs of others.	-0.15	-0.14	-0.14	-0.11	0.16	-0.04	-0.06	-0.04	0.12	0.16	-0.03	0.16	-0.20	-0.22	-0.14	0.32	0.33	0.32	0.32	0.28	0.29	0.25	0.66	0.31	0.43	0.30	0.22	
B. In terms of the methods and tools of work:																												
a. *Autonomy*	**-0.49**	-0.58	-0.47	-0.41	**0.81**	0.73	-0.40	0.73	0.72	0.72	0.51	0.72	0.67	0.62	0.63	0.81	0.68	0.65	0.71	0.89	0.83	0.88	**0.69**	0.37	0.66	0.75	0.79	0.20
I. Latitude: ability to decide working time, task order, methods and speed.	-0.52	-0.59	-0.52	-0.43	0.83	0.77	-0.45	0.77	0.77	0.77	0.55	0.77	0.71	0.66	0.66	0.81	0.71	0.69	0.73	0.86	0.81	0.84	0.61	0.24	0.61	0.70	0.77	0.15
II. Control (in reverse): direct control by boss or clients, monitoring of work.	-0.49	-0.54	-0.43	-0.37	0.75	0.66	-0.35	0.66	0.65	0.65	0.46	0.65	0.61	0.57	0.58	0.77	0.63	0.57	0.67	0.85	0.78	0.85	0.73	0.43	0.66	0.75	0.78	0.21
b. *Teamwork:* extent to which the worker has to collaborate and coordinate her actions with other workers	**-0.12**	-0.19	-0.11	-0.12	**0.46**	0.36	-0.12	0.36	0.39	0.34	0.42	0.34	0.30	0.20	0.38	0.52	0.51	0.48	0.56	0.49	0.44	0.49	**0.42**	0.11	0.50	0.34	0.50	0.24
c. *Routine*	**0.57**	0.54	0.61	0.39	**-0.55**	-0.50	0.39	-0.50	-0.56	-0.60	-0.27	-0.60	-0.40	-0.41	-0.32	-0.55	-0.55	-0.55	-0.51	-0.50	-0.46	-0.50	**-0.60**	-0.38	-0.42	-0.60	-0.42	-0.40
I. Repetitiveness: extent to which the worker has to repeat the same procedures	0.69	0.73	0.74	0.41	-0.79	-0.72	0.44	-0.72	-0.76	-0.76	-0.53	-0.76	-0.61	-0.55	-0.61	-0.80	-0.78	-0.77	-0.73	-0.73	-0.64	-0.75	-0.66	-0.24	-0.66	-0.70	-0.62	-0.36
II. Standardisation: extent to which work procedures and outputs are predefined and encoded in a formalised system	0.08	0.06	0.14	0.02	0.15	0.14	0.02	0.14	0.09	0.01	0.29	0.01	0.19	0.09	0.28	0.15	0.13	0.08	0.20	0.15	0.12	0.17	-0.09	-0.25	0.14	-0.05	0.19	-0.22
III. Uncertainty (in reverse): extent to which the worker needs to respond to unforeseen situations	0.33	0.25	0.29	0.32	-0.43	-0.40	0.31	-0.40	-0.42	-0.42	-0.30	-0.42	-0.35	-0.34	-0.31	-0.43	-0.41	-0.36	-0.45	-0.40	-0.38	-0.40	-0.40	-0.24	-0.28	-0.41	-0.41	-0.18
a. *Non-digital machinery (analog)*	**0.71**	0.59	0.69	0.59	**-0.42**	-0.38	0.63	-0.38	-0.43	-0.53	-0.04	-0.53	-0.30	-0.35	-0.19	-0.42	-0.42	-0.44	-0.35	-0.38	-0.38	-0.35	**-0.66**	-0.52	-0.39	-0.59	-0.29	-0.53
b. *Digitally-enabled machinery (non-autonomous computing devices)*	**-0.75**	-0.81	-0.78	-0.58	**0.87**	0.88	-0.58	0.88	0.91	0.90	0.66	0.90	0.77	0.72	0.72	0.79	0.83	0.84	0.76	0.66	0.55	0.70	**0.56**	0.24	0.54	0.68	0.60	0.14
a. Basic ICT (generic office applications)	-0.63	-0.70	-0.69	-0.47	0.85	0.84	-0.50	0.84	0.86	0.85	0.63	0.85	0.75	0.69	0.71	0.78	0.78	0.77	0.74	0.71	0.64	0.73	0.56	0.20	0.59	0.67	0.65	0.15
b. Advanced ICT (programming, admin)	-0.50	-0.58	-0.48	-0.40	0.66	0.63	-0.37	0.63	0.64	0.55	0.72	0.55	0.56	0.39	0.67	0.64	0.66	0.67	0.63	0.57	0.49	0.59	0.26	-0.02	0.43	0.30	0.42	-0.01

Note: *The visual/auditory tasks index is considered as separate index and not included in the aggregate index on information processing (which therefore only refers to processing of codified information) and the overall intellectual index.*

Source: *JRC – Eurofound European database of tasks indices*

Figure 4: Selected bivariate correlations between task content and routine/ICT tasks



Source: *JRC – Eurofound European database of tasks indices*

Final remarks

Since the main aim of this paper is to present a new database of tasks across occupations for public use (and provide details on its construction and main characteristics) there are no conclusions as such. We just hope that, as the previous version of the database, other researchers will find it useful for their own purposes, and that it can contribute to a better understanding of work and its relation with technology in European labour markets. However, we can conclude with some final remarks to emphasize three points that we consider important.

First, the main value of this database is that it is built upon a coherent and comprehensive taxonomy of tasks contents, methods, and tools (Fernández-Macías and Bisello 2020). Although future users of this data are likely to focus on specific indicators or dimensions depending on their research interests, we would like to encourage them to always take into account the complementarities and associations between different categories and dimensions of tasks. As we have illustrated in different parts of this paper, tasks are not isolated forms of labour input that just happen to be in productive processes but building blocks of coherently constructed jobs which are embedded in productive organisations. Any analysis of tasks which focuses on a particular type in isolation risks missing important connections with other types of task content and forms of work organisation.

Second, the database presented in this paper covers the entire EU15 (minus the UK) with a single vector of tasks, without differentiating by country. Thus, possible differences between the task contents, methods and tools across different countries are missing from the database. Previous analysis (Fernández-Macías et al. 2016a; Fana et al. 2020) has shown that the task contents of occupations (the dimensions of physical, intellectual and social tasks in our taxonomy) are much less country-specific than the dimensions of methods (work organisation) and tools (technology). This is because task contents are more directly linked to the material contents of jobs and to the technical division of labour, whereas work organisation reflects cultural and institutional differences whereas technology use reflects economic development. For these reasons, we encourage future users of this database to complement it with the companion country-specific database of tasks contents, methods and tools in five European countries (Fana et al. 2020). Although this companion country-specific database is less rich in detail and depth than the European database presented in this paper, it is still a useful complement to test for possible country variations in the task indicators of our taxonomy.

