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Routine-biased technical change can fail: Evidence from France

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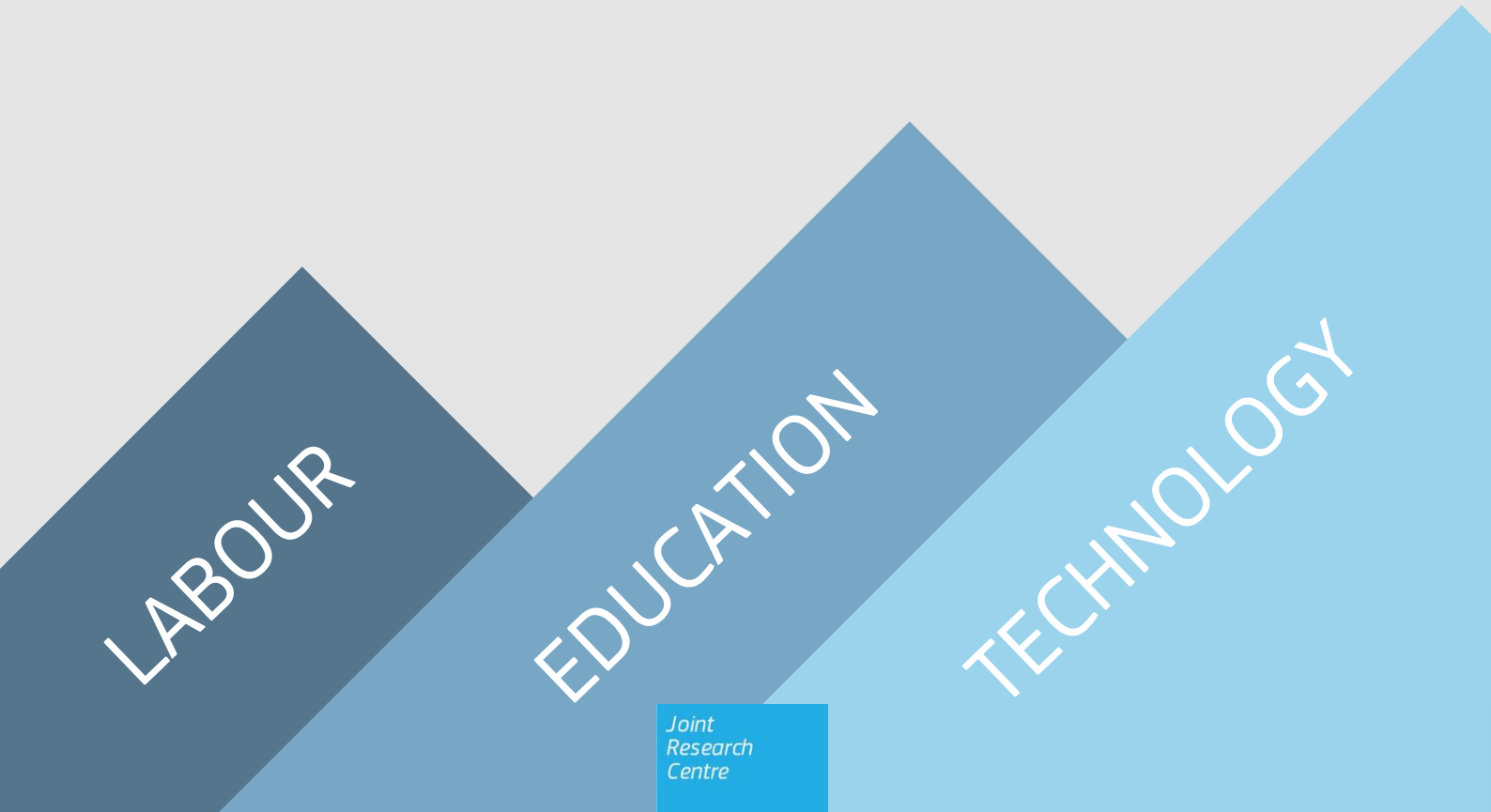

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Routine-biased technical change can fail: Evidence from France

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Abstract

The paper studies the determinants of wage differentials over time within jobs in France, detailing the contribution of different set of explanatory factors by means of a Recentred Influence Function, to estimate the effect of a set of covariates at different point of the wage distribution. We simultaneously test the contribution of tasks performed by workers and organisational methods at the firm level, labour market institutions and individual characteristics. We do so by exploiting a unique database at the worker level, the French *Enquête Complémentaire Emploi: Conditions de travail*, between 2005 and 2016, which covers also monthly wages. Main findings support the hypothesis according to which wages differentials along the wage distribution are almost entirely explained by contractual and work arrangements rather than tasks and organisational practices. Overall evidence run against the main argument of the Routine Bias Technical Change hypothesis.

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Contents

1. Introduction

Evidence of increasing and persistent wage inequality in most advanced economies have been one of the hot topics in academic and policy debate during the last decades. A large body of literature flourished around the topic aimed at explaining wage differentials among workers within and between countries and jobs.

The most influential argument used, especially in the labour economics discipline, known as Routine Bias Technical Change (RBTC), points to the relationship between technological change and wage dynamics as result of employment polarisation. According to its main proponents (Acemoglu & Autor, 2011; Autor et al., 2003; Autor & Handel, 2013; Goos et al., 2014), RBTC interprets labour, capital and technology as technical inputs whose relationship is deterministically driven by comparative cost advantage among them (Autor, 2013; Autor et al., 2003). Indeed, evidence of employment expansion both at the top and bottom of the wage distribution in many countries – i.e., employment polarisation - directly depends on the dynamics of relative prices of production inputs (labour and capital). Under this setting, the analytical lens to study structural change shift from workers' skills endowment - the main explanation until recently within the same field - to tasks performed at work defined as "a unit of work activity that produces output" (Autor, 2013). The more tasks can be easily codified into procedural routines, the more likely they can be substituted by machines, depressing their relative returns. What matters to understand wage dynamics is therefore the extent to which a given task, manual or intellectual, is more or less routinary, more or less codifiable and potentially embodied into machines.

A second strand of recent literature casts doubts on the routinisation hypothesis at least as main and unique driver of wage inequality. According to these scholars, wages and wage inequality strongly depend on institutions and on the way they are shaped by social relations: those directly affecting the labour market like minimum wage, wage indexation mechanisms (Bosch & Manacorda, 2010; Derenoncourt & Montialoux, 2020; Lee, 1999; Wright & Dweyer, 2003), labour market liberalisation (Raitano & Fana, 2019), unionisation (Biewen & Seckler, 2019; Card, 1996; Firpo et al., 2011; Freeman, 1980) and those affecting the society at a much broader level, i.e., welfare state regimes (Esping-Andersen, 1990; G. Esping-Andersen, 2000), trade liberalisation, class relations and power (even within the workplace).

According to this standpoint, historical and institutional variables shape not only how value is distributed among economic agents but also *what and the how* is being produced across countries, as well as how tasks are distributed among workers within and between occupations. Indeed, despite technical feasibility - and even sharing the same level of technological advancement- significant differences persist between and within countries in the organization of the production process (Fana et al., 2020). This heterogeneity strictly depends on social relations and how institutions and regulations shape markets and the dialectics between labour and capital. For example, labour market institutions and policies aimed at keeping wages low act as a disincentive to invest in innovation, since profits margins can be guaranteed and extracted from labour rather than capital and market penetration (Sylos Labini, 1972; 1984). Moreover, differences in tasks distribution across workers are not necessarily related to technical consideration and hold even within the same job. This is the case for the persistent gaps in material tasks, workers' autonomy and forms of control between genders (Fana et al., 2021; West, 1990; Wright et al., 1995) which cannot be explained by supply side factors. Even legislative (and/or cultural) changes can alter the whole production and labour process and force it to re-adjust according to the new regulation. This is the case of working time, which forces firms to

find new forms of industrial and production organization to keep increasing the productivity despite lower working hours and, therefore, intervening on *the how* to produce.

Our paper originally contributes to the literature on the determinants of wage differentials over time detailing the contribution of different set of explanatory factors. Thanks to the richness of the database exploited in this paper, we are able to simultaneously test most of the covariates behind wage inequality used in the relevant literature: tasks performed at work, labour market institutions affecting workers' contractual arrangement and working time, as well as individual characteristics - education, nationality, region of residence, gender and experience - and firms' characteristics, i.e., economic sector, private vs public nature of the employer and firm size. An additional contribution of our paper is its ability to exploit tasks changes within and between jobs dynamically; a degree of granularity which has been exploited, to the best of our knowledge, only by very few papers in the literature (S. O. Becker & Muendler, 2015; Spitz-Oener, 2006) although for a different research question. However, these papers do not account for changes within occupations and sectors jointly considered. They assume instead that a specific occupation is characterised by a given bundle of tasks regardless of the industry of employment and its level of technological advancement and market structure. As discussed in Calvino and Virgillito (2018), the technology-employment relation changes according to both the level of aggregation (firm or sectoral level) and between industries. Hence, ignoring such source of heterogeneity may reduce and bias the true understanding of structural patterns and their determinants. Accordingly, our work accounts for tasks differences within jobs defined as sector-occupation combinations (Hurley et al., 2013; Wright & Dweyer, 2003) so to simultaneously analyse changes along the vertical (occupations) and the horizontal (economic activities) division of labour.

All in all, this is the first paper which studies wage inequality dynamically exploiting data at the level of workers, not occupations, which uses consistent time variant measures of tasks, contrary to most of the literature on the relationship between tasks and wages (Autor & Handel, 2013; Biewen & Seckler, 2019; De La Rica et al., 2020; Firpo et al., 2011; Fortin & Lemieux, 2016; van der Velde, 2020).

For this purpose, we focus on France as an advanced European economy with a long tradition of working condition surveys covering individual-level information on tasks, work organisation, socio-demographic, contractual arrangements, and wages. Beyond data availability, France is an interesting socio-economic context. From a policy perspective, France has been until recently less subjected to the liberalization of the labour market (at least comparatively with respect to other Southern and Eastern member States). At the same time, as for the economic perspective, in the last twenty years, France experienced a slight compression of the wage distribution i.e., a reduction in wage inequality, while studies on the evolution of the employment structure point to non-monotonic patterns. Indeed, using the "job-approach", Fernández-Macías (2012) shows a pattern of polarization between 1995 and 2007, followed by a process of mid-upgrading between 2011 and 2016, with top occupations growing more than the bottom ones according to (Fernández-Macías et al., 2017). France is characterised by larger occupation wage heterogeneity at the regional level. For example, Ile de France experienced a stronger occupational growth in the low-paid occupations, while Rhone-Alpes experienced an upgrading pattern (Hurley et al., 2019).

The rest of the paper is structured as follow: Section 2 critically reviews the standard tasks approach; Section 3 presents the dataset and the methodology for the construction of the tasks profile and wages, our main dependent variable, and provides also descriptive evidence on the evolution of both tasks on wages. Section 4 introduces the econometric method applied, while Section 5 discusses main empirical findings. Finally, Section 6 concludes.

2. The task approach: critical review

The theoretical foundation of the RBTC hypothesis - at the core of the standard task-approach - is grounded on the deterministic link between production inputs (i.e., human labour and machines) spurring from relative prices and therefore comparative advantages (Autor, 2013).

Within this approach labour is intended as a bundle of tasks, i.e., work activities, required to produce a certain amount of output. Therefore, wages and employment contraction (expansion) are ultimately related to the extent to which a given task can(not) be codified into standardised procedures – routinised – and therefore executed by machines rather than relatively more expensive labour input.

Established as the most influential approach to the study of wage differentials across occupations, the tasks approach has been implemented as main hypothesis in a long list of empirical contributions. All these works share a common aim: explaining patterns of employment polarisation and increasing wage inequality assuming that exists a strong complementarity with ICT at the top and substitutability in the middle of both employment and wage distribution. Most of the related empirical literature find evidence in favour of this (Autor & Handel, 2013; De La Rica et al., 2020; Firpo et al., 2011; Fortin & Lemieux, 2016; van der Velde, 2020). Conversely, a recent study by Domini et al. (2020) finds no wage inequality- enhancing effect of firms' investments in AI in France.

