

Cirillo, Valeria; Sostero, Matteo; Tamagni, Federico

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Wage dispersion and technology: A firm-level analysis on European data

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Institute of Economics
Scuola Superiore Sant'Anna

Piazza Martiri della Libertà, 33 - 56127 Pisa, Italy
ph. +39 050 88.33.43
institute.economics@sssup.it

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Valeria Cirillo °
Matteo Sostero °
Federico Tamagni °

° Institute of Economics, Scuola Superiore Sant'Anna, Pisa, Italy

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Wage dispersion and technology: A firm-level analysis on European data *

Valeria Cirillo^a, Matteo Sostero^a, and Federico Tamagni^{† a}

^aInstitute of Economics, Scuola Superiore Sant'Anna, Pisa, Italy

Abstract

Within-firm wage dispersion represents a relevant dimension of the overall wage inequality. A large stream of literature has analysed the wage-technology link without explicitly taking into account within-firm wage dispersion. In this work we aim to empirically investigate how technology affects within-firm wage dispersion and how it changes according to employer size. By exploiting employer-employee data from a survey of European firms (Eurostat's Structure of Earnings Survey - 2010) matched with information on sector innovation derived from the Community Innovation Survey, we look at the impact of innovation across small and medium-large firms both on the average wages paid by firms and on the degree of within-firm wage inequality. Furthermore, we distinguish between high-paying and low-paying firms and more equal and unequal firms by means of a quantile regression approach.

Keywords: Wage inequalities, innovation, quantile regressions, employer-employees matched data.

JEL classification: J31, O30, C21

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[†]*Corresponding author:* Federico Tamagni, Scuola Superiore San'Anna, Pisa, Italy. Postal address: c/o Institute of Economics, Scuola Superiore Sant'Anna, Piazza Martiri 33, 56127, Pisa, Italy, *E-mail* f.tamagni@sssup.it, *Tel* +39-050-883343.

The wage-technology relation has been often investigated at the individual level, for instance comparing standard wage equations across groups of workers with different skills or different working position in firms. The economic literature has traditionally envisaged two distinct channels for the effect of innovation on wages and, consequently, wage dispersion. On the one hand the rent-sharing hypothesis posits that the rents deriving from innovative production activities are partly passed on to workers as higher wages. On the other hand, the efficiency wage theory suggests that firms may decide to pay wages above the marginal value of product in order to motivate workers and increase productivity. These high-productivity firms being also more likely to be among those who adopt new technologies, one would observe that more innovative firms pay higher wages, all else being equal. In this work we adopt a firm-level perspective and we are interested in the role of innovation in explaining wages and within-firm wage dispersion. We first look at the relationship between innovation and the average wage paid by different firms and on the overall wage dispersion. While this issue has already received wide scrutiny in the literature, we use quantile regressions, allowing us to detail whether the wage-innovation link is stable across firms paying different average wages. Second – and more interesting given the limited literature on the subject – we estimate the relationship between innovation and the degree of within-firm wage dispersion, which we measure as the ratio of the 90th to the 10th percentile of the wages paid within the same firm. Also in this case we compare standard linear regressions with quantile regressions, providing evidence on whether the innovation-dispersion relationship changes across firms characterized by different degrees of wage dispersion, that is across more egalitarian vs. more unequal firms. Finally, we explicitly take into account the mediating role of firm size. In fact, a huge literature document the importance of size for wages, showing that larger firms tend to be more productive and hence better able to pay higher wages, and there is also evidence that size matters for wage dispersion. We therefore interact innovation and firm size, in order to disentangle differentiated impacts of technology on wage levels and wage dispersion between large and small-medium firms.

The analysis exploits an original dataset merging information about wages, worker and job characteristics with other sources on innovation, for a representative samples of workers employed within a large sample of firms active in major EU economies. This allows us to control for sector-country specific unmeasured factors, and to include a relatively large list of controls for both employees and firm characteristics.

1 Conceptual background

Wage dispersion is a crucial dimension of overall labour earnings inequality (Fournier and Koske, 2013). As a within-firm phenomenon, it accounts for more than half of the overall dispersion across workers in the economy (almost 80% for selected countries – Denmark, Finland, Norway, Sweden, Belgium, France, Germany, Italy, Netherlands, United States – Lazear and Shaw (2007)) which suggests the relevance of the within-firm dispersion with respect to the between-firms component. Therefore, the labour economic literature has tried to connect wage dispersion to a variety of potential determinants, such as firms characteristics and plant-specific factors (Davis and Haltiwanger, 1995), employment relationships – employment protection legislation and temporary contracts – (Skans et al., 2006), type of collective bargaining (Dell’Aringa and Pagani, 2005), level of unionisation (Freeman,

1982), labour mobility (Kandel and Lazear, 1992; Baker et al., 1994) and, mostly, skills (Zoghi, 2011; Zoghi and Mohr, 2012; Iranzo et al., 2008). Furthermore, at the firm-level, wage dispersion has been analysed in relation to firm performance and, mainly, productivity. Focusing on the latter, (Lazear, 1989; Milgrom and Roberts, 1990; Lallemand et al., 2004; Winter-Ebmer and Zweimüller, 1999) analyse how higher wage dispersion is positively associated with higher productivity – the “rank-order tournaments thesis” (Lazear and Rosen, 1981)) – or, conversely, lower productivity – through a fairness and cooperation effect among workers – the so-called wage compression argument (Adams, 1963; Akerlof and Yellen, 1990).

Overall, the existence of wage disparities both between and within firms underlines the inability of pure labour-market theories to explain why returns to skill vary across industries, firms and similar workers within firms. Relaxing the analysis by skill level and focusing directly on wage dispersion, Butters (1977); Burdett and Judd (1983); Mortensen and Pissarides (1999); Burdett and Mortensen (1998); Bontemps et al. (2000); Postel-Vinay and Robin (2002); Hornstein et al. (2005); Hagedorn and Manovskii (2010) have determined conditions under which wage dispersion is the outcome of a labour market with search frictions even if all employers and employees are identical in their productivity. As recognized by Zoghi and Mohr (2012), institutional factors – such as collective bargaining, implicit or explicit minimum wages, monopsony power, or hierarchical wage setting – play a fundamental role in determining the relationship between skills and wages, and consequently wage dispersion.

In this framework, technology also affects skills and wages by contributing to shape wage dispersion. From this point of view, while the existence of a relationship between wage and technology has been widely investigated both at the individual, firm and sectoral level highlighting the existence of wage differentials among workers, even with comparable skills; the direct link between technology and within-firm wage dispersion remains quite unexplored. Of course, the *Skill-Bias Technical Change* approach has explicitly taken into account the technology-wage dynamic in terms of different skills explaining the positive link between technology and high skilled workers. Under this framework, Acemoglu (2002); Autor et al. (2003) detect a technology premium for high skilled workers. This has subsequently been questioned under the more recent *routine-biased technical change* explanation on wage and job polarization. However, with the exception of the *skill-biased technical change* framework focusing on the high-skills to low-skills ratio, a proper understanding of wage dispersion as within firm dynamic is lacking.

Certainly, looking at wage differentials in terms of wage disparities between similar workers, technology plays a leading role affecting the wage change both through a direct and indirect mechanism.