A final remark concerns the possibility of a dedicated European survey of task contents, methods and tools. The database presented in this paper (and the companion country-specific database discussed in the previous paragraph) will surely be a useful resource for a better understanding of work in European labour markets, but it still has some limitations that could only be overcome with a new dedicated survey on tasks in Europe. We hope that our contribution raises awareness of the importance of having good and detailed measures of tasks contents, consistently measured at the individual worker level and at different points in time, in order to understand better how technical change and other factors are continuously changing the nature of work and the associated skills demand and job quality. A future European tasks survey could precisely provide that.

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Annex 1

Table A 1: Publications based on the taxonomy developed by Fernández-Macías et al. (2016a and 2016b) and Fernández-Macías and Bisello (2020) and/or version 1.0 of the European task database

Source	**Application**
What do Europeans do at work? A task-based analysis: European Jobs Monitor 2016 (Fernández-Macías et al. 2016a).	They present the framework of version 1.0 of the European task database and use this data for the analysis of the distribution and evolution of task content, methods and tools in Europe.
Skills forecast: trends and challenges to 2030 (Cedefop and Eurofound 2018).	Projections of employment and skills for the future. The authors investigate which tasks will be performed in jobs up to 2030.
Cedefop's Skills Panorama: Tasks within occupations.	The authors analyse the importance of various tasks required for occupations at the 2-digit ISCO code level.
EULFS: ad hoc module on *job skills* (forthcoming).	Special module on tasks at work. Module to be implemented in 2022 (for more info see I and II).
The tasks content and dynamics of the occupations in Spain (Torrejón, 2019).	An analysis of the relationship between the task content of occupations and its trajectory in Spain (1995-2010)
Vulnerable occupations and workers (Torrejón Pérez, 2017).	The author creates an index (IRR) that measures which are the occupations and workers facing a higher risk to be replaced.
Does AI Qualify for the Job? A Bidirectional Model Mapping Labour and AI Intensities (Martínez-Plumed et al., 2020).	They analyze (1) what impact current or simulated AI research activity has or would have on labour-related tasks and occupations, and (2) what areas of AI research activity would be responsible for a desired or undesired effect on specific labour tasks and occupations.
A comparative national tasks database (Fana et al., 2020).	Building a comparative tasks database based on national sources for 5 EU countries, the authors study how employment distribute in terms of both tasks content and organizational methods within and across those countries.
Future Employment and Automation (Suta et al., 2018).	The authors provide an estimate of the share of future job openings in the EU at high risk of automation.
The wage and task profiles of employment in Europe in 2030 (Storrie and Anton, 2018).	This report examines the projected structural change for the wage and task structure of employment in EU Member States, up to 2030.
Do old and new labour market risks overlap? Automation, offshorability, and non-standard employment (Malo and Cueto, 2019).	This article analyses analyse the relationship between the risk of automation and offshorability and the type of contact in the case of Spain.
How computerisation is transforming jobs (Bisello et al. 2019).	This paper analyses changes in the task content, methods and tools of European jobs from 1995 to 2015.
EU Jobs at Highest Risk of Covid-19 Social Distancing: Will the Pandemic Exacerbate Labour Market Divide? (Pouliakas and Branka, 2020)	The authors identify individual and job factors most likely to be impacted by social distancing measures and practices due to the Covid-19 pandemic.
Teleworkability and the COVID-19 crisis: a new digital divide? (Sostero et al., 2020)	The authors assess which jobs can be done from home and those that cannot, and on this basis quantify the fraction of employees that are in teleworkable occupations across EU countries, sectors and socio-economic profiles.
Measuring the Occupational Impact of AI: Tasks, Cognitive Abilities and AI Benchmarks (Tolan et al., 2020)	The authors analyse the impact of AI on occupations, by identifying the abilities through which AI is most likely to affect jobs.

Table A 2: Principal component factor analysis over the entire framework

Variable	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Uniqueness
physical	-0.2253	-0.4274	-0.7994	-0.1896	-0.1768	0.0914	-0.0346	0.0509
strength	-0.2849	-0.4285	-0.612	-0.2957	-0.1916	0.1578	0.0312	0.2106
dexterity	-0.1536	-0.4296	-0.5949	-0.1728	-0.2404	0.1264	-0.0236	0.3337
navigation	-0.1866	-0.2764	-0.8665	-0.0738	-0.0368	-0.0213	-0.0773	0.1248
intellectual	0.5808	0.6362	0.2783	0.3811	0.1093	-0.0484	0.1109	0.0087
inforproc	0.4339	0.81	0.2816	0.2467	0.02	-0.0529	0.069	0.0075
uncodified	-0.1998	-0.3444	-0.8342	-0.0741	0.0116	-0.001	-0.0989	0.1301
codified	0.4339	0.81	0.2816	0.2467	0.02	-0.0529	0.069	0.0075
literacy	0.3873	0.7483	0.2851	0.3456	0.1851	-0.0737	0.0674	0.0451
business	0.3604	0.7471	0.3585	0.1929	0.2763	-0.1016	0.0885	0.0517
technical	0.3093	0.4463	-0.0494	0.659	-0.1619	0.0394	-0.023	0.2401
humanities	0.3604	0.7471	0.3585	0.1929	0.2763	-0.1016	0.0885	0.0517
numeracy	0.4449	0.8052	0.2549	0.1273	-0.147	-0.0277	0.0649	0.0459
accounting	0.3685	0.8306	0.3064	-0.0787	-0.0336	-0.0643	0.0779	0.0628
analytic	0.4719	0.6483	0.1505	0.3665	-0.2668	0.0227	0.0385	0.1269
probsolving	0.6728	0.4205	0.2527	0.4773	0.1848	-0.0402	0.1415	0.023
evaluation	0.4057	0.46	0.3036	0.6148	0.2586	-0.0432	0.1538	0.0613
infogath	0.2946	0.4872	0.3453	0.6039	0.2787	-0.0784	0.0894	0.1
conceptual~n	0.5227	0.3495	0.1928	0.5419	0.1886	0.019	0.2337	0.1833
resolution	0.8509	0.332	0.1733	0.2874	0.0914	-0.0324	0.1127	0.031
creativity	0.8304	0.203	0.1468	0.2641	0.106	-0.0395	0.1428	0.1447
planning	0.8055	0.4037	0.1806	0.2842	0.0742	-0.0249	0.0824	0.0618
social	0.6644	0.3868	0.1805	-0.0336	0.5724	-0.0739	0.0575	0.0388
serving	0.3614	0.1631	0.2592	-0.3704	0.5496	-0.1106	-0.0616	0.3203
teaching	0.7024	0.3709	0.0402	0.2818	0.2049	0.0406	0.1009	0.2343
selling	0.5934	0.545	0.2162	-0.0904	0.3848	-0.0804	0.0627	0.1374
managing	0.7132	0.5039	0.0174	0.0577	0.1332	0.0244	0.1483	0.1934
caring	0.2346	-0.0733	0.1029	0.1369	0.8609	-0.1267	0.0073	0.153
autonomy	0.8788	0.3328	0.204	0.0737	0.1133	-0.0822	0.0235	0.0497
latitude	0.7639	0.3825	0.2409	0.1294	0.1204	-0.1354	0.0601	0.1589
control	0.8947	0.2732	0.1631	0.029	0.0999	-0.0388	-0.004	0.0859
team	0.1691	0.2353	-0.1699	0.3636	0.1736	0.2283	0.4654	0.4561
routine	-0.2476	-0.2131	-0.1698	-0.0852	-0.131	0.8213	-0.3985	0.0067
repetitiv	-0.4651	-0.3763	-0.2534	-0.235	-0.2324	0.398	0.0034	0.3102
standard	0.0905	0.0293	0.0236	0.052	-0.0739	0.8992	0.1113	0.1613
certainty	-0.195	-0.1298	-0.141	-0.0314	0.0291	0.1561	-0.8773	0.1295
machines	-0.1825	-0.2834	-0.5888	-0.0448	-0.5088	0.2982	-0.0124	0.1897
ICT	0.2555	0.5824	0.4466	0.3244	0.2082	-0.049	0.1314	0.2279
ICTbasic	0.2676	0.6437	0.2749	0.2354	0.2435	-0.0513	0.0351	0.3199
ICTadvanced	0.2668	0.1557	0.3492	0.6846	-0.1694	-0.0537	-0.0806	0.2759