However, the theoretical ground informing RBTC has been questioned from different schools of thoughts which converge in contesting the exclusion of all dimensions related to human agency and social relations characterising the production process. This critical assessment argues that the production process is not a self-determined mixed of inputs interacting in a black box, but rather an organization characterised by social relations embedded in the hierarchical division of labour (Cetrulo et al., 2020; Thompson & McHugh, 1995), mechanisms of command and control over the labour force (Dosi & Marengo, 2015; Edwards, 1982) which are historically and institutionally dependent (Dosi, 1995).[1]

According to this critical assessment, grounded on both the evolutionary approach (Dosi et al., 2001) and the Labour Process Theory (thereafter LPT, see Braverman, 1974; Edwards, 1982; Knights David & Hugh, 1990), the technical content of the production process goes hand in hand with work organization made explicit in a set of procedures and standards, i.e., organizational routines (M. C. Becker, 2004; Clegg, 1981; Coriat & Dosi, 1998).

Therefore, routine defines a way of performing task, rather than the task itself to be performed, as defined by the RBTC. To clarify, the same manual or intellectual tasks can be performed in a more or

[1] As organisational practices, including routines, are historically and institutionally contingent, they are highly heterogeneous across sectors and countries even in the case of similar level of technological advancement/adoption (Fana et al., 2020). Hence, using data measured on a specific country may lead to substantial biased, if not misleading, result when the same measure is applied to other socio-economic structures. This is true even when the different countries share similar levels of technological development, especially if non-market variables, like institutions, are left out the analysis.

less routinised or autonomous way depending on the organisational practices prevailing at the workplace.

But what routines are about and how ICT deployment at the workplace shape them?

In the standard Autor, Levy and Murnane (2003) model, "a task is "routine" if it can be accomplished by machines following explicit programmed rules" and this is made possible because "these tasks require methodical repetition of an unwavering procedure". Routine appears as an innate tasks' attribute. However, routines as "recurrent actions patterns" (Dosi et al., 2001) which may or may not be codified into technological devices (digital or not) are a collective social outcome. Historically, even Taylorism is about tasks routinization whose aim was not the substitution of human tasks by machines *per se* but a mechanism able to codify tacit knowledge and shift the control over the production process from the worker to the management.

This is what LPT defines as the *deskilling* of the workforce (Braverman, 1974). As stated by Edwards (1982) "computers can send instructions according to its pre-programmed routine as to what operations or activities workers are to perform" and then send information to a central programming computer controlled by the management who can indirectly follow the entire production process and its phases. In other words, while computers might substitute several workers' tasks, like computing, their adoption at the workplace may took place without replacement of human labour. A well-established example drawn from reality is the adoption of digital tools at the shopfloor used by the management to monitor and dictate the pace of work to subordinates. In this, as in other cases, the choice to introduce new digital devices always respond to the balance of power and its dialectic among workers and management/ownership and only to a lesser extent to technical considerations. At the same time, digital-enabled machines are learning tools acquiring information and workers' knowledge on specific tasks like the ability to solve problems as they emerge during a production phase. Computers therefore store tacit knowledge which will be incorporated into instructions and procedures to be followed once similar events occur. In this case, the replacement between machine and human labour do not relate to the repetitiveness of tasks but workers' analytical capacity which will be subtracted from their control (leading to a deskilling process). At the same time, the possibility to codify analytical tasks into procedure transform workers' tasks by making them more standardised.

Consequently, the positive relationship between the deployment of new technologies and wages of those in charge of supervisory activities can no longer be attributed to a technical complementarity but to their political role within the workplace. Conversely, declining wages for workers' subject to more standardisation (because of the introduction of new technology) depend on the ability to disempower them rather than actual substitutability. Yet, the latter relationship will be one of the focuses of the present study.

Following the social embedded definition of routine, Fernández-Macías and Bisello (2021) propose an extended conceptual taxonomy of tasks which classifies tasks into two main dimensions: contents vs methods of work and tools. The first dimension includes a number of task indicators map *what people do* (content of work), that is the activities required to produce output from a technical perspective. The second dimension of the framework aims at capturing *how workers do what they do,* that is the organizational practices prevailing in a specific production process and the tools (digital and non-digital) used at work.

From an analytical point of view, the conceptual framework applied here is able to grasp the complexity and multidimensionality of social relations embodied in jobs. It is paramount to note that differently from the standard or other task approaches proposed in the literature, the extended

framework discriminates routine from other forms of control/autonomy (De La Rica et al., 2020; Marcolin et al., 2016) as well as managerial tasks which pertain to the social content of tasks and not to a generic abstract analytical content (Autor et al., 2003; Autor & Handel, 2013).

At the same time, impersonal and codified forms of control can co-exist with different level of autonomy, depending on the specificities of the production process as well the internal organisation. Looking into more detail at routine, as described above, we distinguish between repetitiveness and standardisation, two different concepts which do not necessarily overlap nor distribute accordingly across jobs. The conceptual choice has already been proven consistent empirically: for instance, Bisello et al. (2021) show that - at the European level - workers characterised by higher level of repetitiveness are also highly standardised, while the opposite does not necessarily hold, especially at the top of the occupational ranking.

We then move forward and refine the measure of routine as it appears in Fernandez-Macias and Bisello's (2021) framework by detailing the concept of standardisation following Edwards (1982). According to this scholar, standardisation (captures institutionalised control and can take two different forms: 1) *bureaucratic control* and 2) *technical control*.

In Edwards' own words: "*more formal, consciously contrived controls could be embedded in either the physical structure of the labour process (producing "technical" control) or in its social structure (producing "bureaucratic" control). New systems made control more institutional and hence less visible to workers. Technical control reduces workers to attendants of prepaced machinery." Instead, "This system, [bureaucratic control], is the institutionalisation of hierarchical power. Rule of law replaces rule by supervisory command in the direction of work, the procedure for evaluating workers' performance, and the exercise of the firm's sanctions and rewards; supervisors and workers alike become subject to the dictates of "company policy"* (1982, pp. 20–21).

3. Data and Methodology

The dataset

The empirical analysis employs data from the *Enquête Complémentaire Emploi: Conditions de travail* (Complementary Survey of Employment: Working Conditions, EC afterwards) carried out since 1978 by the Direction de l'Animation de la Recherche, des Études et des Statistiques (DARES) of the French Ministry of Labour. The EC represents the oldest European database that collects information at the individual level on working conditions, task content, work organization, mechanical and digital tools use at work, socio-demographic characteristics, contractual arrangements, and wages. It is nowadays run every three years and covers almost the entire spectrum of occupations at four-digit and economic sectors at two-digit level, depending on the wave. We restrict the analysis using two main waves, 2005 and 2016, so to avoid any inconsistency driven by potential effects induced by reorganisation and/or restructuring practices during the 2008 Crisis.

The survey is representative of the entire working population (employees or not) resulting in a database of around 15,196 observations in 2005 and 18,048 in 2016. Over time, the main building blocks and questions have been maintained almost unaltered especially on work content and organisational practices with some minor changes across waves (for a detailed description of the survey see Dares, 2005). Major changes relate to the inclusion of wages since 2005 and a detailed section on health and safety since 2013.

The consistent structure over a long-time span allows to overcome some limitations that apply to most databases used for tasks analysis. The EC allows to measure tasks directly and consistently over time within jobs (occupation by sector combinations) together with detailed employment structure and individual characteristics.

Classification for economic sectors and occupations are coded in both the French and International classifications, which allows to overcome problems related to changes in the ISCO classification. For the sake of consistency, our empirical analysis uses information from the *Classification of Professions and Socioprofessional Categories*2003 (henceforth PCS 2003) three-digit level recorded in both waves and an aggregation of economic sectors based on high-tech statistics provided by Eurostat (2020) for both Nace rev11 and Nace rev2 to avoid changes due to the update of the NACE classification occurred in 2008. The resulting aggregation consists in nine macro-sectors: Primary; Construction; Low-Tech Industries; High-Tech Industries; Low Knowledge-Intensive Sectors; Knowledge-Intensive Sectors; Public administration; Education and Health.[2]

To capture the composition of the employment structure at the aggregate level and to characterise work activity at the individual level, we use jobs as unit of analysis (Hurley, John et al., 2013; Wright & Dweyer, 2003) where each job, a cell, is defined as the combination between occupation and sector. Using this definition, the resulting job matrix consists of 1,742 cells (jobs) in 2005 and 2,239 in 2016, where each cell has a different size in terms of employment given by population weights (with some missing cells because of null employment: e.g., Fishermen in the Health sector).

Tasks measures

Using data for 2005 and 2016 from the EC survey, we build individual tasks profiles refining the conceptual framework developed by Fernández-Macías and Bisello (2021)

Measures of tasks content.

We distinguish among three groups of task indicators for the content of work: physical, intellectual, and social tasks. Physical tasks are proxied by *physical strength* (i.e., the requirement of moving or carrying heavy loads), while within intellectual ones we restrict our analysis to *conceptualization* which refers to conceptualization, learning and abstraction activities as form of complex information processing. Finally, we measure social tasks detailing between *serving and attending* activities which measure whether the worker is in direct contact with the public like clients or customers and *managing and coordinating* (whether the respondent instructs and supervises others' work activities). Distinguishing between the type of social tasks performed is relevant since it captures very different forms of interactions: while serving and attending is a material input of work towards the production of output (a sales worker interacts with clients to sell them some goods/services), the activity of managing and/or supervising does not transform material inputs but applies hierarchical power over subordinates.

[2] The aggregation used in this paper follows Eurostat reclassification of manufacturing and service industries according to their technological intensity. In order to reduce the number of groups we incorporate "medium-high technology" sectors with the high-tech ones and "low-tech technology" group into the low technology one. Table A *1* in Appendix provides the aggregation for Nace rev2 data while the corresponding table for Nace rev 11 data can be found at https://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an2.pdf and https://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an3.pdf

Measures of methods of work and tools.

Methods of work capturing organisational practices are operationalized using three groups of indicators. The first one refers to *teamwork*, that is the extent to which workers collaborate with colleagues in the execution of their tasks. The second involves workers' autonomy captured by the degree of workers' *latitude* in carrying out their tasks and forms of direct *control* (*internal* and *external*)[3] exercised over them. More precisely, *latitude* is measured by bundling questions related to workers' ability to interrupt their own work beyond pre-established breaks; whether instructions by the hierarchy establish both what to do and how to perform the task; freedom not to strictly follow hierarchical instructions on procedures and goals. Then, *internal control* indicates the degree of direct control that workers experience from their bosses or supervisors within their organization while *external control* refers to the degree of control exerted on the workers by figures external to their workplace, such as a client influencing deadlines. The last set of indicators within methods of work captures the extent of routine at work, which encompasses both the degree of *repetitiveness* and *standardization* of the labour process. *Repetitiveness* draws from a direct question asking whether the execution of one's work implies the continuous repetition of gestures or operations. *Standardisation* captures the extent to which work execution follows pre-codified standards and procedures (Harry Braverman, 1974; Edwards, 1982). Using the information provided in the EC and following Edwards (1982) our measure of standardisation is detailed into:

- *technical control* measuring if the pace and rhythm of work is imposed by the automatic cadence of a part or movement of a machine;
- *bureaucratic control* further decomposed into a) *digital monitoring*: whether pace of work is imposed on workers by computerized tracking and monitoring systems and b) *objective*: whether the worker has to achieve specified quantifiable objective.

Finally, tools used at work complete the second dimension coherently with the theoretical arguments outlined in the previous section. Briefly, technological tools (whether digital or mechanical) complement the organisational structure and their adoption directly depend on work organisation and simultaneously shape the division of labour.

In what follow, we measure the types of digital tools used at work distinguishing between *basic Ict* and *digitally-enabled machines.* The first indicator includes the use of internet for professional purposes, emails, and internal networks (i.e., intranet), while the second bundle together different type of machines: mobile phone, microcomputer (whether or not connected to a network or other computers), terminals and desktop and laptops.

Although raw measures for ICT and more broadly computerization remained the same across waves, the complexity and sophistication of the same type of digital machine has evolved rapidly, expanding its application within the workplace both within and between occupations. From a qualitative and technical perspective, what a computer can process and its potential interconnectedness with other devices has changed, as it is the case for the integration between email boxes and other applications (MS Office, monitoring and production flows applications).