The direct channel through which technology affects wages has been mostly explained under the *rent-sharing hypothesis*. There is a positive causality between firm profitability and higher wages as a consequence of the realization of rents. The nature of innovative rents can be understood in a Schumpeterian framework as reward for the development and commercialization of an invention. Rent-sharing might occur due to insider forces such as bargaining power over the worker’s wages causing externalities on the labour market; insiders demand part of the rents made by firms. From a firm-level perspective, Goos and Konings (2001) provide evidence for rent-sharing in Belgium focusing on the profit-wage relationship, workers can receive some of the gains made by the firm through a bargaining process. Consistently with a model where wages are partly determined by a sharing in the rents generated by innovation, Van Reenen (1996) detects the higher average wages for innovative

firms in a panel of British firms. Always from a firm-level perspective, Casavola et al. (1996) quantify the impact of innovation on earnings and employment by skill level on a sample of 20,000 Italian firms. After controlling for workers' and firms' characteristics, they found a 2–6% increase in wages for each professional group due to the technology measures. Laaksonen and Vainiomki (2001) classify manufacturing industries according to four technology levels studying the effect of technology on establishment-level wages. The technology wage premiums are estimated separately for non-manual and manual workers using wage equations with control variables for plant and workforce characteristics over the time period 1974–93. On Spanish manufacturing firms, Martínez-Ros (2001) explicitly adopts the rent-sharing model and verifies whether it fits on Spanish firm level data for the period 1990–1994. At the firm level, Tan and Batra (1997) analyse wage differentials not accounted for by workforce characteristics, collective bargaining and market power in Colombia, Mexico and Taiwan and found that wage differentials result from firms' technology-generating activities. From an indirect perspective, the efficiency wage framework has also explained wage differentials without making explicitly reference to technology and mostly focusing on workers' characteristics (Akerlof and Yellen, 1986; Krueger and Summers, 1988; Dickens and Katz, 1987; Katz et al., 1989). The existence of a causal relationship between wage level and workers' on-the-job productivity leads employers to pay higher wages, above the so called market-clearing wage, in order to capture the increment in workers' productivity. Under the same framework, shrinking, turnover, adverse selection, sociological explanation and “union threat” arguments ground on the wage-productivity link to deal with wage differentials mostly among workers with similar characteristics. Most of this empirical literature has carried out analysis at the individual level (Arbache, 2001; da Silva Freguglia and Menezes-Filho, 2007; Entorf and Kramarz, 1997) focusing on unobserved individual characteristics. Nevertheless, although the individual level analysis enriches the investigation including detailed workforce characteristics, it does not allow to study firm level dynamics related to technology, sector of activity, firm dimension. Therefore given our research question, it seems to be a less adequate approach. Compared to the efficiency wage explanation, the rent-sharing hypothesis explicitly takes into account the application of advanced technology equipment to realize rents and explain wage differentials. However, both efficiency wage and rent-sharing explanations do not provide a clear interpretation of the mechanisms behind within firm wage dispersion. As Skans et al. (2006) detected for Sweden, wage levels and wage dispersion exhibit a positive correlation, therefore higher wage levels are expected to be correlated to higher wage differentials and wage dispersion. We should verify an increasing wage dispersion with respect to technology which can be produced both under an ex-post rent subdivision mechanism -in case rents are not equally distributed among workers- or, ex-ante, under a productivity incentive which should be more likely observed in high-tech firms.

Without making an explicitly reference to an explanatory framework, in this work we aim to analyse the relationship between technology and within-firm wage dispersion. This empirical analysis cannot disregard the firm-size dimension which has been recognized as a crucial element impacting both on the level of wages (Moore, 1911; Mellow, 1982; Idson et al., 1992; Oi and Idson, 1999) and directly on the wage dispersion (Davis and Haltiwanger, 1991, 1995). As emphasized by Brown and Medoff (1989), the existence of a positive relationship between employer size and within-plant dispersion includes the possibility that larger employers carry out a greater variety of tasks and have a diversified workforce or the usage of incentive-based mechanisms leading to pay differentials. Conversely, a

negative relationship between employer-size and within-plant dispersion can be explained in terms of technologies requiring homogeneous workers, or union intervention which compress wage differentials among workers where unionization is more prevalent among larger firms ((Nickell and Wadhvani, 1990; Nickell et al., 1994)). Furthermore, larger firms are more likely to adopt standard rate policies linking wages to observable worker characteristics. Therefore, a proper investigation of the technology-within firm wage dispersion cannot avoid to consider firm size as a leading factor which has given rise to a large theoretical and empirical literature seeking to account for the presence of wage and wage dispersion size gaps. More recently, Mueller et al. (2015) complement the literature on the firm size-wage effect by examining how within-firm skill premia (wage differentials) vary across firms and over time. By grouping workers in increasing levels of skill, based on their “job level” (a taxonomy applied consistently across firms), they compare wage ratios between high skilled workers and detect increasing wage differentials (within-firm skill premia) with firm size.

Overall, while the wage-technology and wage-firm size links have been deeply studied in the literature, a clear understanding on the relationship between technology and within-firm wage dispersion is still lacking. This work aims to fill this gap by providing empirical evidence on the relationship between innovation, size and working conditions measured both by mean wage and wage dispersion. First, we explore the existence of a link between average wage level and technology – controlling for the size dimension – in order to emphasize the diversity of wage patterns among firms. Second, we analyse how technology influences within firm wage dispersion. Compared to most existent empirical literature focusing on one single country, we carry out the empirical analysis on 4 major European countries – Germany, France, Spain, and Italy – relying on firm level comparable data.

2 Sample, main variables, and descriptive evidence

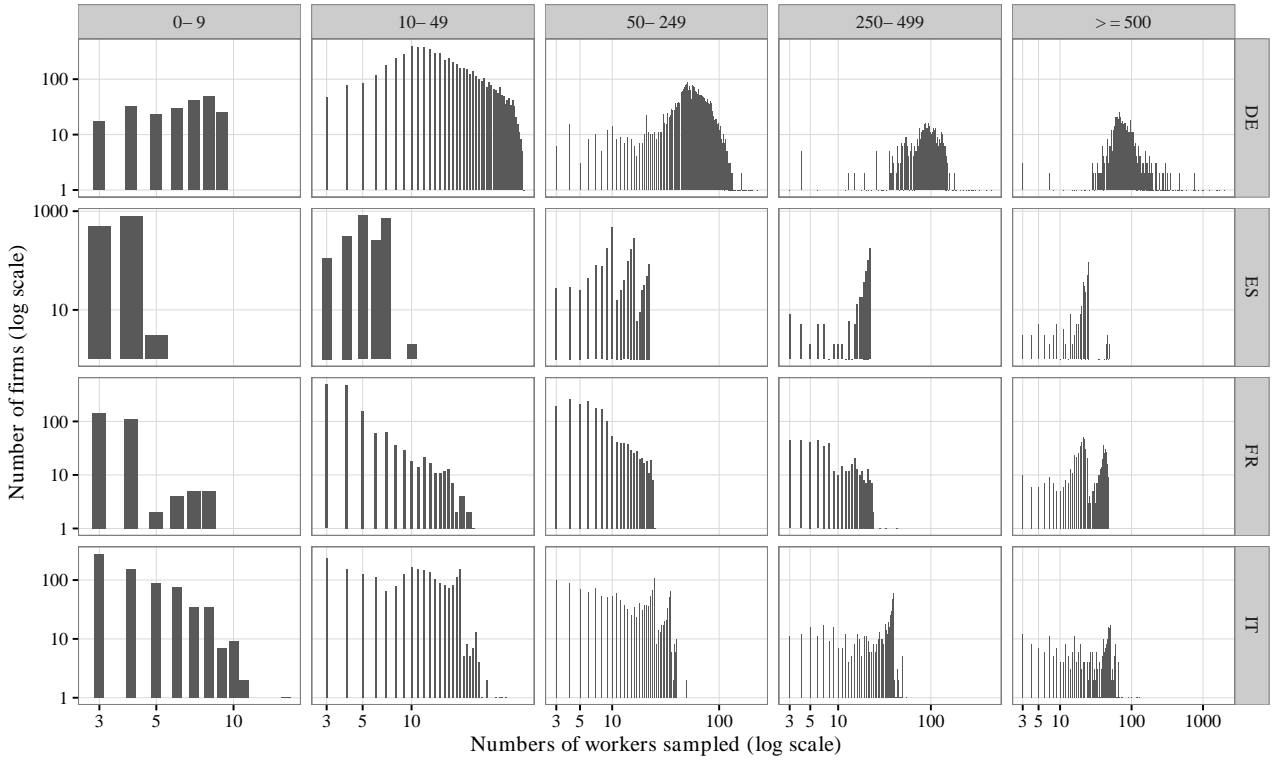
Our empirical analysis draws upon a matched sample that we build combining the European Union Structure of Earnings Survey (SES) and the Community Innovation Survey (CIS).