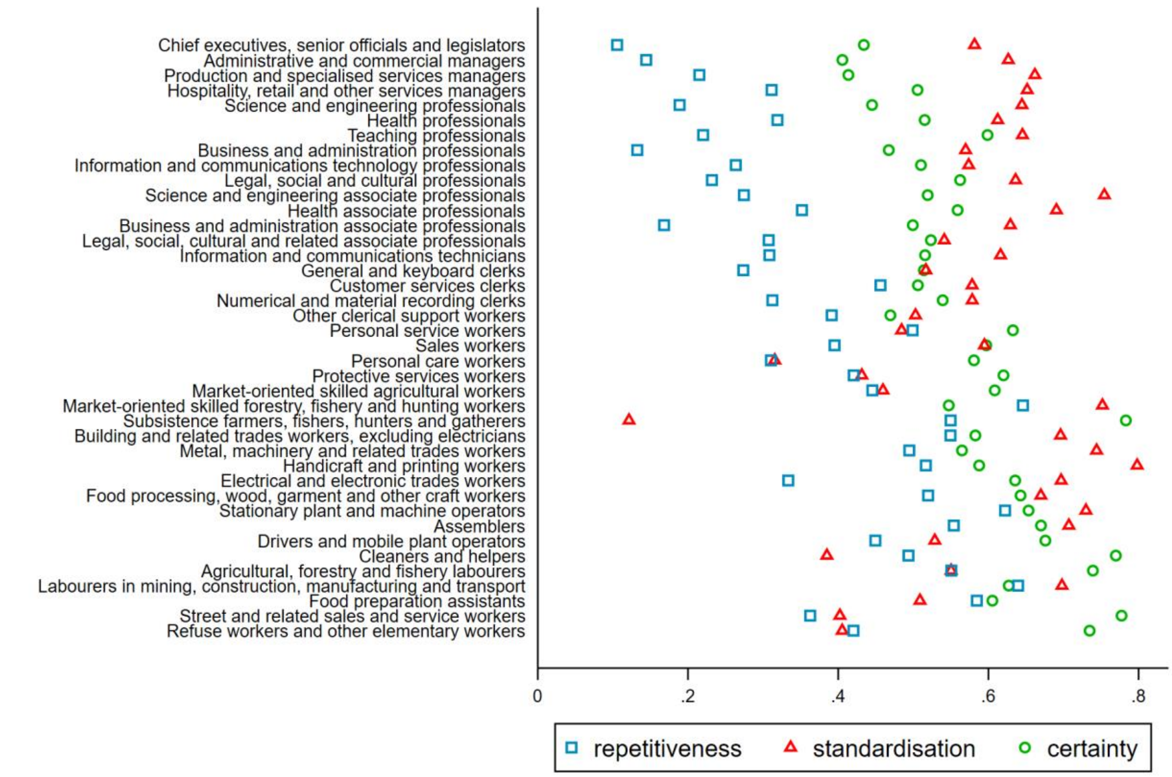
***Source**: JRC – Eurofound European database of tasks indices*

Table A 3: Distribution of task scores by occupations at ISCO08 two-digit level. [Click to enlarge it]