To build the tasks indicators presented above, we use for each of them the same set of questions and variables - reported in Table A *2* in Appendix - across different EC waves. The resulting tasks

[3] The two variables capturing direct control are inverted to capture workers' autonomy from that form of control (the higher the value of *internal* and *external control* indicator, the higher the autonomy).

profile is therefore fully consistent over time. Methodologically, the construction of the task indicators follows the procedure adopted in (Fana et al., 2021) in which, for each indicator, the task score is defined at the worker level as the average score across variables/items related to the specific measure. The only exception refers to ICT indicators which are not originally included in the 2016 wave; therefore, we imputed the average score by job (at three-digit occupational and two-digit sectoral level) and gender using 2013 data. In this case, the resulting indicator is no longer defined at the worker level but at the gender-job one. Moreover, in order to maintain consistency across the two waves, we apply the same procedure to 2005 data.

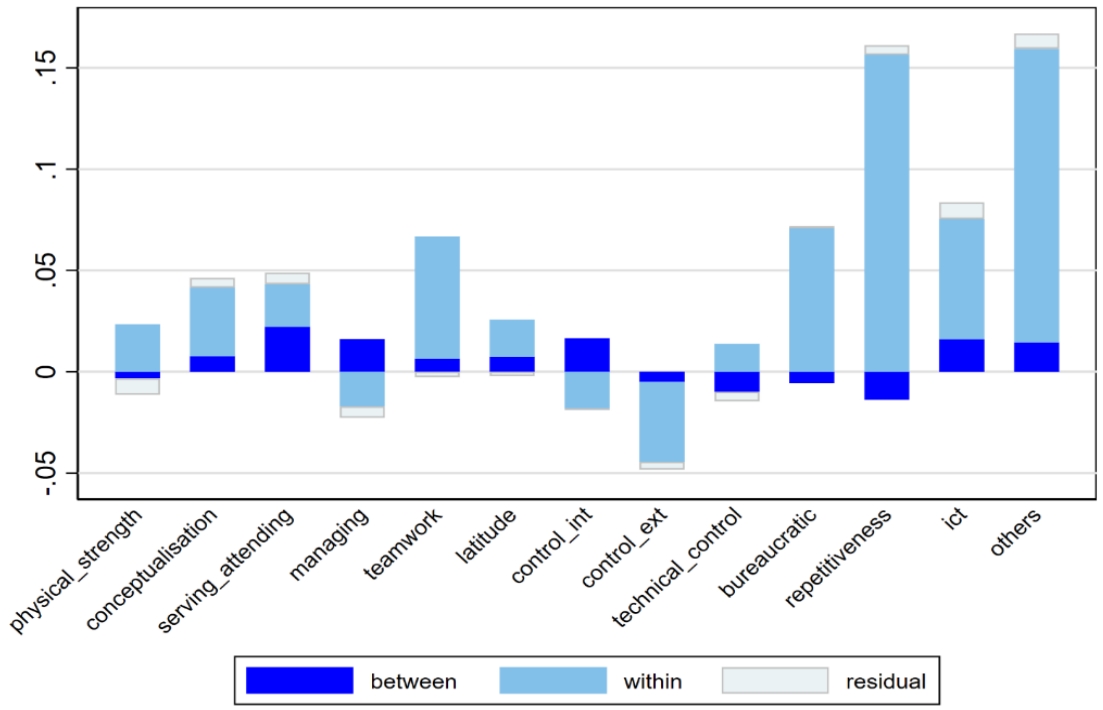
As already pointed out in several recent studies (S. O. Becker & Muendler, 2015; Bisello et al., 2019; Freeman et al., 2020; Marcolin et al., 2019) tasks profiles mostly differ within rather than between occupations and the same do tasks changes over time. This is confirmed in our setting where, by means of a shift share analysis[4] reported in Figure 1, the within job component dominates changes in tasks over time for at least half the tasks indicators considered. A second result spurring from the shift share analysis is the overall increase in repetitiveness as well as bureaucratic control and physical tasks, in line with findings from the European Job Monitor 2016 (Fernández-Macías et al., 2016). For instance, according to the EJM 2016, despite the decrease in routinised jobs, the overall level of routine intensifies over time. Moreover, the substantial relative increase in repetitiveness compared to the other indicators is surprising. The indicator has been built using the same question between the two waves so that potential bias in reporting or measurement are strongly mitigated. A deeper inspection across occupations (detailed using the two-digit PCS 2003 classification) shows that repetitiveness increases for all occupations; higher changes occur at the top of the occupational ranking where repetitiveness more than double for workers performing professional and clerical occupations (see Table A *3* in the Appendix).

Such result can be related to the increase in the standardisation of work, captured by the substantial within increase in bureaucratic control: the more procedures are codified (i.e., standardised), the more tasks become repetitive. This outcome is coherent with the deskilling hypothesis. Indeed, higher ICT adoption increases the possibility to standardise a given task, absorbing the analytical and/or problem-solving part into the machine, while leaving the worker with just the repetitiveness of operation. This interpretation is also in line with our theoretical understanding of routine and the relationship between measures of routine and ICT deployment, which do not necessarily substitute nor complement tasks but enter the workplace to expand the potential of control and its organisational rationalisation (Nobel, 1984; Nuvolari, 2002; Trusson et al., 2018). Furthermore, while the share of the workforce using both basic ICT and other digitally enabled machines increases, the compositional effect is by far outweighed by the more intensive use of digital tools at the workplace (the within component).

[4] The shift share analysis is used to decompose the change in each task indicator over two periods, $\Delta T_{it} = T_{it} - T_{it-1}$, into the between effect capturing the reallocation of workers between jobs and the effect of the change of a given task indicator within each job. The analytical formulation is $\Delta T_{it} = \sum_j \bar{T}_{ij}\, \Delta E_{jt} + \sum_j \bar{E}_{ij}\, \Delta T_{jt} + \varepsilon_{ij} = T_{ij}^{B} + T_{ij}^{W}$ where *j* index jobs, E_{jt} is the employment share of job *j* in period *t*. Overbars indicate average over time of the given quantity: $\bar{T}_{ij} = (T_{jt} + T_{jt+1})/2$ and $\bar{E}_{ij} = (E_{jt} + E_{jt+1})/2$. T_{ij}^{B} and T_{ij}^{W} refer respectively to the between and within component. Finally, ε_{ij} captures the interaction between task and employment change which can be computed as residual.

Finally, it is also interesting to observe the higher contribution of the compositional (between) component - compared to the within variation - for serving and attending activities: it is in line with the expansion of the service sector. Conversely, increases in intellectual tasks, i.e., conceptualisation, is mostly driven by the within component meaning that intellectual activities increase for most of the occupations, even those with low initial levels of conceptualisation.

Figure 1: Shift share analysis, 1995-2016



Source: authors' elaboration on EC data.

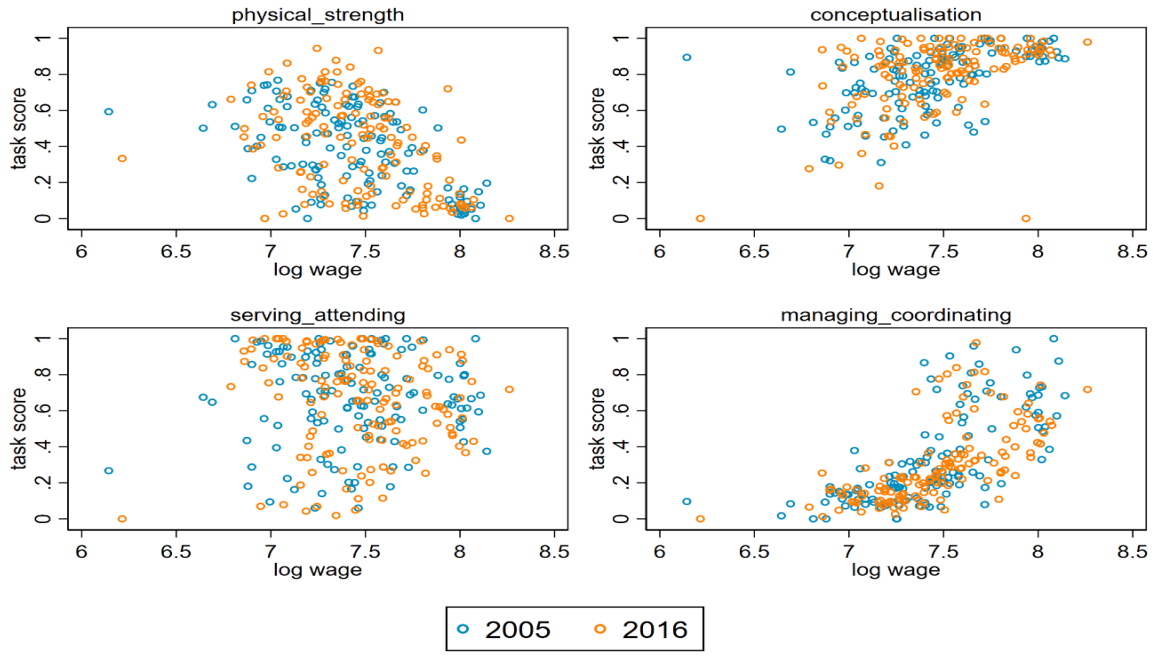
Wage Measures

Detailed information on wages at the individual level are consistently provided within the EC over waves. In particular, workers are asked to report their net monthly wage including, if any, the variable component due to performance-based premia (at the individual, team or company level). To validate the answers, the survey includes additional questions on annual wage and detailed (fourteen) ranges of net monthly wage. After comparing the consistency between monthly and annual wage using the number of months worked during the year, we opt for monthly wage (including premia) the main outcome variable used in the empirical analysis.

According to the RBTC theory, wage dynamic is strictly linked to tasks performed at work more than other explanatory factors, like changing in labour market institutions. Differences in wages across occupations mostly depend on the different tasks profile prevailing across them: the more the routine level the lower the returns, and *viceversa* (Acemoglu & Autor, 2011; D. Autor, 2013a; De La Rica et al., 2020; Fortin & Lemieux, 2016). A preliminary descriptive analysis performed using our data does not confirm such relationship. For instance, plotting tasks indicators against monthly (log) wage – Figure 2 and Figure 3 – clearly shows a positive relationship between wages and managerial tasks

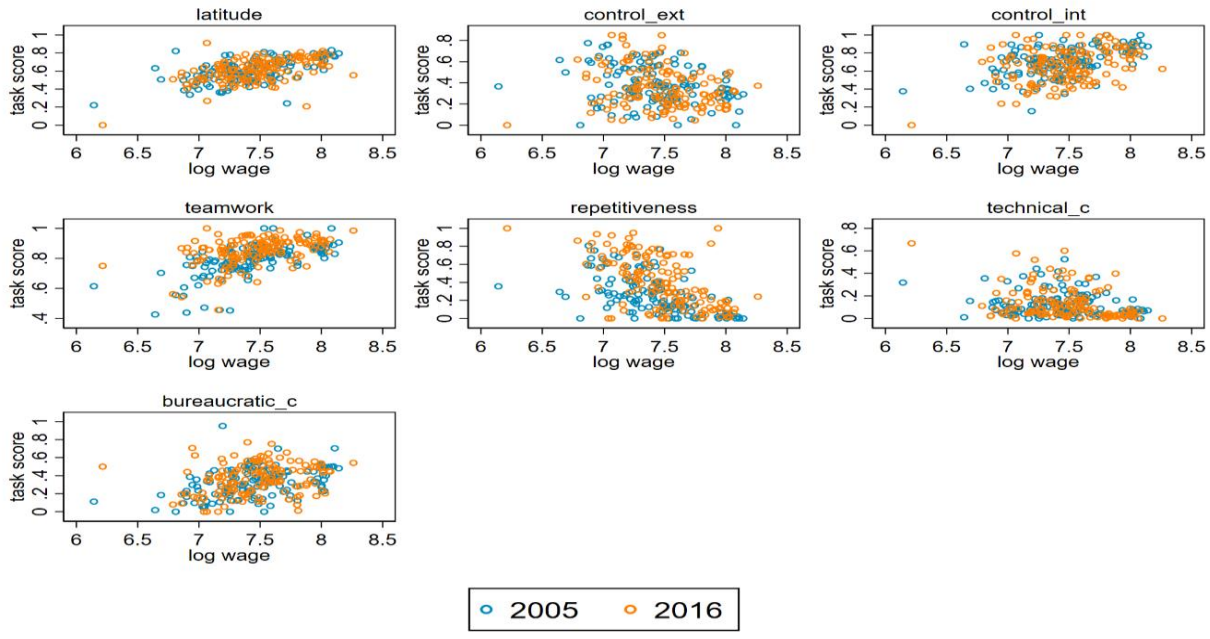
as well as workers' autonomy but also with respect to proxies for standardisation and teamwork. Conversely, wages show a negative association with the level of physical tasks and repetitiveness.