The CIS is a well-known and widely used source of information about innovative activity across European countries, administered by national statistical offices coordinated by Eurostat. A large set of information covering innovation activity is available, refined and extended over the different waves of the survey, at the level of firms, sectors and countries.

The SES is a kind of matched employer-employee dataset. It is built as a representative sample of firms from different EU countries, active in different sectors of activity. Then, for each firm, it collects individual-level information about samples of employees working within the firm. The resulting matched data collect few information on firm characteristics (size class in terms of employment, public vs. private ownership, whether collective bargaining is in place, and the sector of economic activity according to European NACE taxonomy), and a relatively rich set of individual-level variable for each of the employees sampled within each firm (such as age class, gender, education level, professional occupation, and salaries).

Overall, SES data represent a unique source for a consistent comparison of earnings and work-related variables across European economies. Of course, the dataset has its own limitations. First, the sample of business units considered in the survey is restricted to those with at least 10 employees, which limits the analysis as far as very small firms are concerned. Second, for the firms that enter the

Figure 1: Distribution of number of sampled employee observations in relation to firm size by country



data, the sampling rate of employees varies by firm size and by country, thus limiting the information available in some countries. Third, different countries use different grouping of NACE codes to classify firms in their sector of activity, thus creating some issue in building sectoral comparisons.

In this work we consider the 2010 version of SES data for four major European economies, namely Germany, Spain, France and Italy. We use this dataset primarily to compute our dependent variables, that is a measures of average firm-level wages and a measure of within-firm wage dispersion, obtained from the information on wages of the employees sampled within each firm.¹

Of course this implies a number of choices, concerning type of employees, type of contracts, time unit to take as reference. After careful consideration of alternative definitions, we restricted the sample to include only full-time employees who reported to have worked at least eight weeks in the reference year. We thus define the firm-level average wage as the simple average annual wage computed across these type of sampled employees. Next, considering that the different sampling rates across countries and by firm size (see Figure 1) creates variability in the number of employees available per each firm, we define wage dispersion for a generic firm j as

$$w_j^d = \log \left(\frac{w_j^{0.90}}{w_j^{0.10}} \right)$$

where $w_j^{0.90}$ and $w_j^{0.10}$ are the 90th and 10th percentiles of annual earnings for the employees in firm j . This brought us to further restrict the sample to firms with at least three sampled employees.²

¹Other variables from SES used here as controls are described in the following section, presenting the empirical analysis.

²Figure 2 in Appendix provides shows that the distribution of wage dispersion does not change appreciably if we restrict to firms with a higher number of sampled employees.

As common in many such datasets, the SES data are stripped of identifiable information, including firm names, which prevents us from matching it with firm-level measures of innovativeness. We thus rely on sector-level innovation variables. To do that we draw from the sixth wave of the CIS, covering the period 2008-2010. Among the innovation variables available in the CIS, we select the share of firms introducing a product or service innovation in the sector, which yields a proxy of innovation output. This is available for different sectors within both manufacturing and services, and varies by country. Since different countries use different groupings of two-digit NACE codes to classify the sector of economic activity, we developed a uniform taxonomy of sectors, slightly broader than the NACE two-digit classification, in order to be able to classify companies uniformly across countries.³

Table 1 shows basic summary statistics for the variables of interest in the final sample. As one would expect, firms with a larger number of employees tend to pay higher average wages. They also typically have a greater disparity between the highest and lowest wage. The number of distinct employees and firms sampled varies across countries, from a minimum of about 46 000 employees concentrated in about 4 600 firms in Spain, to about 512 000 employees concentrated in about 11 000 firms in Germany.

Table 1: Summary statistics for the working sample

	Germany		Spain		France		Italy	
	10-49	≥ 50	10-49	≥ 50	10-49	≥ 50	10-49	≥ 50
Employees								
Median annual earnings	27679	34863	18489	24183	27304	31722.5	28935	30152
IQR annual earnings	21383	24431	10970	16100	16803	19501	20600	16695
Mean dispersion statistic	1.368	1.151	0.783	0.938	0.901	1.046	0.786	0.808
Std. Dev. Dispersion statistic	0.764	0.539	0.552	0.493	0.563	0.526	0.514	0.443
Number of employees	106 154	406 193	16 889	37 874	8 553	37 362	27 763	51 628
Number of firms	6 139	5 232	3 497	2 551	1 735	2 900	2 905	2 387

3 Innovation, wages and wage dispersion

In this section we present our main empirical analysis exploring the association between innovation, average wages and wage dispersion. Our baseline regression model has the form

$$\log(Y_{j,t}) = \alpha + \beta \text{Innov}_{j,t-1} + \gamma \mathbf{Z}_{j,t} + \epsilon_{j,t}. \quad (1)$$

where the dependent variable is, alternatively, the *average annual wage* or the *dispersion of wages* (*i.e.*, the ratio of the 90th to 10th quantile of annual earnings) computed from the information on the employees sampled within firm j in SES in $t = 2010$; Innov is a proxy for innovativeness; and \mathbf{Z} a set of control variables.

We recall that in the absence of firm-level measures of innovative activity of firms, Innov is the share of firms introducing a product or service innovation in the sector of primary activity of firm j , with $t - 1$ referring to the fact that this information is taken from the 2008-2010 wave of the CIS dataset, and thus with some time-lag with respect to the date of measurement of the dependent variable. Also recall that Innov also varies by country, so that our coefficient of primary interest (β) is identified through sector-country variation. While firm-level proxies of innovative activity would

³See Table 8 in Appendix.

be more precise, sector-country variation in innovation propensity can be seen as exogenous to firm choices, thus limiting issues related to reverse causality from wages and wage dispersion to innovation. Potential endogeneity bias is also limited by the time-lag at which *Innov* enters the estimation.