Occupation (ISCO-08, 2 digits)	1. Physical	a. Strength	b. Dexterity	c. Navigation	2. Intellectual	a. Info processing	I. Visual/auditory	II. Codified info	i. Literacy	a. Business	b. Technical	c. Humanities	ii. Numeracy	a. Accounting	b. Analytic	b. Problem solving	I. Evaluation	i. Info search	ii. Abstraction	II. Resolution	i. Creativity	ii. Planning	3. Social	a. Serving	b. Teaching	c. Selling	d. Managing	e. Caring	a. Autonomy	I. Latitude	II. Control (in reverse)	b. Teamwork	c. Routine	I. Repetitiveness	II. Standardisation	III. Uncertainty (in reverse)	a. Non-digital machinery	b. Digitally-enabled machinery	a. Basic ICT	b. Advanced ICT	Emp. 2019 (thousands)
11. Chief executives, senior officials and legislators	0.15	0.03	0.25	0.10	0.79	0.71	0.05	0.71	0.76	0.94	0.40	0.94	0.66	0.80	0.52	0.88	0.82	0.83	0.84	0.96	0.92	1.00	0.67	0.66	0.58	0.86	0.73	0.55	0.87	0.86	0.89	0.68	0.37	0.12	0.54	0.44	0.03	0.63	0.82	0.20	1195
12. Administrative and commercial managers	0.10	0.03	0.20	0.07	0.79	0.75	0.02	0.75	0.75	0.93	0.40	0.93	0.74	0.87	0.61	0.83	0.79	0.79	0.80	0.88	0.85	0.91	0.57	0.49	0.59	0.75	0.68	0.33	0.81	0.82	0.80	0.68	0.37	0.13	0.59	0.38	0.04	0.73	0.89	0.22	1929
13. Production and specialised services managers	0.22	0.09	0.28	0.27	0.82	0.77	0.15	0.77	0.78	0.90	0.54	0.90	0.76	0.85	0.67	0.86	0.82	0.84	0.81	0.91	0.91	0.92	0.64	0.64	0.61	0.75	0.76	0.43	0.90	0.81	1.00	0.72	0.42	0.20	0.64	0.42	0.18	0.64	0.85	0.24	2722
14. Hospitality, retail and other services managers	0.32	0.23	0.47	0.24	0.58	0.57	0.23	0.57	0.59	0.73	0.31	0.73	0.56	0.73	0.38	0.59	0.51	0.43	0.57	0.67	0.76	0.59	0.56	0.89	0.40	0.63	0.53	0.35	0.83	0.75	0.91	0.59	0.50	0.39	0.67	0.45	0.21	0.45	0.70	0.12	1730
21. Science and engineering professionals	0.26	0.05	0.32	0.37	0.79	0.72	0.16	0.72	0.75	0.73	0.78	0.73	0.69	0.65	0.74	0.86	0.87	0.92	0.82	0.86	0.90	0.83	0.44	0.49	0.47	0.53	0.44	0.26	0.73	0.74	0.72	0.64	0.44	0.18	0.68	0.47	0.16	0.70	0.86	0.38	4653
22. Health professionals	0.37	0.18	0.62	0.31	0.62	0.47	0.26	0.47	0.57	0.65	0.39	0.65	0.37	0.38	0.36	0.77	0.84	0.86	0.81	0.71	0.68	0.73	0.67	0.81	0.53	0.56	0.46	1.00	0.73	0.60	0.87	0.68	0.46	0.32	0.61	0.47	0.16	0.44	0.62	0.18	4365
23. Teaching professionals	0.29	0.10	0.37	0.39	0.64	0.46	0.29	0.46	0.44	0.48	0.36	0.48	0.48	0.38	0.58	0.82	0.79	0.80	0.77	0.85	0.93	0.76	0.59	0.40	0.88	0.52	0.43	0.70	0.62	0.59	0.65	0.66	0.46	0.17	0.60	0.60	0.01	0.45	0.70	0.17	7586
24. Business and administration professionals	0.12	0.05	0.20	0.09	0.77	0.71	0.05	0.71	0.72	0.88	0.41	0.88	0.70	0.81	0.59	0.82	0.87	0.93	0.82	0.77	0.76	0.79	0.53	0.61	0.53	0.65	0.49	0.38	0.78	0.75	0.82	0.61	0.40	0.14	0.61	0.46	0.02	0.72	0.88	0.24	5502
25. Information and communications technology professionals	0.10	0.03	0.21	0.00	0.75	0.65	0.00	0.65	0.70	0.70	0.70	0.70	0.59	0.49	0.68	0.84	0.88	0.94	0.85	0.81	0.84	0.78	0.41	0.49	0.47	0.44	0.34	0.33	0.70	0.70	0.70	0.63	0.45	0.24	0.61	0.49	0.10	0.82	0.88	0.83	2743
26. Legal, social and cultural professionals	0.13	0.06	0.25	0.07	0.62	0.46	0.12	0.46	0.62	0.72	0.43	0.72	0.31	0.37	0.24	0.78	0.86	0.88	0.84	0.71	0.83	0.59	0.51	0.54	0.47	0.67	0.37	0.51	0.83	0.73	0.94	0.57	0.42	0.18	0.54	0.53	0.02	0.59	0.77	0.20	4380
31. Science and engineering associate professionals	0.33	0.10	0.48	0.37	0.66	0.58	0.27	0.58	0.61	0.58	0.66	0.58	0.55	0.52	0.59	0.73	0.76	0.80	0.73	0.70	0.71	0.69	0.37	0.22	0.44	0.43	0.47	0.29	0.56	0.58	0.53	0.66	0.51	0.26	0.75	0.51	0.35	0.50	0.70	0.27	6173
32. Health associate professionals	0.45	0.28	0.69	0.36	0.53	0.37	0.39	0.37	0.47	0.49	0.43	0.49	0.26	0.25	0.28	0.69	0.77	0.81	0.74	0.60	0.60	0.60	0.58	0.72	0.43	0.50	0.36	0.90	0.52	0.53	0.51	0.74	0.49	0.36	0.59	0.52	0.26	0.35	0.50	0.14	5358
33. Business and administration associate professionals	0.14	0.04	0.24	0.14	0.70	0.67	0.08	0.67	0.70	0.84	0.44	0.84	0.64	0.76	0.51	0.73	0.80	0.87	0.72	0.66	0.67	0.65	0.50	0.70	0.38	0.67	0.39	0.35	0.66	0.67	0.65	0.53	0.42	0.16	0.57	0.52	0.03	0.68	0.82	0.20	10561
34. Legal, social, cultural and related associate professionals	0.42	0.23	0.49	0.53	0.51	0.35	0.34	0.35	0.46	0.55	0.28	0.55	0.24	0.27	0.21	0.68	0.70	0.70	0.71	0.66	0.78	0.53	0.52	0.70	0.49	0.48	0.37	0.59	0.59	0.60	0.58	0.66	0.46	0.27	0.52	0.60	0.10	0.38	0.63	0.15	3504
35. Information and communications technicians	0.21	0.06	0.40	0.08	0.68	0.57	0.09	0.57	0.63	0.66	0.56	0.66	0.52	0.44	0.60	0.78	0.82	0.87	0.80	0.74	0.82	0.65	0.35	0.41	0.40	0.41	0.31	0.25	0.62	0.64	0.61	0.65	0.49	0.32	0.65	0.51	0.16	0.75	0.81	0.62	1342
41. General and keyboard clerks	0.14	0.04	0.26	0.12	0.65	0.63	0.04	0.63	0.75	0.88	0.50	0.88	0.50	0.61	0.40	0.67	0.86	1.00	0.71	0.48	0.56	0.41	0.37	0.30	0.28	0.41	0.31	0.52	0.46	0.58	0.33	0.60	0.43	0.27	0.50	0.53	0.03	0.68	0.78	0.24	5498
42. Customer services clerks	0.14	0.06	0.28	0.06	0.49	0.47	0.11	0.47	0.55	0.67	0.32	0.67	0.39	0.50	0.28	0.51	0.66	0.70	0.62	0.37	0.51	0.23	0.46	0.84	0.26	0.59	0.22	0.44	0.33	0.42	0.24	0.63	0.52	0.47	0.61	0.49	0.06	0.62	0.67	0.20	3100
43. Numerical and material recording clerks	0.22	0.11	0.36	0.16	0.61	0.61	0.04	0.61	0.61	0.73	0.36	0.73	0.62	0.75	0.49	0.62	0.76	0.87	0.67	0.47	0.51	0.42	0.29	0.35	0.30	0.37	0.24	0.20	0.45	0.51	0.38	0.60	0.48	0.31	0.55	0.56	0.12	0.59	0.74	0.21	5379
44. Other clerical support workers	0.22	0.10	0.37	0.11	0.48	0.42	0.07	0.42	0.53	0.62	0.36	0.62	0.30	0.35	0.24	0.55	0.70	0.83	0.58	0.40	0.49	0.31	0.35	0.39	0.28	0.39	0.29	0.38	0.45	0.52	0.37	0.56	0.50	0.39	0.48	0.61	0.08	0.44	0.52	0.19	1239