Figure 2: Average occupational (log) wages in 2005 and 2016 by tasks content indicators



Source: Authors' elaboration on EC data.

Figure 3: Average occupational (log) wages in 2005 and 2016 by Methods of work indicators



Source: Authors' elaboration on EC data.

Exploiting the possibility to measure if and to what extent tasks change at the individual level within jobs over time, we are able to inspect dynamically the tasks profile across wage percentiles.

According to these summary statistics, reported in Table 1 , tasks behave as expected across relevant deciles in terms of content, with low-wage earners being characterised by more physical tasks, less conceptualisation and especially a substantially lower level of managing role which strongly decreases over time. Looking at methods of work, top earners are endowed with higher level of autonomy in terms of latitude but not as for direct control. Among routine indicators top earners are subject to less repetitiveness but higher standardisation compared to low-wage earners. However, over time, interesting dynamics emerge: first, routine increases for all groups although different indicators show different patterns. For instance, the relative increase in repetitiveness results in a U-shaped pattern, while a reverse U-shaped pattern is detected for bureaucratic control, where the indicator increases more at the median of the wage distribution. Changes in technical control are substantially negative at the top of the wage distribution while positive at the bottom. Finally, direct control (both internal and external) decreases for all groups, while latitude slightly increases for median and top earners. Putting together evidence on organisational practices, it is as if bureaucratic control (routine) replaces direct supervision exerted by the hierarchy. Managerial roles keep concentrating at the top of the wage distribution which is in line with previous finding.

Table 1: tasks profile by wage decile and relative change, 2005-2016

	10th		**50th**		**90th**		**Delta 2016-2005(%)**		
	2005	*2016*	*2005*	*2016*	*2005*	*2016*	*10th*	*50th*	*90th*
physical strength	0.468	0.487	0.491	0.458	0.291	0.298	4.1	-6.7	2.5
conceptualisation	0.626	0.674	0.734	0.752	0.867	0.883	7.7	2.6	1.9
serving attending	0.691	0.810	0.665	0.717	0.707	0.696	17.2	7.7	-1.4
managing coordinating	0.051	0.042	0.208	0.204	0.376	0.412	-17.0	-1.7	9.6
teamwork	0.594	0.701	0.789	0.826	0.832	0.876	17.9	4.7	5.4
latitude	0.531	0.502	0.559	0.574	0.643	0.673	-5.5	2.7	4.8
control int	0.737	0.688	0.652	0.604	0.740	0.737	-6.6	-7.4	-0.5
control ext	0.519	0.478	0.417	0.287	0.367	0.300	-7.9	-31.2	-18.3
repetitiveness	0.345	0.642	0.339	0.469	0.135	0.226	86.1	38.2	67.7
technical control	0.052	0.067	0.136	0.140	0.094	0.075	30.7	3.1	-19.6
bureaucratic control	0.105	0.140	0.279	0.386	0.322	0.384	33.9	38.3	19.2

Source: Authors' elaboration on EC data.

Considering the wage distribution overall, it is useful to present the wage inequality trajectories over the decade under analysis. The Gini coefficient for both male and female workers slightly reduce from 2005 to 2016 - we have a Gini reduction in the population of about 1 point (from 0.255 to 0.245).

This trend is mostly explained by the increase in the log-wage of the bottom 10th percentile, especially for women who slightly reduce their distance from both the median and top 90th. On the contrary, the distance between the median and top 90 is merely constant.

4. Econometric and statistical methods

To understand if and to what extent the employment structure, tasks, individual characteristics and labour market institutions affect wages and their dispersion over time, we rely on the contribution of Firpo, Fortin and Lemieux (2018; 2011) which allows, by means of a *Recentred Influence Function* (RIF), to estimate the effect of a set of covariates beyond the mean.

In our case, the effects of tasks as well as individual and institutional characteristics may vary across the log-wage distribution. The existing techniques i.e., conditional quantile regression introduced by (Koenker & Bassett, 1978) permit such estimation, but the RIF-OLS method - or unconditional quantile regression (UQR) - introduced by Firpo, Fortin and Lemieux (2009, henceforth FFL), has a clear significant advantage. Indeed, it enables to estimate the (marginal) effects of explanatory variables on the *unconditional* distribution of *y* and how this affects distribution statistics like Gini index, quantiles, variances, etc. The unconditional effect is important because it permits to answers questions about how the covariates' coefficient change along the wage distribution. In our case, for example, to what extent different tasks affect the wage distributions at different points (wage deciles), without conditioning the wage distribution on education (or any other covariate). In other words, the high or low-wage worker is identified in "absolute" way on the log-wage distribution and is not redefined conditional on covariates and, hence, on different subgroups, as in the standard conditional quantile regression.

More formally, the building block of the RIF-OLS is the influence-function. Considering a given distributional statistic v(Fy) – bottom 10th, median and top 90th percentile as well 50/10 and 90/50 ratios in our case – computed on the distribution F, the influence function of v(Fy) represents the effect of an infinitesimal change in the function F at a given point y (of our log-wage distribution). Hampel (1974) provides a formal definition of the influence function (IF) as:

$$IF(y;\ v, Fy) = \frac{v\big((1-\epsilon)Fy + \ \epsilon\Delta y\big) - v(Fy)}{\epsilon} \qquad (1)$$

FFL (2009) recentred the function adding back the distributional statistic to the IF:

$$RIF(y; v, Fy) = v(Fy) + IF(y; v, Fy) \qquad (2)$$

and demonstrate how the distributional statistic v(Fy) can be written in terms of expectations and, applying the law of iterated expectations, also in terms of expectations of the conditional RIF:

$$v(Fy) = \int E[RIF(y; v, Fy) \mid X = x] \ * \ dFx\ (x) \qquad (3)$$

According to equation (3) when covariates are present and we are interested in understanding their effect on a distributional statistic v(Fy), it is necessary to integrate over the $E[RIF(y; v, Fy) \mid X]$.

To do so, FFL (2009) propose a simple OLS regression, obtaining the RIF-OLS:

$$v(Fy) = E[RIF(y; v, Fy)] = E(X\beta) + E(\varepsilon) \qquad (4)$$

where coefficient β can be interpreted unconditionally, in FFL's (2009) terms, the unconditional partial effect (UPE). However, the interpretation of our coefficients is different from the standard OLS regression: β represents the expected change in our distributional statistic if the (unconditional) average of X increases by one unit.

5. Empirical results

In this section, we present estimation results of the RIF-OLS by gender and year over main percentiles (10^{th}, 50^{th} and 90^{th}) in which log monthly wage is regressed on the rich set of explanatory variables capturing three main set of covariates: tasks profile, individual and job characteristics, and contractual and working time arrangements[5], used as proxy for labour market institutions. The analysis is run over the full sample (private and public employees) exploiting variation at the job level, that is controlling for the interaction between occupations and economic sectors classified respectively at the PCS 2003 three digit and nine sectors, aggregated according to Section 3. Those occupations with less than thirty observations have been recoded to the nearest code.

The choice to perform separate analysis by gender is coherent with most recent literature on differences in tasks among men and women. Such differences arise not only because of gender occupational segregation but also within the same occupation (Autor, 2013; West, 1990). Fana et al. (2021), using data from the *Enquête Complémentaire Emploi: Conditions de travail,* show that difference in tasks allocation within the same job are substantial and persist over time also for the case of France.

According to our evidence, for both male and female workers, the effect on wages across the distribution is mostly driven by experience within the firm, contractual arrangement and working time and to a lower extent by education and nationality. Tasks' indicators if any play a very minor role in explaining differences in wages within jobs along the distribution.

More precisely, estimates at the beginning of the period for men – first three columns of Table 2 – show that being a part-time worker has a substantial negative impact[6] along the distribution with major effect at the bottom, while being permanent instead of temporary worker has a positive effect only for workers belonging to the 10^{th} percentile. Seniority is another relevant factor explaining wage differentials, especially at the bottom and at the median of the distribution with monotonic effect as tenure increases. However, returns at the top of the distribution due to seniority within the firm show a positive and significant effect only in the case of more than ten years compared to less than one

[5] Table A *4* in Appendix reports the distribution of each set of covariates at relevant wage percentiles (10^{th}, 50^{th} and 90^{th} percentile) in both points in time.

[6] After controlling for the number of hours worked (coefficients not reported).

year experience. As expected, the effect of formal education is monotonic within each percentile but significant only in the case of upper tertiary education for the 90th percentile.

With respect to tasks indicators, challenging results emerge. First, routine indicators (and each of its component) have a minor effect if any on wages. Indeed, at the bottom 10th the most relevant effect, associated to routine, is about 0.02% (0.017/0.765) of the part-time coefficient. More interestingly, a negative effect on wage is found only for repetitiveness both at the median and top of the distribution. It is worth recalling that we are exploiting differences within jobs, all of which are characterised by a certain degree of repetitiveness, even at the top. Moreover, as for bureaucratic control, an increase of one standard deviation in the average score[7] of monitoring and tracking devices increases rather than decreases wages at the bottom of the distribution, while being subject to predefined objectives has a positive effect at the median and top of the wage distribution. The latter result is somehow expected considering that our wage measure includes performance-based pay (although we cannot distinguish whether at the individual, team, or firm level). Increasing the level of hierarchical authority within the organisation (proxied by managing/coordinating) has the expected positive effect on wages, which increases along the distribution.

Finally, we do not find any supporting evidence for the computerisation hypothesis according to which returns in the middle of the distribution decrease as computerisation expands. For instance, basic ICT use has no significant effect on wages.

On the contrary, other ICT tools show positive monotonic effects. This seems to be reasonable as in 2005 we have a very low average score of different types of digital devices (0.26). Therefore, their use guarantees higher returns along the entire wage distributions which increases at the top. For example, a unit increase in the (unconditional) average score in the use of other ICT tools increases the log-wage at the median by 5.5 per cent (0.412/7.484) and by 8 per cent at the top 90th. To deepen the analysis on the relationship between computerisation and routine, we interacted ICT variables with detailed routine indicators without finding any significant effect nor changes in the sign and magnitude of single covariates. For robustness, we also run an additional specification restricting the sample to private employees only, including firm size as additional control which is available only for the private sector. Once interacting ICT use with firm size, any significant change emerged in terms of tasks' association to log-wage. Furthermore, the use of other ICT tools guarantees additional higher returns at the top 90th in the larger firms in 2005, coherently with the baseline results. The significance vanishes in 2016 as the computers and other digital devices spread across all type of firms and along the entire wage distribution (estimation results are reported in Table A 7 and Table A 8).

Overall, the same general conclusions drawn for 2005 holds for the analysis in 2016. Two main differences emerge: first, contractual and part-time work variables lose their statistical significance at the top of the distribution. Second, basic ICT use turns to be positive and significant at the bottom, while other digital tools lose their explanatory power. Our interpretation for this evidence is that in most recent years, relevance for digital information processing comes from the use of software/applications regardless of the type of physical device. This is in line with an evolutionary and additive character of technological devices which nowadays allow for the integration of different software/applications. For example, a mobile phone in 2005 may not support application for

[7] As anticipated, the coefficient of the independent variable represents the expected change in our outcome if the average of X increases by one unit. We have standardized measures of tasks, therefore we interpret our results as the expected change in outcome if the average of X increases by one standard deviation.

scheduling and communication platforms therefore the possibility for information exchange and processing was possible only when using a desktop or microcomputer.

Turning our attention to the impact of covariates on wages for women, regression results reported in

Table 3 show very similar estimates in terms of tasks compared to male workers. The most interesting effect is the positive and significant effect of physical strength at the bottom 10th. Our intuition is that this effect results from the jobs clustering by gender. In other words, women working in male-jobs obtain higher returns compared to women employed in female-jobs. However, all the tasks' coefficients are all around 0.1% of the part-time effect, implying a very marginal role in our model specification.