Omitted variable bias is potentially more critical, since we do not benefit from a panel structure in the data to control for unobserved heterogeneity. However, we exploit additional information from SES data to include a relatively large number of controls in the set \mathbf{Z} , all measured in $t=2010$. First, we exploit firm-level characteristics directly available in SES. These include a key control for firm size, as a dummy distinguishing medium-large firms (more than 50 employees) from other firms, plus two dummies respectively indicating whether the firm is under public control and whether the firm applies collective agreements in wage-setting. Second, from the individual information on the employees sampled within each firm, we get a picture of basic personal workforce characteristics of firms by computing the modal age of the employees, the share of workers with tertiary education, the share of males employees, and their mean tenure. All these factors are expected to be positively associated to wages and also to wage dispersion, since indeed it is usually the case that older, more educated, longer-serving, and males employees have higher wages. Third, we account for some features of workforce composition via the share of managers and professionals, and via the share of employees with a temporary job contract. The former is expected to be positively associated with both average wage and wage dispersion, to the extent that managers and professionals are typically paid higher wages than other professions. The relative weight of temporary contracts works in an opposite direction, since one expects such jobs to be usually less paid than permanent jobs. Finally, we also include country and sector fixed effects, as a basic control for broad economic and institutional differences across sectors in the different countries.⁴

All the specifications are estimated via simple OLS and also via simultaneous quantile regressions. OLS look at the average effect of innovation, size and other factors on average wages and wage dispersion across firms. Quantile regressions provide an additional interesting information about variation of the coefficients along the quantiles of the conditional distribution of the dependent variables. In particular, simultaneous quantile regressions, with bootstrapped standard errors, allowing to compare the coefficient estimates along the different quantiles of the average wage distribution. Thus, we can address the question whether innovation, size and other factors have different association with wages across the spectrum of low- to high-wage firms (*i.e.*, firms whose average wage lies in different quantiles of the average wage distribution), or whether innovation, size and other factors display different association with wage dispersion across more egalitarian vs. less egalitarian firms (*i.e.*, firms located in different quantiles of the wage dispersion distribution). For the OLS we report robust standard errors clustered at the sectoral level, identifying sectors as the main source of heteroskedasticity, while we rely on bootstrapped standard errors in the case of quantile regression.

3.1 Firm-level average wage

We start by exploring the determinants of average wages. In Table 2 we report the estimates of a basic specification where the innovation proxy is the only regressor, providing an initial check of

⁴The full model with all controls can be seen as an adaptation of the standard wage equation (Layard et al., 1991), where the determination of wages and wage dispersion depends from a combination of firm, employees and institutional-regulation related factors.

the existence of basic correlation between technology and average wages paid at the firm level. As the previous empirical literature suggests, we find indeed a positive and significant relationship. The OLS point estimate indicates that the magnitude is rather modest ($\beta = 0.0016$). Quantile regression results reveal that this positive association is rather stable across quantiles, although a bit stronger (0.18%) for low paying firms and then decreasing (to 0.12%) among high paying ones.

Table 2: Log average annual earnings

(Model I)						
	OLS	Simultaneous Quantile Regression				
		q10	q25	q50	q75	q90
Innovation	0.00161* (2.73)	0.00179*** (28.01)	0.00197*** (41.04)	0.00158*** (38.89)	0.00135*** (15.02)	0.00119*** (18.48)
Constant	10.22*** (233.03)	9.654*** (2054.72)	9.907*** (2330.75)	10.23*** (2913.64)	10.53*** (2018.95)	10.77*** (2128.73)
N	27346	27346				
(pseudo-)R ²	0.0417	0.0258	0.0309	0.0240	0.0155	0.0123

t-statistics in parentheses. * p<0.05, ** p<0.01, *** p<0.001

In Table 3 we show estimates of the baseline model including the full set of firm controls, as well as sector and country fixed effects. We still obtain a positive association between innovation and the average wage paid at the firm level, although the introduction of new controls weakens the magnitude and the significance of the coefficient on *Innov*. We also confirm that the association is rather stable and significant along the quantiles of the wage distribution.

Concerning the controls, we confirm the expectation that large firms tend to pay higher wages, both on average and along the quantiles of the wage distribution. We detect that publicly-controlled firms pay on average lower wages, while the absence of collective pay agreement associates with lower wages, especially in low paying firms. Results on the modal age of employees are in line with findings of the empirical literature on individual level wage equations that suggests a cohort effect, as we indeed find that an higher share of workers between 14 and 30 or an higher share of employees older than 50 associate with lower wages, while employees with age in between 40 and 49 years have higher wages. Further, and in line with a standard mincerian wage equation, tenure in the workplace, tertiary education and higher professional status increase firm wages, both on average (in the OLS) and across the different quantiles. Finally, our estimates support the existence of a gender pay gap, since we find that the share of men in the firm is associated with higher wages. The effect is even more pronounced in the top quantiles of the firm-wage distribution.

Table 3: Log average annual earnings

	(Model II)					
	OLS	Simultaneous Quantile Regression				
		q10	q25	q50	q75	q90
Innovation	0.000916 (2.12)	0.000837*** (6.11)	0.000786*** (11.33)	0.000836*** (10.98)	0.000951*** (11.07)	0.000871*** (7.26)
Medium-large firm	0.0814*** (6.40)	0.120*** (24.07)	0.102*** (20.44)	0.0887*** (29.77)	0.0638*** (11.07)	0.0431*** (6.86)
Country						
Germany	0.122 (1.17)	0.219*** (24.75)	0.202*** (23.00)	0.155*** (25.70)	0.109*** (11.20)	0.0671*** (3.82)
Spain	-0.290** (-4.45)	-0.245*** (-25.45)	-0.258*** (-29.05)	-0.273*** (-40.78)	-0.288*** (-52.67)	-0.280*** (-20.26)
France	-0.0671 (-0.97)	0.0320*** (3.75)	-0.0101 (-1.06)	-0.0655*** (-10.50)	-0.105*** (-11.23)	-0.130*** (-8.86)
Sector						
16,17	0.00476 (0.09)	0.0397 (1.81)	0.0388* (2.45)	0.0184 (1.38)	-0.00557 (-0.37)	-0.0170 (-0.90)
19,20	0.147** (4.29)	0.142*** (11.30)	0.154*** (15.66)	0.162*** (13.76)	0.156*** (11.37)	0.148*** (11.95)
21,23	0.0681 (1.96)	0.0867*** (6.31)	0.100*** (9.59)	0.0730*** (6.29)	0.0530*** (3.62)	0.0460** (2.79)
24,25	0.0407 (0.87)	0.0932*** (4.43)	0.0710*** (5.53)	0.0435** (2.98)	0.0356* (2.43)	0.0170 (0.96)
26,27,33	0.0629 (1.78)	0.106*** (6.78)	0.0937*** (9.49)	0.0667*** (5.81)	0.0458** (3.21)	0.0240 (1.35)
28	0.0757 (2.08)	0.147*** (7.01)	0.113*** (9.30)	0.0853*** (6.13)	0.0557*** (4.11)	0.00921 (0.56)
29,30	0.0507 (1.28)	0.0856*** (3.38)	0.0860*** (6.19)	0.0718*** (4.84)	0.0524*** (3.90)	0.00877 (0.47)
31,32	-0.0268 (-0.49)	-0.0126 (-0.54)	-0.0101 (-0.67)	-0.0201 (-1.54)	-0.0172 (-1.09)	-0.0528* (-2.48)
53,61-63,79	0.0428 (0.92)	0.0288 (1.62)	0.0365** (3.20)	0.0412*** (3.36)	0.0490*** (3.75)	0.0436** (2.60)
60,64	0.0613 (1.33)	-0.00401 (-0.18)	0.0127 (0.90)	0.0485*** (3.53)	0.101*** (5.60)	0.132*** (5.04)
Publicly-controlled firm	-0.0420* (-2.90)	0.0253 (1.66)	-0.0168 (-1.41)	-0.0760*** (-6.91)	-0.0786*** (-6.35)	-0.0774** (-3.00)
No coll. pay agreement	-0.0875* (-2.54)	-0.170*** (-15.52)	-0.137*** (-17.13)	-0.0911*** (-15.29)	-0.0633*** (-9.62)	-0.0403*** (-4.75)
Mode of age in the firm						
14-19	-0.262*** (-5.53)	-0.228*** (-3.35)	-0.215*** (-6.34)	-0.252*** (-6.91)	-0.273*** (-6.54)	-0.264*** (-10.10)
20-29	-0.105*** (-10.06)	-0.101*** (-10.51)	-0.0959*** (-12.07)	-0.0931*** (-16.45)	-0.0951*** (-13.80)	-0.0929*** (-9.29)
40-49	0.0174* (2.52)	0.00738 (0.92)	0.0135* (2.28)	0.0163*** (4.24)	0.0165* (2.43)	0.0255*** (4.26)
50-59	-0.0541* (-2.57)	-0.106*** (-8.70)	-0.0746*** (-10.49)	-0.0477*** (-7.22)	-0.0224* (-2.47)	0.00287 (0.36)
60+	-0.0650 (-1.30)	-0.0618 (-0.61)	-0.0853* (-2.28)	-0.0155 (-0.46)	0.0236 (0.41)	-0.00380 (-0.12)
Average tenure of workers	0.0185*** (7.71)	0.0199*** (37.13)	0.0188*** (43.82)	0.0178*** (31.78)	0.0160*** (24.97)	0.0128*** (15.70)
% with tert. edu.	0.00488*** (7.50)	0.00457*** (23.37)	0.00466*** (28.75)	0.00517*** (25.00)	0.00516*** (33.43)	0.00516*** (21.83)
% of manag. and profes.	0.00537*** (13.26)	0.00439*** (18.38)	0.00503*** (21.74)	0.00537*** (30.30)	0.00625*** (32.23)	0.00685*** (30.54)
% of permanent contracts	0.00474*** (23.08)	0.00471*** (22.91)	0.00473*** (28.24)	0.00484*** (26.68)	0.00462*** (22.65)	0.00438*** (17.48)
% of male employees	0.00173** (4.57)	0.00152*** (9.06)	0.00154*** (18.06)	0.00169*** (20.10)	0.00185*** (17.31)	0.00194*** (14.26)
Constant	9.349*** (130.25)	8.958*** (264.87)	9.136*** (516.47)	9.322*** (436.64)	9.547*** (581.32)	9.791*** (307.28)
N	27346	27346				
(pseudo-)R ²	0.5537	0.3685	0.3709	0.3570	0.3270	0.2995