51. Personal service workers	0.42	0.22	0.68	0.35	0.36	0.30	0.34	0.30	0.30	0.35	0.21	0.35	0.30	0.40	0.21	0.43	0.35	0.23	0.47	0.50	0.71	0.30	0.46	0.83	0.28	0.42	0.32	0.44	0.50	0.51	0.48	0.59	0.54	0.55	0.53	0.55	0.18	0.14	0.42	0.05	7824
52. Sales workers	0.30	0.21	0.48	0.20	0.35	0.37	0.10	0.37	0.33	0.39	0.22	0.39	0.41	0.54	0.27	0.34	0.30	0.18	0.41	0.38	0.46	0.30	0.41	1.00	0.16	0.53	0.16	0.21	0.44	0.41	0.48	0.49	0.50	0.43	0.49	0.58	0.12	0.28	0.43	0.05	10534
53. Personal care workers	0.44	0.39	0.55	0.37	0.29	0.16	0.35	0.16	0.24	0.27	0.20	0.27	0.08	0.10	0.07	0.41	0.42	0.30	0.54	0.40	0.56	0.23	0.39	0.37	0.23	0.34	0.13	0.90	0.32	0.40	0.25	0.57	0.43	0.32	0.49	0.49	0.06	0.17	0.40	0.04	5239
54. Protective services workers	0.52	0.32	0.50	0.75	0.47	0.35	0.87	0.35	0.51	0.51	0.50	0.51	0.20	0.19	0.21	0.59	0.69	0.72	0.66	0.49	0.56	0.41	0.46	0.65	0.32	0.50	0.28	0.58	0.30	0.38	0.21	0.74	0.47	0.41	0.49	0.51	0.23	0.38	0.60	0.16	2009
61. Market-oriented skilled agricultural workers	0.56	0.42	0.70	0.54	0.45	0.38	0.49	0.38	0.36	0.43	0.24	0.43	0.39	0.47	0.31	0.53	0.46	0.38	0.52	0.60	0.65	0.54	0.25	0.32	0.20	0.34	0.29	0.12	0.71	0.70	0.72	0.40	0.56	0.47	0.62	0.60	0.56	0.14	0.49	0.08	3316
62. Market-oriented skilled forestry, fishery and hunting workers	0.88	0.72	0.92	1.00	0.37	0.22	0.85	0.22	0.23	0.25	0.18	0.25	0.21	0.24	0.17	0.52	0.46	0.35	0.56	0.57	0.64	0.50	0.29	0.17	0.31	0.34	0.33	0.30	0.50	0.52	0.47	0.68	0.66	0.73	0.61	0.64	0.65	0.15	0.52	0.03	184
63. Subsistence farmers, fishers, hunters and gatherers	0.65	0.31	0.99		0.33	0.06		0.06	0.10	0.13	0.04	0.13	0.03	0.05	0.00	0.60	0.43		0.43	0.78	0.78		0.10		0.21	0.08	0.00		0.59	0.59		0.56	0.53	0.54	0.32	0.73	0.18	0.03	0.38	0.00	136
71. Building and related trades workers, excluding electricians	0.62	0.47	0.79	0.59	0.37	0.32	0.45	0.32	0.28	0.26	0.34	0.26	0.36	0.34	0.39	0.41	0.38	0.19	0.56	0.44	0.57	0.31	0.20	0.16	0.24	0.28	0.24	0.08	0.39	0.49	0.29	0.64	0.63	0.57	0.72	0.60	0.44	0.10	0.53	0.05	5373
72. Metal, machinery and related trades workers	0.49	0.32	0.76	0.35	0.44	0.38	0.39	0.38	0.37	0.32	0.48	0.32	0.38	0.36	0.39	0.51	0.51	0.40	0.62	0.50	0.57	0.42	0.25	0.25	0.27	0.30	0.26	0.16	0.50	0.50	0.51	0.54	0.62	0.49	0.76	0.60	0.69	0.18	0.39	0.18	5075
73. Handicraft and printing workers	0.47	0.20	0.74	0.25	0.46	0.39	0.19	0.39	0.42	0.42	0.40	0.42	0.36	0.39	0.32	0.54	0.49	0.38	0.56	0.59	0.72	0.45	0.27	0.37	0.27	0.30	0.26	0.16	0.60	0.57	0.64	0.46	0.62	0.49	0.77	0.60	0.49	0.33	0.45	0.21	749
74. Electrical and electronic trades workers	0.50	0.26	0.74	0.42	0.55	0.48	0.43	0.48	0.56	0.51	0.66	0.51	0.40	0.39	0.40	0.61	0.65	0.61	0.69	0.57	0.68	0.47	0.35	0.50	0.33	0.38	0.30	0.25	0.57	0.57	0.59	0.57	0.55	0.35	0.69	0.60	0.47	0.32	0.55	0.28	2371
75. Food processing, wood working, garment and other craft and related trades workers	0.46	0.29	0.72	0.32	0.43	0.35	0.22	0.35	0.33	0.36	0.29	0.36	0.37	0.40	0.33	0.50	0.47	0.39	0.55	0.54	0.68	0.40	0.30	0.41	0.27	0.34	0.30	0.20	0.54	0.55	0.53	0.58	0.64	0.55	0.74	0.63	0.50	0.15	0.46	0.09	2613
81. Stationary plant and machine operators	0.44	0.25	0.69	0.30	0.30	0.24	0.36	0.24	0.24	0.21	0.28	0.21	0.25	0.26	0.24	0.36	0.39	0.31	0.46	0.32	0.39	0.25	0.13	0.00	0.22	0.16	0.20	0.07	0.31	0.32	0.29	0.54	0.69	0.63	0.79	0.67	0.79	0.15	0.25	0.12	3313
82. Assemblers	0.40	0.22	0.73	0.21	0.30	0.23	0.20	0.23	0.24	0.19	0.33	0.19	0.22	0.20	0.23	0.37	0.40	0.32	0.47	0.33	0.36	0.29	0.11	0.00	0.22	0.12	0.19	0.00	0.30	0.31	0.28	0.60	0.72	0.58	0.85	0.72	0.58	0.13	0.20	0.11	980
83. Drivers and mobile plant operators	0.64	0.29	0.67	0.97	0.25	0.22	1.00	0.22	0.26	0.25	0.26	0.25	0.18	0.21	0.15	0.27	0.33	0.26	0.39	0.22	0.38	0.05	0.18	0.29	0.12	0.20	0.11	0.17	0.32	0.32	0.32	0.39	0.58	0.48	0.50	0.76	0.64	0.12	0.31	0.06	5467
91. Cleaners and helpers	0.40	0.30	0.58	0.31	0.10	0.04	0.22	0.04	0.07	0.08	0.06	0.08	0.01	0.03	0.00	0.15	0.15	0.03	0.25	0.16	0.31	0.00	0.20	0.27	0.05	0.11	0.06	0.54	0.28	0.36	0.20	0.23	0.56	0.51	0.45	0.73	0.11	0.03	0.33	0.01	6173
92. Agricultural, forestry and fishery labourers	0.62	0.50	0.75	0.62	0.28	0.16	0.57	0.16	0.12	0.09	0.17	0.09	0.19	0.16	0.23	0.41	0.33	0.24	0.42	0.49	0.52	0.45	0.15	0.10	0.17	0.17	0.17	0.13	0.34	0.37	0.32	0.52	0.62	0.56	0.57	0.71	0.48	0.03	0.23	0.04	1012
93. Labourers in mining, construction, manufacturing and transport	0.51	0.40	0.66	0.47	0.26	0.24	0.33	0.24	0.22	0.22	0.23	0.22	0.26	0.25	0.28	0.27	0.38	0.34	0.42	0.15	0.26	0.05	0.10	0.00	0.15	0.12	0.15	0.06	0.15	0.29	0.00	0.61	0.65	0.64	0.68	0.62	0.48	0.13	0.29	0.07	3898
94. Food preparation assistants	0.44	0.31	0.68	0.33	0.15	0.11	0.27	0.11	0.09	0.09	0.09	0.09	0.12	0.14	0.10	0.20	0.22	0.06	0.38	0.18	0.34	0.03	0.20	0.37	0.15	0.16	0.15	0.17	0.18	0.26	0.11	0.68	0.58	0.63	0.59	0.52	0.28	0.06	0.30	0.02	1203
95. Street and related sales and service workers	0.36	0.34	0.44	0.27	0.22	0.24	0.20	0.24	0.16	0.19	0.08	0.19	0.32	0.43	0.21	0.20	0.13	0.00	0.26	0.27	0.54	0.00	0.28	0.79	0.04	0.47	0.02	0.13	0.56	0.60	0.51	0.30	0.45	0.35	0.23	0.79	0.06	0.02	0.37	0.01	145
96. Refuse workers and other elementary workers	0.52	0.36	0.56	0.60	0.20	0.15	0.46	0.15	0.18	0.19	0.17	0.19	0.11	0.12	0.11	0.26	0.31	0.23	0.37	0.19	0.35	0.03	0.25	0.46	0.14	0.22	0.11	0.35	0.25	0.33	0.15	0.49	0.54	0.44	0.44	0.75	0.32	0.08	0.31	0.05	1273