Seniority within the firm has a positive and monotonic effect both for female workers belonging to the 10th and 50th percentiles. Working part time has, as expected, a negative and significant effect which decreases as one moves from the bottom to the top of the wage distribution. However, the part-time effect is much weaker compared to male counterpart i.e., it seems that males have more to lose compared to women. Nonetheless, this basically reflects the worse starting conditions of women who are more concentrated in atypical form of employment.

Individual characteristics matter as well. In particular, higher levels of education have higher returns at each point of the distribution although they are not necessarily significant: only holding a Baccalauréat plus two years of tertiary education or upper-level tertiary education (four or more years) matter. As expected, returns to education are higher for top wage earners. Finally, being foreigners and in particular naturalised French citizen reduce wage more at the bottom than at the top. Also for female workers, the comparison between 2005 and 2016 results into minor differences not reversing any of the argument presented above.

Table 2: RIF OLS Male by relevant percentiles, 2005 and 2016.

	2005			*2016*		
	10th	*50th*	*90th*	*10th*	*50th*	*90th*
Tasks						
digital monitoring	0.017**	0.007	-0.001	0.036***	0.01	-0.01
objectif	-0.000	0.013**	0.022*	0.018	0.012	0.021
technical_control	-0.002	0.005	0.012	0.014	0.017*	0.009
repetitiveness	-0.001	-0.013*	-0.019**	-0.01	-0.008	-0.02
managing_coordinating	0.029***	0.03***	0.049***	0.013	0.041***	0.059***
physical_strength	0.010	-0.037***	-0.032**	-0.016	-0.021*	-0.05**
basic_ict	0.031	-0.033	-0.035	0.270***	0.108	0.014
others	0.278***	0.412***	0.661***	-0.01	0.129	-0.106
Contractual arrangements						
Part-Time=1	-0.765***	-0.235***	-0.156**	-0.825***	-0.243***	0.136
permanent=1	0.248***	-0.013	0.01	0.253***	0.041	0.024
Tenure:						
between 1 and 5 ys	0.09**	0.047**	-0.003	0.031	0.039	0.073
between 5 and 10 ys	0.194***	0.101***	0.039	0.113*	0.04	0.049
>10 ys	0.273***	0.240***	0.165***	0.149**	0.175***	0.242***
Individual characteristics						
Aucun diplÔme	-0.045*	-0.039**	-0.007	-0.072	-0.037	0.039
Bac tech ou profes.	-0.04	-0.031	0.056	-0.02	0.005	0.031
Bac général brevet supérieur	-0.056*	-0.01	0.065	0.014	0.040	0.01
Bac+2	-0.002	0.002	0.051	-0.007	0.060*	-0.02
Bac+3 ou Bac+4	0.013	-0.014	0.130	-0.045	0.013	-0.075
Dip. supérieur À bac+4	0.033	0.028	0.193*	0.058	0.092**	0.170
Naturalized French	0.01	-0.041	-0.055	0.004	0.034	0.051
Foreigner	0.01	0.027	-0.026	-0.073	-0.027	-0.112
Constant	7.702***	7.634***	7.368***	7.725***	7.864***	7.815***
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Job FE	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.404	0.495	0.404	0.522	0.484	0.414
N	6103	6103	6103	6265	6265	6265
Rif-Mean	7.109	7.484	8.084	7.093	7.515	8.056

Table 3: RIF OLS Female at relevant percentiles, 2005 and 2016

	2005			*2016*		
	10th	*50th*	*90th*	*10th*	*50th*	*90th*
Tasks						
digital monitoring	-0.003	0..025***	-0.002	0.041*	0.018**	0.013
objectif	0.012	0.013*	0.023*	-0.032	0.009	0.029*
technical control	0.026	0.007	-0.004	0.065*	-0.005	-0.027*
repetitiveness	0.017	-0.014*	-0.018**	-0.031	-0.029***	-0.019
managing coordinating	0.010	0.023***	0.065***	-0.0121	0.010	0.075***
physical strength	0.046*	-0.014*	-0.009	0.099***	-0.023*	-0.027
Basic ict	0.039	0.293***	-0.021	0.047	0.174**	0.015
others	-0.264	-0.249	0.256	0.399	0.06	0.483**
Contractual arrangements						
part-Time=1	-0.294***	-0.204***	-0.145***	-0.454***	-0.165***	-0.049
permanent=1	0.150**	-0.029	-0.044*	0.405***	0.095***	0.063*
Tenure:						
between 1 and 5 ys	0.404**	0.073***	-0.006	0.205	-0.013	-0.002
between 5 and 10 ys	0.489***	0.156***	0.019	0.299**	0.057*	0.035
>10 ys	0.576***	0.270***	0.209***	0.360***	0.169***	0.128**
Individual characteristics						
Aucun diplôme	-0.116*	-0.017	-0.015	-0.217	-0.030	0.036
Bac tech ou profes.	0.028	-0.016	0.032	-0.059	-0.025	-0.001
Bac général brevet supérieur	0.07	0.024	0.057*	-0.023	-0.025	-0.01
Bac+2	0.109*	0.07***	0.074*	0.104	-0.002	0.025
Bac+3 ou Bac+4	0.107	0.056**	0.07	0.159	0.034	0.02
Dip. supérieur à bac+4	0.120	0.120***	0.313***	0.100	0.081**	0.152*
Naturalized French	-0.193*	-0.066*	-0.118***	-0.176	0.087*	0.062
Foreigner	-0.104	-0.087**	-0.071	-0.242	-0.02	-0.057
Constant	3.804***	7.195***	7.710***	3.952***	7.125***	7.391***
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Job FE	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.39	0.522	0.377	0.448	0.538	0.43
N	6787	6787	6787	9105	9105	9105

Rif-Mean	6.554	7.281	7.812	6.622	7.313	7.836

After presenting empirical results at the relevant percentiles, we discuss the effect of the long list of covariates on inequality measures, namely the 90-50 and 50-10 wage ratios to better understand if and to what extent drivers of inequality differ once evaluated at the top and bottom half of the distribution. Estimation outcomes confirm previous evidence: routine, if any, plays a very minor role in explaining wage differentials while the main determinant appears contractual arrangement and working time as well as tenure within the firm. Overall, our study supports the strand of literature pointing to labour market institutions and embedded social relations in explaining determinants and patterns of wage inequality among workers, at least for the country under scrutiny, France. More precisely, a 1% increase in the share of employees working on a permanent base decreases the 50/10 wage ratio in 2016 for both male and female workers by 0.22% and 0.30%, respectively. Similar considerations apply for those who work full-time where the effect of 1% increase in the share of full-time male workers reduces the 50/10 ratio by almost 0.63% (compared to 0.28% for women). Experience within the firm has a comparable magnitude, although the effect is not necessarily significant in 2016. As shown in

Table 4, left panel, nor education nor nationality play any role on wage inequality at the bottom. More importantly, among tasks indicators, we find that standardisation in the form of computerised tracking and monitoring systems has a negative but minor effect only for male in 2016. Furthermore, coherently with the results at relevant percentiles, physical strength reduces the 50/10 wage ratio for female in both 2005 and 2016, while the monotonic positive effect of managing significantly increases the 90/50 wage ratio for women in both years.

Again, the impact of ICT tools is significant for men in 2016, for whom the use of basic ICT tends to decrease the 50/10 wage ratio. According to our data and econometric exercise, inequality do not necessarily decrease at the bottom half of the wage distribution because of an expansion of computerisation or routine. If a negative effect of ICT on bottom inequality exists this is due to the increase in very low wages induced by ICT rather than a decrease at the middle of the wage distribution.

Finally, looking the 90/50 ratio, we find an ICT induced increase in wage dispersion following an increase of other digital tools for women in 2016, while in 2005 they seem to experience a reduction in the 90/50 ratio as the use of basic ICT increases, confuting the main hypothesis of the RBTC according to which inequality at the top would increase because of the complementarity between top earners and ICT, while substitution should prevail between the machine and median workers.

To sum up, this last exercise reveals that labour market institutions have a dominant role in determining the 50/10 wage ratio for both males and females. Differently, tenure within the firms and the use of basic ICT affects the 90/10 wage ratio for women and only in 2005, while other digital devices and part-time are most relevant in 2016.

Table 4: RIF OLS on wage ratios by gender and year

	50th / 10th				90th / 50 th			
	Female		Male		Female		Male	
	2005	2016	2005	2016	2005	2016	2005	2016
Tasks								
digital monitoring	0.059	-0.045	-0.016	-0.045*	-0.046*	-0.01	-0.01	-0.03
objectif	0.000	0.081	0.02	-0.01	0.02	0.03	0.019	0.01
Technical control	-0.045	-0.137*	0.01	0.003	-0.018	-0.033	0.014	-0.015
repetitiveness	-0.067	0.001	-0.018	-0.002	-0.005	0.020	-0.012	-0.016
Managing coordinating	0.026	0.044	0.001	0.042*	0.068***	0.097**	0.038*	0.021
Physical strength	-0.132**	-0.239***	-0.068***	-0.005	0.010	-0.003	0.005	-0.041
Basic ict	0.524	0.254	-0.093	-0.270*	-0.530*	-0.266	-0.008	-0.158
others	0.074	-0.647	0.173	0.209	0.846	0.623*	0.502	-0.375
Contractual arrangements								
Part-Time=1	0.232	0.553***	0.820***	0.955***	0.105	0.199**	0.130	0.611***
permanent=1	-0.395***	-0.598**	-0.394***	-0.343***	-0.025	-0.062	0.052	-0.032
Tenure:								
between 1 and 5 ys	-0.752***	-0.424	-0.072	0.008	-0.134***	0.017	-0.091	0.047
between 5 and 10 ys	-0.768***	-0.470*	-0.148**	-0.115	-0.232***	-0.042	-0.109	0.001
>10 ys	-0.725***	-0.364	-0.067	0.024	-0.110*	-0.09	-0.122	0.077
Individual characteristics								
Aucun diplôme	0.224	0.361	0.012	0.059	0.003	0.104*	0.058	0.121
Bac tech ou profes.	-0.096	0.06	0.017	0.043	0.080	0.04	0.162*	0.039
Bac général brevet supérieur	-0.106	-0.006	0.07	0.039	0.054	0.021	0.142	-0.05

Bac+2	-0.098	-0.206	0.005	0.101	0.005	0.042	0.092	-0.130
Bac+3 ou Bac+4	-0.125	-0.243	-0.040	0.091	0.023	-0.026	0.269*	-0.135
Dip. supérieur à bac+4	-0.019	-0.034	-0.01	0.044	0.316**	0.094	0.313*	0.105
Naturalised French	0.294	0.515*	-0.076	0.045	-0.085	-0.050	-0.029	0.02
Foreigner	0.052	0.431	0.022	0.076	0.03	-0.054	-0.098	-0.125
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Job FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	8.04***	6.812***	0.773*	1.04*	1.678***	1.324**	0.199	0.763
R-squared	0.267	0.325	0.263	0.357	0.209	0.266	0.235	0.244
N	6787	9105	6103	6265	6787	9105	6103	6265
Rif-Mean	2.067	1.996	1.455	1.525	1.701	1.685	1.832	1.708

6. Conclusions

In this paper we have shown that within jobs individual tasks and organisational methods play a very marginal role in determining wages along the wage distribution. On the contrary, labour market institutions, proxied by contractual arrangement and working time, together with experience within the firm are the principal determinants of individual wage.