t-statistics in parentheses; * p<0.05, ** p<0.01, *** p<0.001.

Reference country is Italy; reference sector group is 68,72-74,77; reference modal age is 30-39.

3.2 Within-firm wage dispersion

We next turn to the analysis of the role of innovation on the degree of within-firm wage dispersion.

Table 4: Log-difference in earnings between 90th 10th percentile

	(Model I)					
	OLS	q10	Simultaneous Quantile Regression			q90
			q25	q50	q75	
Innovation	0.00190*** (8.27)	0.00133*** (21.83)	0.00146*** (23.48)	0.00180*** (17.10)	0.00220*** (15.60)	0.00266*** (14.73)
Constant	0.922*** (30.70)	0.291*** (72.83)	0.503*** (91.99)	0.800*** (121.67)	1.245*** (116.77)	1.699*** (100.08)
N	27346	27346				
(pseudo-)R ²	0.0293	0.0143	0.0134	0.0130	0.0140	0.0164

t-statistics in parentheses. * p<0.05, ** p<0.01, *** p<0.001

The estimates in Table 4 provide basic correlation between innovation and wage dispersion. More innovative firms feature higher levels of wage dispersion – by about 0.2% on average. This positive relationship is even stronger in the upper part of the wage dispersion distribution, namely innovation is positively associated with wage dispersion even more among more unequal firms.

In Table 5, we present results of the specification with the full set of controls. We find that innovation is associated with higher levels of wage dispersion, even if the introduction of controls reduces the magnitude of the coefficient appreciably (to 0.04% in the OLS). The effect is increasing, and almost doubling from the bottom to the top quantile.

Among the controls, the OLS estimates on the dummy for firm size imply that medium-large firms display on average a significantly higher wage dispersion (approximately 5% higher) than small firms. This “size effect” tends to decline across the wage dispersion distribution, and turns negative in the 90th percentile, meaning that among more unequal firms, medium-large firms have actually a less remarked wage inequality. Furthermore, publicly controlled firms have a smaller wage gap according to both OLS and quantile regressions estimates, which is consistent with previous findings in the literature. Conversely, the absence of collective bargaining contributes to widening the wage gap, both on average and along the wage dispersion quantiles. Finally, personal characteristics and composition of the workforce influence wage dispersion as well. On the one hand, a younger and more qualified – both in terms of education and skills – workforce associates with higher wage dispersion. On the other hand, a longer tenure, an higher share of permanent contracts and an higher share of males all associates with less inequality in the within-firm pay structure. This is explained by the fact that longer-tenured workers, permanent contracts and men already tend to be paid more on average, thus an increase in the majority share of this types of workers decreases inequality.