***Source**: JRC – Eurofound European database of tasks indices*

Figure A 1: Distribution of standardisation, repetitiveness and uncertainty (in reverse) by Isco08 two-digit



***Source**: JRC – Eurofound European database of tasks indices*

Annex 2: variables used

In this annex, the variables selected from the different sources (and the full wording of the questions) to construct the different tasks indices are listed.

European Working Conditions Survey (EWCS)

Physical tasks

An index of "**Strength**"

-Q30a Does your main paid job involve tiring or painful positions?

-Q30b Does your main paid job involve lifting or moving people?

-Q30c Does your main paid job involve carrying or moving heavy loads?

Intellectual tasks

An index of "**Conceptualization, learning and abstraction**"

-Q53e Generally, does your main paid job involve complex tasks?

-Q53f Generally, does your main paid job involve learning new things?

An index of "**Creativity**"

-Q53c Generally, does your main paid job involve solving unforeseen problems on your own?

-Q61i Select the response which best describes your work situation: You are able to apply your own ideas in your work.

Work organization

An index of "**Autonomy - Latitude**"

-Q42 How are your working time arrangements set?

-Q54a Are you able to choose or change your order of tasks?

-Q54b Are you able to choose or change your methods of work?

-Q54c Are you able to choose or change your speed or rate of work?

-Q61f You can take a break when you wish –at work-

-Q47 Would you say that for you arranging to take an hour or two off during working hours to take care of personal or family matters is…?

An index of "**Teamwork**"

-Q58 Do you work in a group or team that has common tasks and can plan its work?

Complementary variables are used to enrich the content of Q58, as explained at point 4. These are:

-Q60a For the team in which you work mostly, do the members decide by themselves on the division of tasks?

-Q60b For the team in which you work mostly, do the members decide by themselves who will be head of the team?

-Q60c For the team in which you work mostly, do the members decide by themselves the timetable of the work?

An index of “**Repetitiveness**”

-Q30e Does your main paid job involve repetitive hand or arm movements

-Q48a Does your job involve short repetitive tasks of less than 1 minute?

-Q48b Does your job involve short repetitive tasks of less than 10 minute?

-Q53d Generally, does your main paid job involve monotonous tasks?

An index of “**Standardization**”

-Q50c On the whole, is your pace of work dependent, or not, on numerical production targets or performance targets?

-Q53a Generally, does your main paid job involve meeting precise quality standards?

An index of “**Uncertainty in reverse**”

-Q51 How often do you have to interrupt a task you are doing in order to take on an unforeseen task?

Tools and technology

An index of “**Non-digital machinery (analog)**”

-Q29a Are you exposed at work to vibrations from hand tools, machinery, etc.?

-Q50d On the whole, is your pace of work dependent, or not, on automatic speed of a machine or movement of a product?

An index of “**Computing devices**”

-Q30i Does your main paid job involve working with computers, laptops, smartphones etc.?

Indagine Campionaria delle Professioni (ICP 2012)

Physical tasks

An index of “**Strength**”

-D32 The ability to exert maximum muscle force to lift, push, pull, or carry objects.

-D33 The ability to use short bursts of muscle force to propel oneself (as in jumping or sprinting) or to throw an object.

-D34 The ability to exert muscle force repeatedly or continuously over time. This involves muscular endurance and resistance to muscle fatigue.

-D35 The ability to use your abdominal and lower back muscles to support part of the body repeatedly or continuously over time without “giving out” or fatiguing.

-D36 The ability to exert yourself physically over long periods of time without getting winded or out of breath.

An index of “**Dexterity**”

-D22 The ability to keep your hand and arm steady while moving your arm or while holding your arm and hand in one position.