Specifically, at the bottom of the distribution being employed part-time has a stronger negative effect, while having a permanent contract positively contributes to the log-wage. These associations strengthen over-time, suggesting a worsening economic condition for those employed under more precarious working relations. Furthermore, the larger coefficients observed for men compared to women suggest that male workers have relatively more to lose compared to female colleagues, which reflects the worse starting conditions of female employment. The use of ICT tools has a positive and monotonic impact on wages although this is not the case for any type of tool. For instance, what matters for wages in 2005 is the use of digitally-enable machines (mobile phone, microcomputer, terminals, and laptops), while in more recent years the positive effect on wages holds only at the bottom of the wage distribution and is prompted by application-type of ICT (Internet, intranet, etc..). This is an interesting result since, on the one hand, our findings confirm that ICT cannot be synthetised into a generic computerisation hypothesis as it would be in the standard RBTC approach. The evolving and additive nature of technological adoption reveals to be pivotal in understanding its role into the labour process. On the other hand, the outcome of our empirical analysis show that in more recent times, if a significant association exists, it occurs at the bottom of the wage distribution, not at the top nor in its middle. More interestingly, the effect of ICT use on wage ratio, both 90/50 and 50/10 is not significant. Again, the computerisation hypothesis as main explanation for wage inequality is not confirmed. Conversely, findings related to labour market institutions still hold when we look directly at the wage ratios, 50/10 and 90/50. More precisely, a 1% increase in the share of employees with a permanent contract decreases the 50/10 in 2016 for both men and women, by 0.31 and 0.22 percent respectively.

Being the contract arrangement and the working time, together with the experience within firm, the main determinants of both log-wage and measures of inequality, our study finds evidence against the Routine-Biased Technical Change theory according to which tasks are a fundamental predictor of the dynamics of wage distribution and inequality (Acemoglu & Autor, 2011; D. Autor et al., 2003; D. H. Autor & Handel, 2013; Goos et al., 2014). Conversely, our findings support the alternative hypothesis which identifies institutions as the main locus from which wage inequality spurs (Card, 1996; Firpo et al., 2011, Derenoncourt & Montialoux, 2020, Esping-Andersen, 2000, etc.).

Furthermore, these findings contribute to the literature on the determinant of wage distribution by means of a rigorous econometric method, i.e., RIF-OLS (Firpo et al., 2009), and an extremely rich database at the worker level consistent over time which enabled to detail measures related to tasks, individual and job characteristics as well as work arrangements. At the same time, the analytical approach is a novelty in the field. First, our study is carried out within jobs where both occupations (at the three-digit levels) are combined with economic sectors, rather than just occupations, therefore capturing heterogeneity which may spur form the horizontal division of labour. Second, our detailed measures of tasks, theoretically consistent with the Labour Process Theory (Edwards, 1982), enhances the understanding of actual activities carried at work as well as the multifaceted forms of social relations prevailing at the workplace. Indeed, departing from the standard task approach, routine is not simply defined as a technical attribute of a given work activity, rather a specific characteristic of work organisation covering different concepts: repetitiveness and indirect forms of control, where the latter capture technical and bureaucratic control. Exploiting data from the *Enquête Complémentaire Emploi: Conditions de travail,* we have been able to measure these concepts at the individual level over time showing that both repetitiveness and standardisation are not a prerogative of workers in the middle of the wage distribution and the negative effect on wages is marginal and relates only to repetitiveness. Our paper also suggests that the theoretical ground matters in informing socio-economic research and that a classical understanding of the labour and production processes is better suited to explain current dynamics within the labour market.

To conclude, it is important to recall that our findings refer to France therefore will be interesting to test the same hypothesis on other countries exploiting database which allow detailed measures as the ones used in our work.

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Appendix

Table A 1: Correspondence table between Nace rev2 two-digit and High-tech classification

NACE Rev.2 two-digits	***Sector***
Crop and animal production, hunting and related service activities	Prim
Forestry and logging	Prim
Fishing and aquaculture	Prim
Mining of coal and lignite	Prim
Extraction of crude petroleum and natural gas	Prim
Mining of metal ores	Prim
Other mining and quarrying	Prim
Mining support service activities	Prim
Manufacture of food products	LTI
Manufacture of beverages	LTI
Manufacture of tobacco products	LTI
Manufacture of textiles	LTI
Manufacture of wearing apparel	LTI
Manufacture of leather and related products	LTI
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	LTI
Manufacture of paper and paper products	LTI
Printing and reproduction of recorded media	LTI
Manufacture of coke and refined petroleum products	LTI
Manufacture of chemicals and chemical products	HTI
Manufacture of basic pharmaceutical products and pharmaceutical preparations	HTI
Manufacture of rubber and plastic products	LTI
Manufacture of other non-metallic mineral products	LTI
Manufacture of basic metals	LTI
Manufacture of fabricated metal products, except machinery and equipment	LTI
Manufacture of computer, electronic and optical products	HTI
Manufacture of electrical equipment	HTI
Manufacture of machinery and equipment n.e.c.	HTI
Manufacture of motor vehicles, trailers and semi-trailers	HTI
Manufacture of other transport equipment	HTI
Manufacture of furniture	LTI
Other manufacturing	LTI
Repair and installation of machinery and equipment	LTI
Electricity, gas, steam and air conditioning supply	LTI
Water collection, treatment and supply	LTI
Sewerage	LKIS
Waste collection, treatment and disposal activities; materials recovery	LKIS
Remediation activities and other waste management services	LKIS
Construction of buildings	Constr
Civil engineering	Constr
Specialised construction activities	Constr
Wholesale and retail trade and repair of motor vehicles and motorcycles	LKIS
Wholesale trade, except of motor vehicles and motorcycles	LKIS
Retail trade, except of motor vehicles and motorcycles	LKIS
Land transport and transport via pipelines	LKIS

Water transport	KIS
Air transport	KIS
Warehousing and support activities for transportation	LKIS
Postal and courier activities	LKIS
Accommodation	LKIS
Food and beverage service activities	LKIS
Publishing activities	KIS
Motion picture, video and television programme production, sound recording and music publishing activities	KIS
Programming and broadcasting activities	KIS
Telecommunications	KIS
Computer programming, consultancy and related activities	KIS
Information service activities	KIS
Financial service activities, except insurance and pension funding	KIS
Insurance, reinsurance and pension funding, except compulsory social security	KIS
Activities auxiliary to financial services and insurance activities	KIS
Real estate activities	LKIS
Legal and accounting activities	KIS
Activities of head offices; management consultancy activities	KIS
Architectural and engineering activities; technical testing and analysis	KIS
Scientific research and development	KIS
Advertising and market research	KIS
Other professional, scientific and technical activities	KIS
Veterinary activities	KIS
Rental and leasing activities	LKIS
Employment activities	KIS
Travel agency, tour operator and other reservation service and related activities	LKIS
Security and investigation activities	KIS
Services to buildings and landscape activities	LKIS
Office administrative, office support and other business support activities	LKIS
Public administration and defence; compulsory social security	PubAdm
Education	Educ
Human health activities	Health
Residential care activities	Health
Social work activities without accommodation	Health
Creative, arts and entertainment activities	KIS
Libraries, archives, museums and other cultural activities	KIS
Gambling and betting activities	KIS
Sports activities and amusement and recreation activities	KIS
Activities of membership organisations	LKIS
Repair of computers and personal and household goods	LKIS
Other personal service activities	LKIS
Activities of households as employers of domestic personnel	LKIS
Undifferentiated goods- and services-producing activities of private households for own use	LKIS
Activities of extraterritorial organisations and bodies	LKIS

Table A 2: Questions and variables used to create tasks indicators

Task indicator	Variable	Question	2005	2016
Strength		*Does the execution of your work require:*		
	cwdebou	to stand for longtime	x	x
	cwdepla	to walk frequently or for long distances	x	x
	cwlourd	to carry or move heavy loads	x	x
Conceptualization, learning and abstraction	nouvelle	Does the execution of your work allow to learn new things?	x	x
Serving / attending	public	Are you in direct contact with the public?	x	x
Managing/coordinating	encad	Dans votre emploi principal, vous arrive-t-il de superviser d'autres salariés		x
	chef	Do you give orders to other employees?	x	
Teamwork	aidcoll	If you have trouble doing delicate, complicated work, is it that you are helped by your colleagues	x	x
	collect	Do you have the opportunity to approach collectively, with other people from your workshop or department, questions organization or operation of your work unit?	x	x
	horangt	In case of unforeseen circumstances, can you modify your schedules by arranging with your colleagues?	x	x
	corrcop	To do your job properly, do you usually have the possibility of cooperation (exchange of information, mutual assistance, etc.)	x	x
Latitude	interup	Do you have the possibility to interupt your own work as you prefer?	x	x
	delais	Do you have the possibility to change already fixed deadlines?	x	x
	comment	Instructions by your hierarchical superiors tell you what to do. Do they tell you how to do as well?	x	x
	stark	You receive orders, goals and instructions?	x	x
External control	rwdemand	Is the pace of your work imposed by external demand (clients, public) without imposing an immediate answer?	x	x
	rwdem	Is the pace of your work imposed by external demand (clients, public) imposing an immediate answer?	x	x
Internal control	rwsurv	Is the pace of your work imposed by a hierarchical supervisor?	x	x
Repetitiveness	repete	Does the execution of your work imply the continuous repetition of gestures or operations?	x	x
Standardisation-1. Bureaucratic control	objectif	Do you have to achieve specific quantified objectives?	x	x
		Is the rythm of your work imposed by:		
	rwinfo	a computerised monitoring and tracking system?	x	x
	rwcad	the automatic rate of a machine?	x	x

Standardisation-2. Technical control	rwdep	the automatic movement of a product or a part?	x	x
	rwtech	other technical constraints?	x	x
Basic Ict	internet	Use internet	x	x
	melcoll	Use of collective electronic mailbox	x	x
	melindiv	Use of individual electronic mailbox	x	x
Other Ict Tools		*During your work, do you use (even occasionally):*		
	teleport	mobile phone	x	x
	micro1	a microcomputer connected to a network or to other computers	x	x
	micro2 (a)	an unconnected microcomputer	x	x
	micro3	a portable microcomputer	x	
	micro	a microcomputer	x	x
	ordi	a terminal and no microcomputer connected	x	
	termi	terminal or computer consol	x	x

Note: (a) includes *termi* of previous wave

Table A 3: average score for repetitiveness across occupation and change, 2005-2016

Classification of Professions and Socioprofessional Categories detailed level (PCS 2003)	2005	2016	abs. Change 2005-16	rel. Change 2005-2016 (%)
Professions libérales	0.03	0.064	0.034	113.3
Cadres de la fonction publique	0.027	0.079	0.052	192.6
Professeurs, professions scientifiques	0.052	0.17	0.118	226.9
Professions de l'information, des arts et des spectacles	0.11	0.231	0.121	110.0
Cadres administratifs et commerciaux d'entreprises	0.047	0.123	0.076	161.7
Ingénieurs et cadres techniques d'entreprises	0.034	0.112	0.078	229.4
Instituteurs et assimilés	0.079	0.257	0.178	225.3
Professions intermédiaires de la santé et du travail social	0.157	0.29	0.133	84.7
Professions intermédiaires administratives de la fonction publique	0.137	0.281	0.144	105.1
Professions intermédiaires administratives et commerciales des entreprises	0.18	0.318	0.138	76.7
Techniciens	0.133	0.204	0.071	53.4
Contremaîtres, agents de maîtrise	0.209	0.341	0.132	63.2
Employés civils et agents de service de la fonction publique	0.352	0.617	0.265	75.3
Policiers et militaires	0.28	0.343	0.063	22.5
Employés administratifs d'entreprise	0.28	0.498	0.218	77.9
Employés de commerce	0.407	0.608	0.201	49.4
Personnels des services directs aux particuliers	0.353	0.63	0.277	78.5
Ouvriers qualifiés de type industriel	0.495	0.617	0.122	24.6
Ouvriers qualifiés de type artisanal	0.319	0.564	0.245	76.8
Chauffeurs	0.369	0.639	0.27	73.2
Ouvriers qualifiés de la manutention, du magasinage et du transport	0.461	0.657	0.196	42.5
Ouvriers non qualifiés de type industriel	0.7	0.832	0.132	18.9
Ouvriers non qualifiés de type artisanal	0.462	0.796	0.334	72.3

Source: Authors' elaboration on EC data.

Table A 4: employment distribution across relevant percentiles by covariate and year.