Table 5: Log-difference in earnings between 90th 10th percentile

	(Model II)					
	OLS	Simultaneous Quantile Regression				
		q10	q25	q50	q75	q90
Innovation	0.000474** (3.93)	0.000348** (3.20)	0.000347** (3.03)	0.000395*** (4.47)	0.000404** (3.26)	0.000694** (2.74)
Medium-large firm	0.0538** (3.43)	0.131*** (17.15)	0.131*** (17.42)	0.0923*** (12.23)	0.00157 (0.15)	-0.0545*** (-4.11)
Country						
Germany	0.225*** (8.03)	0.175*** (15.89)	0.160*** (16.17)	0.155*** (12.98)	0.211*** (7.70)	0.218*** (6.31)
Spain	-0.0974*** (-4.99)	-0.0664*** (-6.01)	-0.0820*** (-9.95)	-0.0834*** (-7.45)	-0.0795*** (-6.36)	-0.109*** (-4.41)
France	0.0973*** (5.44)	0.0477*** (3.88)	0.0672*** (7.82)	0.0890*** (7.79)	0.130*** (7.51)	0.133*** (5.11)
Sector						
16,17	0.0104 (0.33)	0.0652*** (3.52)	0.0519** (2.69)	0.0230 (1.47)	-0.0104 (-0.40)	-0.0715 (-1.38)
19,20	0.0913** (4.13)	0.124*** (6.38)	0.104*** (7.47)	0.0873*** (5.83)	0.0790*** (3.34)	0.0601 (1.52)
21,23	0.00191 (0.07)	0.0407** (2.74)	0.0189 (1.19)	0.0111 (0.65)	-0.00674 (-0.22)	-0.0450 (-1.02)
24,25	0.0487 (1.68)	0.0636*** (3.55)	0.0650*** (4.43)	0.0400** (2.75)	0.0418 (1.69)	-0.0264 (-0.44)
26,27,33	0.0701* (3.08)	0.104*** (6.90)	0.0918*** (7.16)	0.0782*** (4.04)	0.0618*** (3.36)	0.00920 (0.27)
28	0.0922** (3.29)	0.122*** (6.82)	0.109*** (6.27)	0.0962*** (4.00)	0.0916*** (3.69)	0.000633 (0.01)
29,30	0.0290 (1.05)	0.0714*** (3.62)	0.0519*** (3.56)	0.0359 (1.92)	0.0153 (0.73)	-0.0573 (-1.42)
31,32	0.103** (3.65)	0.0426* (2.34)	0.0536*** (3.82)	0.0784*** (3.29)	0.0989** (3.01)	0.133** (2.68)
53,61-63,79	-0.0450* (-2.39)	-0.000751 (-0.04)	-0.0349 (-1.80)	-0.0482** (-2.65)	-0.0813** (-3.20)	-0.0738 (-1.57)
60,64	0.0513* (2.50)	0.0606** (2.70)	0.0874*** (4.05)	0.0605** (3.02)	0.0211 (0.98)	-0.0480 (-1.01)
Publicly-controlled firm	-0.122** (-3.31)	-0.0511*** (-6.13)	-0.109*** (-13.39)	-0.117*** (-6.27)	-0.139*** (-6.36)	-0.182*** (-4.71)
No coll. pay agreement	0.190*** (8.45)	0.0981*** (11.32)	0.149*** (15.81)	0.229*** (18.55)	0.227*** (13.81)	0.211*** (12.11)
Mode of age in the firm						
14-19	0.819*** (7.56)	0.671*** (5.87)	0.895*** (8.34)	0.871*** (12.61)	0.794*** (12.22)	0.748*** (5.27)
20-29	0.183*** (12.53)	0.0325** (2.93)	0.105*** (7.72)	0.189*** (14.51)	0.216*** (11.95)	0.226*** (8.15)
40-49	-0.0440** (-3.72)	-0.0198** (-2.79)	-0.0189* (-2.14)	-0.0290* (-2.32)	-0.0267 (-1.50)	-0.0490 (-1.80)
50-59	-0.0367** (-3.42)	-0.0225* (-2.26)	-0.0191 (-1.57)	-0.0203 (-1.56)	-0.0213 (-1.08)	-0.0157 (-0.47)
60+	0.00926 (0.09)	-0.122 (-1.60)	-0.0487 (-1.11)	0.00737 (0.12)	0.00357 (0.04)	0.282 (1.23)
Average tenure of workers	-0.00662*** (-6.16)	-0.00259*** (-5.49)	-0.00505*** (-12.03)	-0.00861*** (-9.86)	-0.00927*** (-9.85)	-0.00820*** (-5.69)
% with tert. edu.	0.000610 (0.96)	0.00130*** (7.52)	0.00105*** (5.45)	0.000725*** (5.12)	0.000893** (2.62)	0.000239 (0.46)
% of manag. and profes.	0.00422*** (7.04)	0.00220*** (15.05)	0.00352*** (14.25)	0.00452*** (20.23)	0.00545*** (14.13)	0.00721*** (13.41)
% of permanent contracts	-0.00824*** (-5.99)	-0.00320*** (-13.44)	-0.00581*** (-16.87)	-0.00962*** (-19.22)	-0.0142*** (-20.92)	-0.0185*** (-25.30)
% of male employees	-0.00143** (-4.39)	-0.000696*** (-5.77)	-0.00102*** (-6.61)	-0.00153*** (-10.24)	-0.00187*** (-11.67)	-0.00214*** (-6.76)
Constant	1.626*** (16.27)	0.521*** (19.19)	0.986*** (26.70)	1.685*** (30.61)	2.508*** (33.16)	3.327*** (32.00)
N	27346	27346				
(pseudo-)R ²	0.2652	0.1132	0.1247	0.1537	0.1841	0.1931

t-statistics in parentheses. * p<0.05, ** p<0.01, *** p<0.001
Reference country is Italy; reference sector group is 68,72-74,77; reference modal age is 30-39.

3.3 The mediating role of firm size

As further step in the analysis we consider the interplay between size and innovation. Indeed, while size and innovation alone have been studied as determinant of both wages and wage inequality, their combined role is less understood, also in relationship to the classical divide between Schumpeterian processes of creative destruction and creative accumulation predicting that innovation can be driven by either small or large firms, depending on the sector and on the technology.

We modify the baseline regression model 1 by adding an interaction term which explicitly takes into account the simultaneous effect of firm size and technology

$$\log(Y_{j,t}) = \alpha + \beta_1 \text{Innov}_{j,t-1} + \beta_2 \text{Size}_{j,t} + \beta_3 \text{Size}_{j,t} \times \text{Innov}_{j,t-1} + \beta_4 \mathbf{Z}_{j,t} + \epsilon_{j,t}. \quad (2)$$

As in previous sections, the dependent variable is, alternatively, the average annual wage or the dispersion of wages (ratio between 90th to the 10th percentile), while *Size* is a dummy equal to 1 for medium-large firms (with more than 50 employees). The coefficient on the interaction term (β_3) captures potential differences in the “effect” of innovation across firms of different size, as we can expect given the potentially different innovation propensity and performance across small and larger firms, and the expected variation in the way wage levels and dispersion are set in small vs. larger firms. Accordingly, the coefficient on *Innov* (β_1) gives the “effect” of innovation for small firms (*Size*=0), while the “effect” of innovation for medium-large firms is given by $\beta_1 + \beta_3$.

Estimates of the average-wage equation are presented in Table 6. We find that innovation has two counteracting effects between small and medium-large firms. For small firms, the OLS estimates reveal that innovation is associated with a higher average wage, and the strength of the association is quite stable along the quantiles of the firm wage distribution. However, the negative coefficient on the interaction term implies a reduction in the wage premium of innovation for medium-large firms as compared to small firms. The magnitude of the estimates is such that the overall effect of innovation for medium-large firms is still positive and significant, as indeed we always reject that $\beta_1 + \beta_3 = 0$. Results on the controls are well in tune with the patterns observed for the baseline model without size-technology interaction.

A similar contrasting effect of innovation across small vs. medium-large firms emerges also from estimates of the wage-dispersion equation, reported in Table 7. On the one hand, for small firms, we estimate a positive association (positive and significant β_1) between innovation and wage inequality, both on average (in the OLS) and along the quantiles of the wage dispersion distribution. On the other hand, this effect is completely offset in the case of medium-large firms, as we indeed observe that innovation is associated with reduced wage inequality in this case: $\beta_1 + \beta_3$ is negative, and significantly different from 0.