-D23 The ability to quickly move your hand, your hand together with your arm, or your two hands to grasp, manipulate, or assemble objects.

-D24 The ability to make precisely coordinated movements of the fingers of one or both hands to grasp, manipulate, or assemble very small objects.

-D25 The ability to quickly and repeatedly adjust the controls of a machine or a vehicle to exact positions.

-D26 The ability to coordinate two or more limbs (for example, two arms, two legs, or one leg and one arm) while sitting, standing, or lying down. It does not involve performing the activities while the whole body is in motion.

-D27 The ability to choose quickly between "two or more movements" in response to "two or more different signals" (lights, sounds, pictures). It includes the speed with which the correct response is started with the hand, foot, or other body part.

-D28 The ability to time your movements or the movement of a piece of equipment in anticipation of changes in the speed and/or direction of a moving object or scene.

-D29 The ability to quickly respond (with the hand, finger, or foot) to a signal (sound, light, picture) when it appears.

-D30 The ability to make fast, simple, repeated movements of the fingers, hands, and wrists.

-D31 The ability to quickly move the arms and legs.

-D39 The ability to coordinate the movement of your arms, legs, and torso together when the whole body is in motion.

-D40 The ability to keep or regain your body balance or stay upright when in an unstable position.

An index for "**Navigation**"

-D18 The ability to know your location in relation to the environment or to know where other objects are in relation to you.

-D46 The ability to judge which of several objects is closer or farther away from you, or to judge the distance between you and an object.

Intellectual tasks

An index of "**Visual and auditory processing of uncodified info**"

-D42 The ability to see details at a distance.

-D44 The ability to see under low-light conditions.

-D45 The ability to see objects or movement of objects to one's side when the eyes are looking ahead.

-D47 The ability to see objects in the presence of a glare or bright lighting.

-D48 The ability to detect or tell the differences between sounds that vary in pitch and loudness.

-D49 The ability to focus on a single source of sound in the presence of other distracting sounds.

-D50 The ability to tell the direction from which a sound originated.

An index of "**Literacy: Business**"

-B1 Knowledge of business and management principles involved in strategic planning, resource allocation, human resources modelling, leadership technique, production methods, and coordination of people and resources.

-B2 Knowledge of administrative and clerical procedures and systems such as word processing, managing files and records, stenography and transcription, designing forms, and other office procedures and terminology.

-H5 How frequently does your current job require written letters and memos?

An index of “**Literacy: Technical**"

-G21 Providing documentation, detailed instructions, drawings, or specifications to tell others about how devices, parts, equipment, or structures are to be fabricated, constructed, assembled, modified, maintained, or used.

An index of “**Literacy: Humanities**”

-D1 The ability to listen to and understand information and ideas presented through spoken words and sentences.

-D2 The ability to read and understand information and ideas presented in writing.

-D3 The ability to communicate information and ideas in speaking so others will understand.

-D4 The ability to communicate information and ideas in writing so others will understand the meaning and spelling of words, rules of composition and grammar, and pronunciation.

-C3 Communicating effectively in writing as appropriate for the needs of the audience.

-B24 Knowledge of the structure and content of the Italian language including the meaning and spelling of words, rules of composition, and grammar;

-B25 Knowledge of the structure and content of a foreign (non-Italian) language including the meaning and spelling of words, rules of composition and grammar, and pronunciation;

An index of “**Numeracy: Accounting**”

-B3a Knowledge of economic and accounting principles and practices, the financial markets, banking, and the analysis and reporting of financial data.

-D13 The ability to add, subtract, multiply, or divide quickly and correctly.

An index of “**Numeracy: Analytic**”

-D12 The ability to choose the right mathematical methods or formulas to solve a problem.

-C5 Using mathematics to solve problems.

An index of “**Information search and retrieval**”

-G1 Observing, receiving, and otherwise obtaining information from all relevant sources.

-G8 Compiling, coding, categorizing, calculating, tabulating, auditing, or verifying information or data.

-G24 Entering, transcribing, recording, storing, or maintaining information in written or electronic/magnetic form.

An index of " **Conceptualization, learning and abstraction**"

-C8 Understanding the implications of new information for both current and future problem-solving and decision-making.

-D8 The ability to apply general rules to specific problems to produce answers that make sense.

-D9 The ability to combine pieces of information to form general rules or conclusions (includes finding a relationship among seemingly unrelated events).

-D10 The ability to arrange things or actions in a certain order or pattern according to a specific rule or set of rules (e.g., patterns of numbers, letters, words, pictures, mathematical operations).

-G9 Identifying the underlying principles, reasons, or facts of information by breaking down information or data into separate parts.

An index of "**Creativity**"

-G11 Developing, designing, or creating new applications, ideas, relationships, systems, or products, including artistic contributions.

-E19 Who does this work can experience their own ideas.

-D5 The ability to come up with a number of ideas about a topic (the number of ideas is important not their quality, correctness, or creativity).

-D6 The ability to come up with unusual or clever ideas about a given topic or situation, or to develop creative ways to solve a problem.

-F15 Job requires creativity and alternative thinking to develop new ideas for and answers to work-related problems.

An index of "**Planning**"

-C18 Analyze the characteristics and requirements of tools, services or products necessary for the realization of a project.

-G13 Establish long-term goals and specify strategies and actions to achieve them.

-G14 Planning events, plans and activities; or other people's work.

Social tasks

An index of " **Serving attending**"

-B5 Knowledge of principles and processes for providing customer and personal services. This includes customer needs assessment, meeting quality standards for services, and evaluation of customer satisfaction.

-H8 How important are interactions that require you to deal with external customers (as in retail sales) or the public in general (as in police work)?

-G32 Performing for people or dealing directly with the public. This includes serving customers in restaurants and stores, and receiving clients or guests.

An index of "**Teaching/training/coaching**"

-G35 Identifying the educational needs of others, developing formal educational or training programs or classes, and teaching or instructing others.

-G37 Identifying the developmental needs of others and coaching, mentoring, or otherwise helping others to improve their knowledge or skills.

-G38 Providing guidance and expert advice to management or other groups on technical, systems-, or process-related topics.

-C15 Teaching others how to do something.

An index of "**Selling/influencing**"

-G31 Handling complaints, settling disputes, and resolving grievances and conflicts, or otherwise negotiating with others.

-C13 Persuading others to change their minds or behaviour.

-C14 Bringing others together and trying to reconcile differences.

An index of "**Managing/coordinating**"

-G33 Getting members of a group to work together to accomplish tasks.

-G36 Providing guidance and direction to subordinates, including setting performance standards and monitoring performance.

-C35 Motivating, developing, and directing people as they work, identifying the best people for the job.

-H9 In your current job, how important are interactions that require you to coordinate or lead others in accomplishing work activities (not as a supervisor or team leader)?