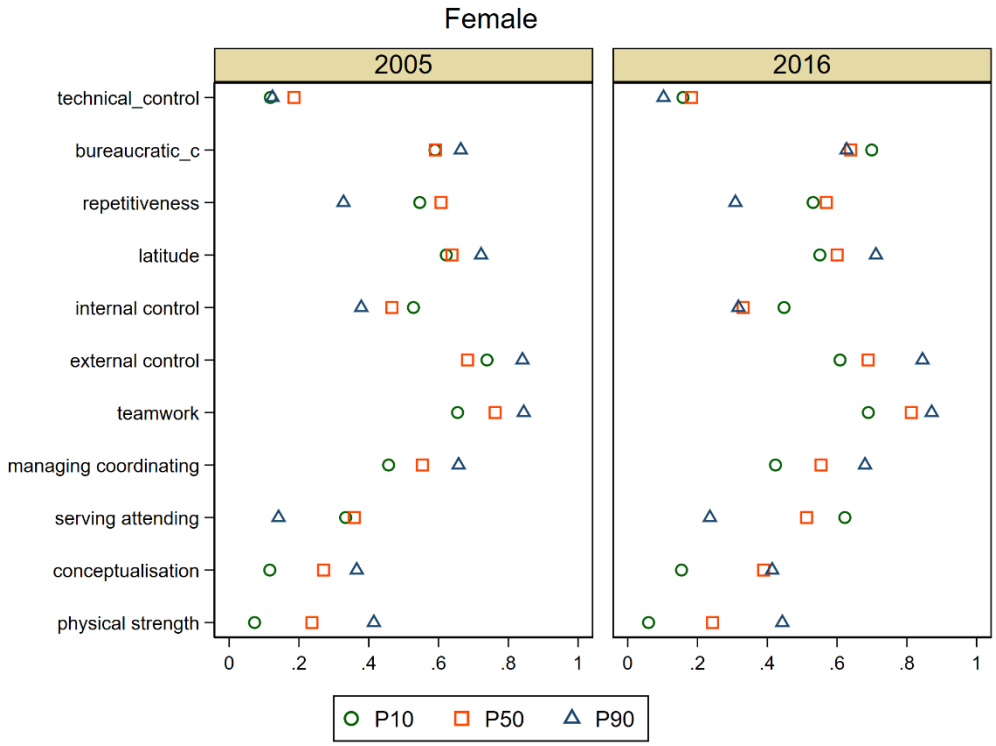
	2005			2016		
	10th	*50th*	*90th*	*10th*	*50th*	*90th*
Contract_type						
Permanent	62.2	89.4	95.4	75.9	94	97.8
Temporary Agency work	2.1	3.5	1.1	1.4	1.3	0.3
Apprenticeship contract	9.6	0.1	0	0.5	0.1	0
Other temporary	23.5	6.9	3.5	20.1	4.3	1.8
No contract	2.5	0.2	0	2.2	0.3	0.2
Total	100	100	100	100	100	100
Part-time						
No	24.5	91	93.6	15.3	87.7	94.7
Yes	75.5	9	6.4	84.7	12.3	5.3
Total	100	100	100	100	100	100
Type part-time						
<=50%	69.5	19.1	26	54.7	6.9	2.3
Btw 50-80%	24.9	18.3	20	35.5	13.2	11.5
>=80%	5.6	62.6	54	9.8	79.9	86.2
Total	100	100	100	100	100	100
Involuntary Temporary contract						
No	71.8	71.6	52.2	73.8	69.9	61.8
Yes	28.2	28.4	47.8	26.2	30.1	38.2
Total	100	100	100	100	100	100
Gender						
Female	76.2	46.2	42.3	83.3	60.8	47.8
Male	23.8	53.8	57.7	16.7	39.2	52.2
Total	100	100	100	100	100	100
Education						
Aucun diplÃ´me	37	25.6	8.2	15.5	5.7	1.8
CEP Brevet des collÃ¨ges, BEPC, CAP, BEP	35.3	40.7	25	46.7	40.6	15.2
Bac tech ou profes. ou dipl.de ce niveau	7	7.8	4.9	10.8	14.7	8.5
Bac gÃ©nÃ©ral brevet supÃ©rieur	8.8	8.1	11.9	7.3	7.4	6.8
Bac+2	3.7	10.4	19.7	8.5	15.3	20.4
Bac+3 ou Bac+4	5.7	5.8	17.3	8.2	11.9	27.2
Dip. supÃ©rieur À bac+4	2.5	1.6	13.1	3	4.4	20.1
Total	100	100	100	100	100	100
Nationality						
French	88.2	93.1	95.8	88.7	95.1	94.8
Naturalized French	4	3.4	2	5	3.3	3.2
Foreigner	7.8	3.5	2.2	6.3	1.6	2.1
Total	100	100	100	100	100	100
Experience within the firm						
<1 year	27.3	7.7	2.8	14.9	5.3	3.8
between 1 and 5 ys	34.5	26.2	16	25.1	15.7	10.9
between 5 and 10 ys	14.4	18.8	10.9	24.9	22.1	13
>10 ys	23.8	47.3	70.3	35.1	56.9	72.3
Total	100	100	100	100	100	100

Source: Authors' elaboration on EC data.

Figure A 1: Tasks profile by year, Male

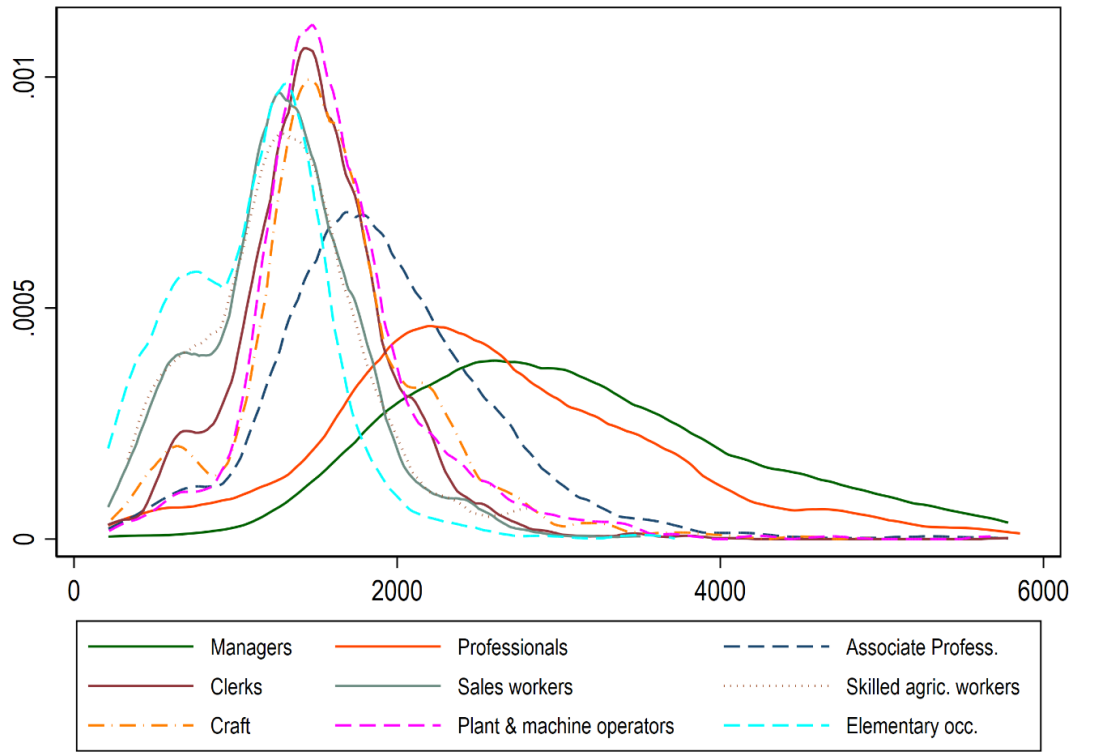
Source: Authors' elaboration on EC data.

Figure A 2: Tasks profile by year, Female



Source: Authors' elaboration on EC data.

Figure A 3: Monthly wage distribution by Occupational groups at one-digit, 2005 (top) and 2016 (bottom)



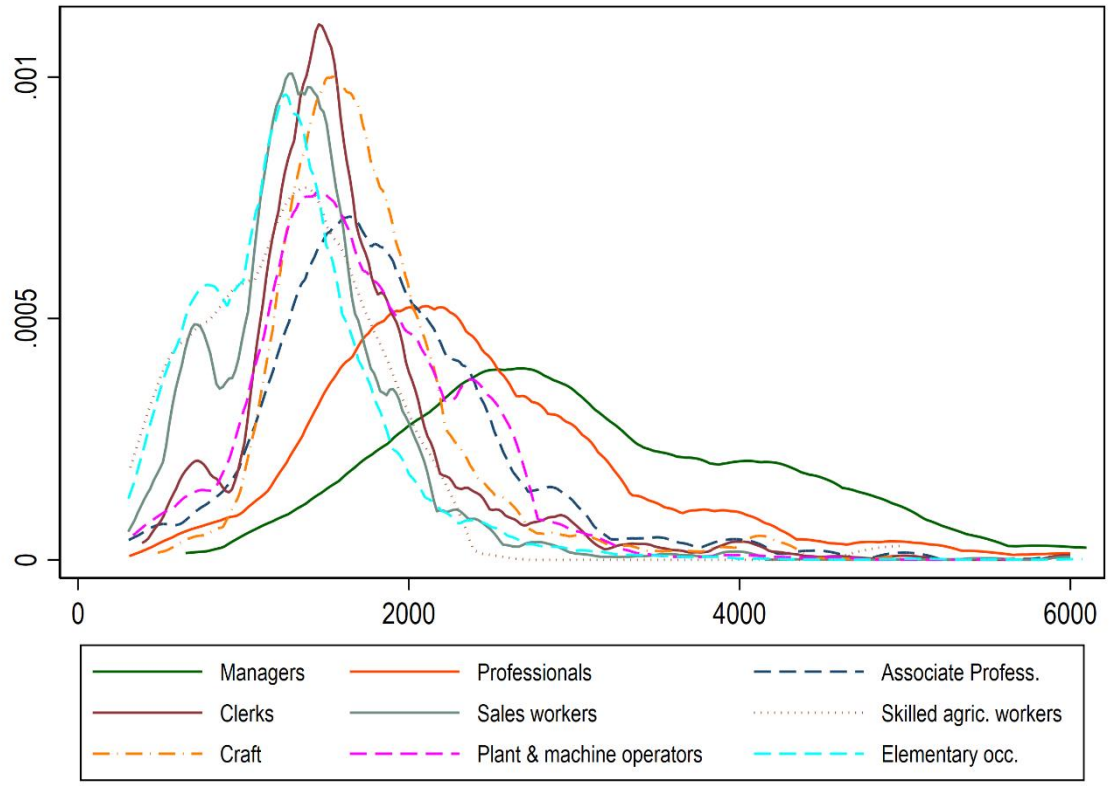


Figure A 4: distribution of monthly wage by working time arrangement and gender, 2005 and 2016