Table 6: Log average annual earnings

	(Model III)					
	OLS	Simultaneous Quantile Regression				
		q10	q25	q50	q75	q90
Innovation	0.00103* (2.28)	0.000961*** (7.17)	0.001000*** (9.34)	0.00105*** (14.06)	0.00104*** (17.11)	0.000987*** (7.99)
Medium-large firm	0.101*** (5.54)	0.138*** (16.79)	0.134*** (20.00)	0.118*** (17.90)	0.0849*** (14.07)	0.0626*** (6.32)
Innovation × M-L firm	-0.000338 (-2.03)	-0.000329** (-2.84)	-0.000532*** (-5.80)	-0.000497*** (-7.03)	-0.000323*** (-4.03)	-0.000307** (-2.65)
Country						
Germany	0.125 (1.18)	0.221*** (14.95)	0.207*** (21.08)	0.158*** (17.18)	0.110*** (12.49)	0.0665*** (6.49)
Spain	-0.291** (-4.45)	-0.244*** (-31.88)	-0.257*** (-35.44)	-0.273*** (-51.35)	-0.289*** (-32.72)	-0.281*** (-26.29)
France	-0.0670 (-0.97)	0.0313*** (3.62)	-0.0105 (-1.51)	-0.0649*** (-9.55)	-0.105*** (-12.54)	-0.129*** (-11.62)
Sector						
16,17	0.00290 (0.05)	0.0377* (2.10)	0.0376* (2.30)	0.0204* (2.04)	-0.00686 (-0.73)	-0.0238 (-1.25)
19,20	0.147** (4.23)	0.142*** (9.50)	0.153*** (11.41)	0.164*** (15.96)	0.154*** (18.05)	0.148*** (9.70)
21,23	0.0676 (1.92)	0.0865*** (4.56)	0.0987*** (6.51)	0.0766*** (7.19)	0.0500*** (4.34)	0.0458* (2.27)
24,25	0.0382 (0.82)	0.0927*** (4.32)	0.0660*** (3.43)	0.0427*** (4.01)	0.0295** (2.58)	0.0133 (0.70)
26,27,33	0.0626 (1.76)	0.106*** (7.45)	0.0919*** (7.76)	0.0684*** (9.12)	0.0450*** (4.57)	0.0250 (1.46)
28	0.0749 (2.04)	0.145*** (8.27)	0.110*** (9.30)	0.0880*** (7.69)	0.0537*** (5.06)	0.00880 (0.51)
29,30	0.0485 (1.22)	0.0843*** (4.95)	0.0817*** (4.81)	0.0724*** (7.71)	0.0475*** (4.66)	0.00589 (0.28)
31,32	-0.0274 (-0.51)	-0.0158 (-0.83)	-0.00972 (-0.59)	-0.0159 (-1.57)	-0.0236* (-2.09)	-0.0511* (-2.15)
53,61-63,79	0.0406 (0.87)	0.0247 (1.20)	0.0310** (3.00)	0.0416*** (5.34)	0.0467*** (5.60)	0.0433* (2.00)
60,64	0.0601 (1.32)	-0.00778 (-0.31)	0.0106 (0.65)	0.0508*** (5.14)	0.0999*** (8.00)	0.132*** (7.26)
Publicly-controlled firm	-0.0381* (-2.65)	0.0300 (1.91)	-0.00827 (-0.76)	-0.0717*** (-7.09)	-0.0743*** (-7.17)	-0.0905*** (-4.43)
No coll. pay agreement	-0.0902* (-2.55)	-0.173*** (-16.27)	-0.143*** (-17.25)	-0.0940*** (-14.23)	-0.0657*** (-6.90)	-0.0389*** (-3.80)
Mode of age in the firm						
14-19	-0.260*** (-5.52)	-0.229*** (-3.85)	-0.236*** (-6.47)	-0.258*** (-6.89)	-0.272*** (-9.27)	-0.268*** (-6.80)
20-29	-0.104*** (-9.97)	-0.101*** (-9.14)	-0.0958*** (-8.78)	-0.0928*** (-12.14)	-0.0941*** (-12.10)	-0.0943*** (-9.80)
40-49	0.0178* (2.60)	0.00639 (0.76)	0.0154* (2.19)	0.0175** (2.91)	0.0168* (2.31)	0.0260** (3.13)
50-59	-0.0534* (-2.53)	-0.108*** (-11.30)	-0.0711*** (-9.47)	-0.0455*** (-5.30)	-0.0209* (-2.02)	0.00266 (0.23)
60+	-0.0644 (-1.28)	-0.0574 (-0.62)	-0.0829** (-2.61)	-0.0154 (-0.30)	0.0300 (0.58)	0.00243 (0.10)
Average tenure of workers	0.0184*** (7.60)	0.0199*** (34.03)	0.0186*** (46.52)	0.0178*** (34.14)	0.0159*** (23.87)	0.0128*** (18.04)
% with tert. edu.	0.00490*** (7.53)	0.00457*** (26.88)	0.00468*** (28.24)	0.00519*** (34.99)	0.00515*** (28.68)	0.00513*** (20.42)
% of manag. and profes.	0.00535*** -13.26	0.00439*** (24.19)	0.00505*** (25.76)	0.00542*** (34.38)	0.00622*** (41.36)	0.00689*** (22.22)
% of permanent contracts	0.00472*** (22.84)	0.00474*** (20.64)	0.00472*** (32.40)	0.00470*** (37.48)	0.00464*** (33.06)	0.00432*** (16.97)
% of male employees	0.00173** (4.58)	0.00150*** (11.12)	0.00158*** (13.08)	0.00170*** (24.31)	0.00187*** (22.64)	0.00195*** (14.34)
Constant	9.345*** (128.74)	8.951*** (346.23)	9.123*** (382.82)	9.318*** (621.51)	9.540*** (665.03)	9.788*** (337.11)
N	27346	27346				
(pseudo-)R ²	0.5541	0.3688	0.3717	0.3576	0.3273	0.2998

t-statistics in parentheses. * p<0.05, ** p<0.01, *** p<0.001.

Reference country is Italy; reference sector group is 68,72-74,77; reference modal age is 30-39.