-G14 Scheduling events, programs, and activities, as well as the work of others.

An index of “**Caring**”

-C16 Actively looking for ways to help people.

-G29 Providing personal assistance, medical attention, emotional support, or other personal care to others such as co-workers, customers, or patients.

Work organization

An index of “**Latitude**”

-H52 How much freedom do you have to determine the tasks, priorities, or goals of your current job?

-G15 Developing specific goals and plans to prioritize, organize, and accomplish your work.

An index of “**Control**”

-F14 Job requires developing one's own ways of doing things, guiding oneself with little or no supervision, and depending on oneself to get things done.

-H48 In your current job, how much freedom do you have to make decisions without supervision?

-E20 Those who do this work plan their activities with little supervision.

An index of “**Teamwork**”

-H7 How important are interactions that require you to work with or contribute to a work group or team to perform your current job?

-F7 Job requires preferring to work with others rather than alone, and being personally connected with others on the job.

An index of “**Repetitiveness**”

-H42 How much time in your current job do you spend making repetitive motions?

-H51 How important to your current job are repetitious activities, either physical or mental, carried on in a relatively short time span (less than one hour)?

Tools and technology

An index of “**Non-digital machinery (analog)**”

-G18 Using either control mechanisms or direct physical activity to operate machines or processes (not including computers or vehicles).

-G20 Running, maneuvering, navigating, or driving vehicles or mechanized equipment, such as forklifts, passenger vehicles, aircraft, or water craft.

-C24 Watching gauges, dials, or other indicators to make sure a machine is working properly.

An index of “**Advanced ICT**”

-B9 Knowledge of electronic circuits, processors, chips of electronic equipment, computer hardware and software, including knowledge of application packages and programming languages.

-G19 Use computers and computer systems (software and hardware) to program, write software, adjust functions, enter data, or process information.

-C22 Writing computer programs for various purposes.

<u>OECD Survey of Adult Skills (PIAAC)</u>

Intellectual tasks

An index of “**Business literacy**”

-G_q01b In your job, how often do you usually read letters, memos or e-mails?

-G_q01g In your job, how often do you usually read bills, invoices, bank statements or other financial statements?

-G_q02a In your job, how often do you usually write letters, memos or e-mails?

An index of “**Technical literacy**”

-G_q01a In your job, how often do you usually read directions or instructions?

-G_q01f In your job, how often do you usually read manuals or reference materials?

-G_q01h In your job, how often do you usually read diagrams, maps or schematics?

-G_q02c In your job, how often do you usually write reports?

-G_q02d In your job, how often do you usually fill in forms?

An index of “**Humanities literacy**”

-G_q01c In your job, how often do you usually read articles in newspapers, magazines or newsletters?

-G_q01d In your job, how often do you usually read articles in professional journals or scholarly publications?

-G_q01e In your job, how often do you usually read books?

-G_q02b In your job, how often do you usually write articles for newspapers, magazines or newsletters?

An index of “**Accounting numeracy**”

-G_q03b In your job, how often do you usually calculate prices, costs or budgets?

-G_q03c In your job, how often do you usually use or calculate fractions, decimals or percentages?

-G_q03d In your job, how often do you usually use a calculator - either hand-held or computer based?

An index of “**Analytic numeracy**”

-g_q03f In your job, how often do you usually prepare charts, graphs or tables?

-g_q03g In your job, how often do you usually use simple algebra or formulas?

-g_q03h In your job, how often do you usually use more advanced math or statistics such as calculus, complex algebra, trigonometry or use of regression techniques?

An index of “**Problem solving**”

-F_q05a The next question is about "problem solving" tasks you do in your job. Think of "problem solving" as what happens when you are faced with a new or difficult situation which requires you to think for a while about what to do next. How often are you usually faced by relatively simple problems that take no more than 5 minutes to find a good solution?

-F_q05b And how often are you usually confronted with more complex problems that take at least 30 minutes to find a good solution? The 30 minutes only refers to the time needed to THINK of a solution, not the time needed to carry it out.

An index of “**Conceptualization, learning and abstraction**”

-D_q13a In your own job, how often do you learn new work-related things from co-workers or supervisors?

-D_q13b How often does your job involve learning-by-doing from the tasks you perform?

-D_q13c How often does your job involve keeping up to date with new products or services?

Social tasks

An index of “**Teaching/training/coaching**”

-F_q02b How often does your job usually involve instructing, training or teaching people, individually or in groups?

-F_q02c How often does your job usually involve making speeches or giving presentations in front of five or more people?

An index of “**Selling/influencing**”

-F_q02d How often does your job usually involve selling a product or selling a service?

-F_q04a How often does your job usually involve persuading or influencing people?

-F_q04b How often does your job usually involve negotiating with people either inside or outside your firm or organisation?

-F_q02e How often does your job usually involve advising people?

An index of “**Managing/coordinating**”

-F_q03b How often does your job usually involve planning the activities of others?

-D_q07a Do you have employees working for you? Please include family members working paid or unpaid in the business.

-D_q07b How many people do you employ? Would that be ...

-D_q08a Do you manage or supervise other employees?

-D_q08b How many employees do you supervise or manage directly or indirectly? Would that be ...

Methods

An index of “**Latitude**”

-D_q11a To what extent can you choose or change the sequence of your tasks?

-D_q11b To what extent can you choose or change how you do your work?

-D_q11c To what extent can you choose or change the speed or rate at which you work?

-D_q11d To what extent can you choose or change your working hours?

An index of “**Teamwork**”

-F_q01b In your job what proportion of your time do you usually spend cooperating or collaborating with co-workers?

Tools and technology

An index of “**Computing devices**”

-G_q05a In your job, how often do you usually use email?

-G_q05c In your job, how often do you usually use the internet in order to better understand issues related to your work?

-G_q05e In your job, how often do you usually use spreadsheet software, for example Excel?

-G_q05f In your job, how often do you usually use a word processor, for example Word?

-G_q05g In your job, how often do you usually use a programming language to program or write computer code?

-G_q05d In your job, how often do you usually conduct transactions on the internet, for example buying or selling products or services, or banking?

-G_q05h In your job, how often do you usually participate in real-time discussions on the internet, for example online conferences, or chat groups?

-G_q04 Do you use a computer in your job?

-G_q06 What level of computer use is needed to perform your job?

An index of “**Basic ICT**”

-G_q05a In your job, how often do you usually use email?

-G_q05c In your job, how often do you usually use the internet in order to better understand issues related to your work?

-G_q05e In your job, how often do you usually use spreadsheet software, for example Excel?

-G_q05f In your job, how often do you usually use a word processor, for example Word?

An index of “**Advanced ICT**”

-G_q05g In your job, how often do you usually use a programming language to program or write computer code?

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