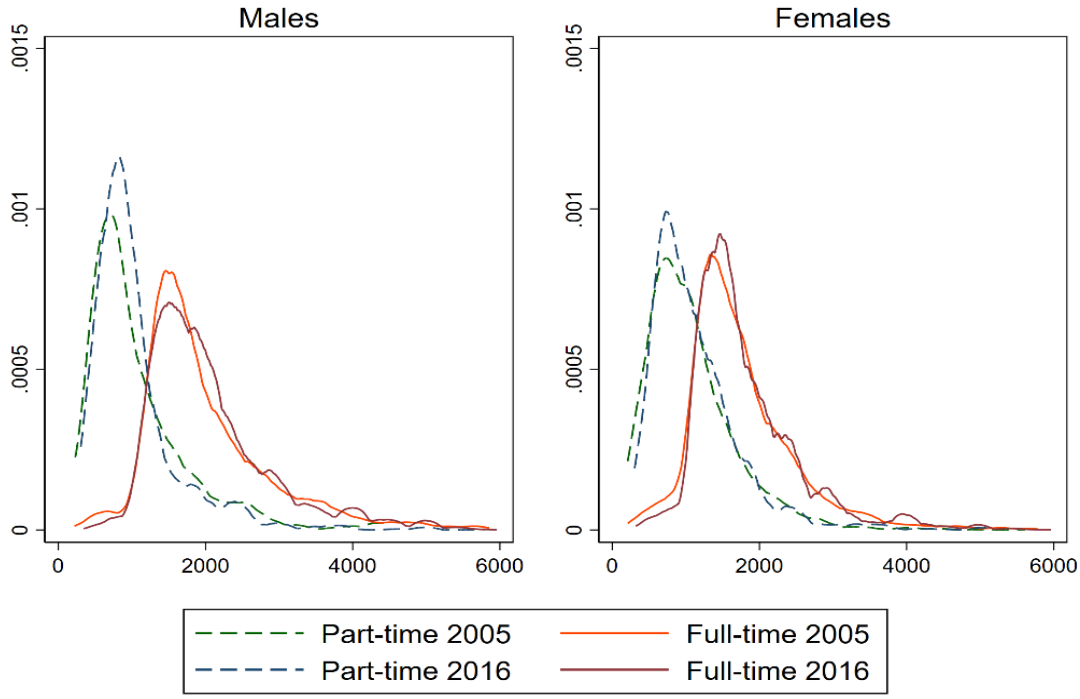


Figure A 5: distribution of monthly wage by type of contract and year

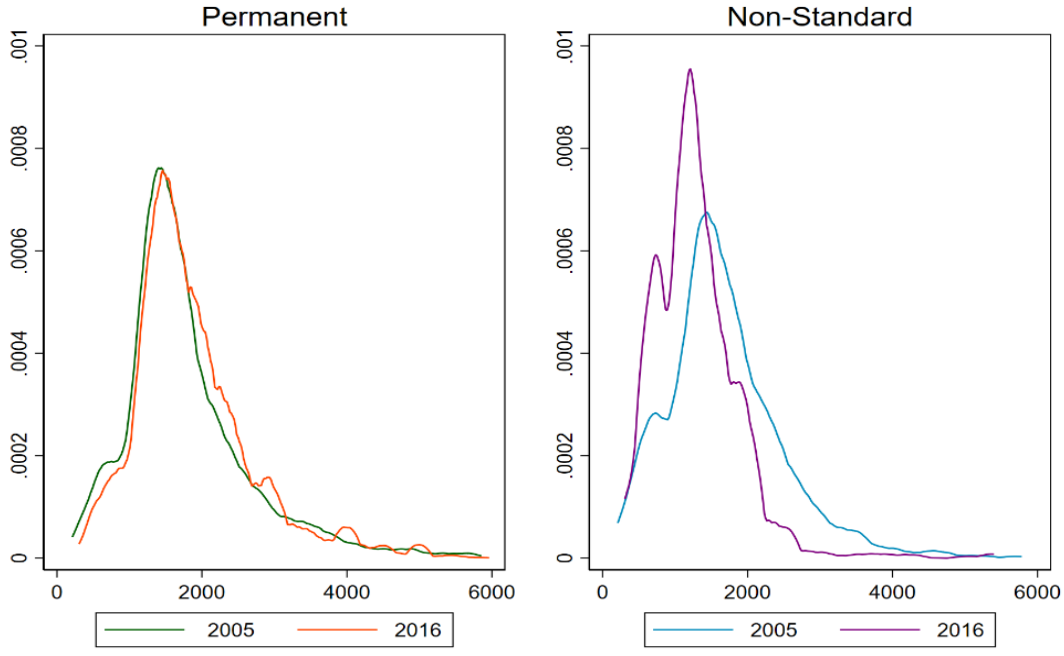


Table A 5 : OLS regression, 2005

	log_wage	log_wage	log_wage
Tasks			
bureaucratic control	0.028***	0.018***	0.017***
technical control	0.008*	0.004	0.004
repetitiveness	-0.012**	-0.009**	-0.007*
latitude	0.026***	0.015***	0.013***
external control	-0.002	-0.001	-0.002
internal control	0.007*	0.004	0.006*
managing coordinating	0.058***	0.033***	0.033***
physical strength	-0.044***	-0.033***	-0.029**
conceptualisation	0.005	0.008**	0.005
serving_attending	-0.012**	-0.005	-0.006
teamwork	0.031***	0.019***	0.018***
basic_ict	0.071*	0.054*	0.039
others	0.529***	0.392***	0.298***
Contractual arrangement			
Part-Time=1		-0.266***	-0.268***
permanent=1		0.047***	0.061***
Tenure: between 1 and 5 ys		0.085***	0.089***
between 5 and 10 ys		0.144***	0.159***
>10 ys		0.270***	0.293***
Age: 15-29		0.566***	0.565***
30-34		0.774***	0.765***
35-39		0.717***	0.706***
>=40		0.809***	0.791***
Individual characteristics			
men			0.058***
Aucun diplÔme			-0.043***
Bac tech ou profes.			-0.001
Bac général brevet supérieur			0.018
Bac+2			0.055***
Bac+3 ou Bac+4			0.056***
Dip. supérieur à bac+4			0.143***
Naturalized French			-0.053***
Foreigner			-0.016
Job FE	Yes	Yes	Yes
Region	Yes	Yes	Yes
Constant	7.597***	7.094***	7.109***
R-squared	0.526	0.702	0.708
N	13335	12890	12890

Table A 6 : OLS regression, 2016

	log_wage	log_wage	log_wage
Task			
bureaucratic control	0.027***	0.017***	0.021***
technical control	0.007*	-0.000	0.005
repetitiveness	-0.019***	-0.015***	-0.014**
latitude	0.014***	0.011***	0.015***
external control	0.002	0.005*	0.011**
internal control	0.009***	0.008***	0.006
managing coordinating	0.071***	0.042***	0.037***
physical strength	-0.027**	-0.035***	-0.038**
conceptualisation	0.010***	0.010***	0.012**
serving attending	-0.009**	-0.009***	-0.013**
teamwork	0.019***	0.012***	0.007
basic_ict	0.184***	0.142***	0.102**
others	0.196***	0.106***	0.128**
Contractual arrangement			
Part-Time=1		-0.232***	-0.247***
permanent=1		0.145***	0.122***
Tenure: between 1 and 5 ys		0.004	0.023
between 5 and 10 ys		0.038***	0.066***
>10 ys		0.147***	0.176***
Age: 15-29		0.402***	0.420***
30-34		0.628***	0.679***
35-39		0.559***	0.586***
>=40		0.660***	0.697***
Individual characteristics			
men			0.065***
Aucun diplÔme			-0.047**
Bac tech ou profes.			0.002
Bac général brevet supérieur			-0.005
Bac+2			0.024
Bac+3 ou Bac+4			0.034*
Dip. supérieur à bac+4			0.119***
Naturalized French			0.009
Foreigner			-0.059**
Job FE	Yes	Yes	Yes
Region	Yes	Yes	Yes
Constant	7.349***	6.589***	6.511***
R-squared	0.525	0.685	0.719
N	15669	15502	15483

Table A 7: RIF-OLS Males, firm-size and ICT interaction – private sector only.

	2005			*2016*		
	10th	*50th*	*90th*	*10th*	*50th*	*90th*
Tasks						
digital monitoring	0.017**	0.004	0.008	0.040**	0.005	-0.029
objectif	-0.002	0.006	0.020	0.010	0.016	0.055
technical_control	-0.001	0.006	0.009	0.037**	0.017	-0.003
repetitiveness	-0.002	-0.008	-0.022**	-0.032*	-0.013	-0.052
managing_coordinating	0.027***	0.033***	0.050***	0.023	0.042**	0.138***
physical_strength	0.004	-0.040***	-0.025*	-0.053**	-0.022	-0.062
Firm-size##ICT						
Basic_ict	0.184	0.098	0.053	0.202	0.534***	0.157
50-499	0.086	0.026	-0.019	-0.095	0.082	0.304
>500	0.077	0.019	-0.087	0.099	0.123	-0.122
Basic_ict#50-499	-0.156	-0.078	-0.265	0.354*	-0.150	0.605
Basic_ict#>500	-0.185	-0.150*	0.000	-0.052	-0.364*	0.044
Others	0.206	0.186	0.319	0.160	0.081	0.131
Others#50-499	-0.006	0.066	0.615*	-0.325	-0.084	-1.659
Others#>500	0.017	0.244*	0.453*	-0.239	0.033	-0.002
Contractual arrangements						
Part-Time=1	-0.705***	-0.187***	-0.161*	-0.537**	-0.140	-0.135
permanent=1	0.531***	0.076**	-0.005	0.547***	-0.033	-0.130
between 1 and 5 ys	0.027	0.024	0.009	-0.054	0.078	0.120
between 5 and 10 ys	0.089*	0.058**	0.056	-0.012	0.017	0.221
>10 ys	0.151***	0.184***	0.174***	0.074	0.184***	0.392***
Individual characteristics						
Aucun diplÔme	-0.006	-0.035*	-0.019	-0.109	-0.030	0.158
Bac tech ou profes.	-0.031	-0.031	0.048	0.006	0.062	0.049
Bac général brevet supérieur	-0.067*	-0.009	0.021	0.016	0.033	0.175
Bac+2	0.003	0.005	0.061	0.051	0.092*	-0.010
Bac+3 ou Bac+4	-0.003	-0.001	0.127	-0.019	-0.012	-0.068
Dip. supérieur À bac+4	0.024	0.026	0.200*	0.052	0.134**	-0.037
Naturalized French	-0.015	-0.055	-0.079	-0.037	-0.057	0.071
Foreigner	0.019	0.009	-0.019	0.019	-0.059	-0.237
Constant	7.086***	6.850***	7.578***	4.652***	6.804***	7.789***
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Job FE	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.436	0.487	0.415	0.585	0.575	0.437
N	4,768	4,768	4,768	2,351	2,351	2,351
Rif-Mean	7.100	7.466	8.084	7.107	7.560	8.147

Table A 8: RIF-OLS Females, firm-size and ICT interaction – private sector only.

	2005			*2016*		
	10th	*50th*	*90th*	*10th*	*50th*	*90th*
Tasks						
digital monitoring	0.014	0.010	-0.000	0.016	0.011	0.015
objectif	0.006	0.016*	0.008	-0.084**	0.009	0.031
technical_control	0.052*	0.005	-0.000	0.052	-0.017	-0.019
repetitiveness	0.002	-0.016*	-0.020*	-0.015	-0.056***	-0.046*
managing_coordinating	0.024	0.024***	0.078***	0.030	0.016	0.059
physical_strength	0.040	-0.029**	-0.003	0.015	-0.044*	-0.014
Firm-size##ICT						
Basic_ict	0.067	0.239**	0.181	-0.000	-0.139	0.125
50-499	-0.076	0.009	-0.067	-0.419	-0.098	-0.071
>500	0.181	0.089*	-0.106*	-0.313	-0.008	-0.224
Basic_ict#50-499	-0.024	0.093	-0.193	-0.111	0.317	-0.411
Basic_ict#>500	0.047	0.039	-0.108	0.116	0.266	-0.312
Others	-0.358	-0.294	-0.315	0.188	0.136	-0.644
Others#50-499	0.548	-0.071	0.727*	0.996	-0.251	0.657
Others#>500	-0.429	-0.133	0.682*	0.383	-0.275	1.218
Contractual arrangements						
Part-Time=1	-0.149	-0.184***	-0.125*	-0.585***	-0.064	0.095
permanent=1	0.812***	0.149***	-0.011	0.107	0.050	-0.040
between 1 and 5 ys	0.128	0.006	0.011	-0.044	0.022	0.035
between 5 and 10 ys	0.106	0.098***	0.052	0.040	0.119*	0.032
>10 ys	0.228*	0.182***	0.180***	0.107	0.219***	0.127
Individual characteristics						
Aucun diplÔme	-0.099	-0.022	0.003	0.283	0.024	-0.031
Bac tech ou profes.	0.090	0.004	0.005	0.256*	-0.009	-0.038
Bac général brevet supérieur	0.078	0.027	0.023	0.163	0.008	-0.173*
Bac+2	0.154**	0.086***	0.082	0.265**	-0.042	-0.037
Bac+3 ou Bac+4	0.126	0.059*	0.045	0.243*	-0.004	-0.013
Dip. supérieur À bac+4	0.124	0.158***	0.186*	0.253*	0.106*	0.084
Naturalized French	-0.105	-0.099**	-0.183***	0.101	0.156**	0.276
Foreigner	-0.430*	-0.095*	-0.071	-0.183	0.054	0.122
Constant	0.699	6.912***	7.833***	6.162***	7.316***	7.246***
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Job FE	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.399	0.501	0.432	0.583	0.593	0.558
N	3,866	3,866	3,866	2,241	2,241	2,241
Rif-Mean	6.604	7.236	7.791	6.835	7.335	7.908

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