Table 7: Log-difference in earnings between 90th 10th percentile

	(Model III)					
	OLS	Simultaneous Quantile Regression				
		q10	q25	q50	q75	q90
Innovation	0.000753*** (5.25)	0.000446*** (3.41)	0.000635*** (5.23)	0.000658*** (4.25)	0.000677*** (3.57)	0.00120*** (3.71)
Medium-large firm	0.104*** (5.32)	0.141*** (24.02)	0.173*** (23.34)	0.138*** (15.83)	0.0525*** (3.82)	0.0300 (1.29)
Innovation × M-L firm	-0.000859** (-3.57)	-0.000191 (-1.43)	-0.000715*** (-5.94)	-0.000822*** (-7.68)	-0.000857*** (-4.74)	-0.00167*** (-5.53)
Country						
Germany	0.230*** (8.10)	0.174*** (13.59)	0.164*** (18.17)	0.159*** (11.48)	0.216*** (9.35)	0.234*** (8.01)
Spain	-0.0992*** (-5.09)	-0.0669*** (-6.63)	-0.0806*** (-9.08)	-0.0869*** (-7.48)	-0.0823*** (-7.73)	-0.110*** (-5.60)
France	0.0977*** (5.33)	0.0479*** (4.42)	0.0662*** (8.26)	0.0892*** (12.18)	0.131*** (9.90)	0.143*** (5.08)
Sector						
16,17	0.00571 (0.18)	0.0671** (3.12)	0.0497*** (4.31)	0.0222 (0.95)	-0.0257 (-0.90)	-0.0923* (-2.12)
19,20	0.0909** (3.83)	0.126*** (6.05)	0.104*** (6.30)	0.0905*** (3.47)	0.0743* (2.54)	0.0558 (1.33)
21,23	0.000581 (0.02)	0.0428* (2.27)	0.0169 (1.07)	0.0136 (0.57)	-0.0186 (-0.53)	-0.0558 (-1.11)
24,25	0.0425 (1.45)	0.0650*** (3.64)	0.0604*** (4.02)	0.0359 (1.38)	0.0286 (0.97)	-0.0321 (-0.71)
26,27,33	0.0694* (2.97)	0.106*** (5.73)	0.0911*** (6.90)	0.0797*** (3.30)	0.0535* (2.22)	0.00944 (0.29)
28	0.0899* (3.05)	0.124*** (5.64)	0.106*** (5.44)	0.0969** (3.17)	0.0790** (2.71)	-0.00915 (-0.25)
29,30	0.0234 (0.80)	0.0732*** (3.33)	0.0468** (3.05)	0.0310 (1.08)	0.00192 (0.08)	-0.0707 (-1.81)
31,32	0.102** (3.66)	0.0454* (2.47)	0.0543** (3.02)	0.0742* (2.24)	0.0867 (1.87)	0.124* (2.11)
53,61-63,79	-0.0506* (-2.66)	0.000306 (0.02)	-0.0409*** (-3.66)	-0.0540* (-2.55)	-0.0922*** (-3.45)	-0.0948* (-2.28)
60,64	0.0482* (2.43)	0.0628** (3.23)	0.0862*** (6.02)	0.0585** (3.19)	0.00752 (0.24)	-0.0626 (-1.33)
Publicly-controlled firm	-0.112** (-3.42)	-0.0436*** (-4.00)	-0.101*** (-11.29)	-0.113*** (-6.46)	-0.122*** (-6.97)	-0.149*** (-4.71)
No coll. pay agreement	0.183*** (7.65)	0.0973*** (10.30)	0.145*** (17.12)	0.221*** (12.01)	0.219*** (8.64)	0.199*** (8.17)
Mode of age in the firm						
14-19	0.823*** (7.63)	0.674*** (5.43)	0.896*** (9.00)	0.870*** (13.65)	0.800*** (14.43)	0.737*** (4.76)
20-29	0.183*** (12.67)	0.0320* (2.18)	0.110*** (10.15)	0.189*** (14.16)	0.213*** (11.68)	0.216*** (7.30)
40-49	-0.0430** (-3.57)	-0.0203* (-2.47)	-0.0167** (-2.68)	-0.0261*** (-3.62)	-0.0270* (-2.17)	-0.0530* (-2.29)
50-59	-0.0350* (-3.16)	-0.0235* (-2.32)	-0.0159 (-1.51)	-0.0191 (-1.40)	-0.0165 (-0.94)	-0.0212 (-0.80)
60+	0.0109 (0.11)	-0.119 (-1.49)	-0.0362 (-0.97)	-0.00132 (-0.02)	0.0247 (0.45)	0.263 (1.53)
Average tenure of workers	-0.00676*** (-6.16)	-0.00267*** (-5.03)	-0.00524*** (-9.86)	-0.00847*** (-13.55)	-0.00935*** (-10.27)	-0.00824*** (-5.13)
% with tert. edu.	0.000673 (1.09)	0.00135*** (6.02)	0.00108*** (4.21)	0.000862*** (5.35)	0.000944** (3.06)	0.000136 (0.32)
% of manag. and profes.	0.00418*** (7.16)	0.00214*** (10.23)	0.00352*** (13.49)	0.00448*** (20.72)	0.00530*** (11.55)	0.00715*** (9.08)
% of permanent contracts	-0.00827*** (-6.02)	-0.00320*** (-17.28)	-0.00583*** (-18.62)	-0.00978*** (-23.79)	-0.0143*** (-27.86)	-0.0184*** (-24.17)
% of male employees	-0.00142** (-4.40)	-0.000662*** (-6.27)	-0.00102*** (-8.00)	-0.00157*** (-10.54)	-0.00186*** (-7.25)	-0.00220*** (-5.30)
Constant	1.615*** (16.13)	0.513*** (17.38)	0.971*** (30.08)	1.685*** (40.71)	2.504*** (47.82)	3.316*** (42.91)
N	27346	27346				
(pseudo-)R ²	0.2665	0.1133	0.1254	0.1544	0.1847	0.1947

t-statistics in parentheses. * p<0.05, ** p<0.01, *** p<0.001.

Reference country is Italy; reference sector group is 68,72-74,77; reference modal age is 30-39.

4 Conclusions

This work provides an investigation of the empirical relationship of innovation with wages and wage inequality within and across firms. By exploiting employer-employee data from a survey of European firms matched with information on sector innovation derived from the Community Information Survey, we look at the impact of innovation on the average wages paid by firms and the degree of within-firm wage inequality, also distinguishing “innovation-premia” across small and medium-large firms.

Overall, our findings suggest that innovation tends in general to have a significant association with both wages and within-firm wage inequality, and that firm size plays an important mediating role. On the one hand, we find a positive association between innovation and average wages, but such technology premium is smaller across medium-large firms as compared to small firms. On the other hand, we find a similarly counteracting effect due to size also concerning the relationship of innovation with wage dispersion. In fact, wage inequality increases with innovation for small firms, while it associates with a reduced wage dispersion across medium-large firms. Quantile regression estimates reveal that the main patterns are valid across both low wage and high wage firms, and across more or less “egalitarian” firms. The main patterns are also robust to inclusion of a relatively large set of controls, including sector and country fixed effects, as well as firm-level and employee-level characteristics, which are of course crucial components of both average wages and wage dispersion observed within each firm.

The observed effects on average wages and wage dispersion are not straightforward. We provide here a tentative interpretation in relationship with existing theories and previous empirical analysis. The starting point from a theoretical point of view is that innovation, and in particular if measured (as we do) in terms of innovation output, is in general associated with value creation. Innovation therefore brings about higher rents to be distributed within the firm, either in the form of profits (retained or further invested in the firm) or in the form of wages. In this sense, whether and how innovation affects wages and wage dispersion depends on two factors: one pertaining to how much value is created across different firms, and one pertaining to the mechanism of distribution of such value, due to the relative ability of owners and employees to appropriate the rents from innovation. And the two mechanisms can interact, of course.

Accordingly, two channels may explain why innovation increases average wages less within medium-large firms as compared to small firms. First, it may simply be that innovation by small firms involves more valuable activities and products than innovation carried on by larger firms. Even assuming equal rent-sharing mechanism across small vs. medium-large firms, this would be enough to observe, as we do, a “technology-premium” on wages in small firms. Second, and not in contrast with the first mechanism, our findings suggest that rents from innovation are more easily or more frequently passed on to wages within small-firms, while rent-sharing is more favorable to owners within medium-large firms. This wedge due to different rent-sharing mechanisms would be enough to explain our results even assuming innovation is equally valuable across small and medium-large firms.

The mechanisms behind the observed innovation-wage dispersion relationship can be partly similar, but not completely overlapping. On the one hand, explanations may refer to theories linking wage inequality across employees to skill bias or occupational bias. If these biases are in place within the same firm, then our result that wage inequality is higher for small firms can be interpreted as a signal that smaller firms are more likely to employ more skilled workers or to pay higher wages to apical

occupations, as compared to larger firms. On the other hand, since we do control for workforce composition and education levels, a better explanation may be that an additional rent-sharing mechanism plays a role, although between different employees rather than between the employees and the owners. In this sense, our findings support that a more equitable rent-sharing across employees is in place in larger firms than in smaller firms.

Overall, a consistent story seems to be that, in medium-large firms, employees appropriate less of the rents from innovation, leading to lower average wages, but the appropriated rents are more evenly distributed among the employees than in small firms.

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A Appendix

Table 8: Distribution of firms in the sample, by group of sectors of economic activity

NACE r.2 sectors	Description	Firms	Share (%)
16; 17	wood and products of wood and cork; pulp, paper and paper products	888	5.8
19; 20	coke, refined petroleum products and nuclear fuel; chemicals and chemical products	1,341	8.76
21; 23	chemicals and chemical products; other non-metallic mineral products	1,189	7.76
24; 25	basic metals; fabricated metal products, except machinery and equipment	1,301	8.49
26; 27; 33	electrical machinery and apparatus, nec; radio, television and communication equipment; medical, precision and optical instruments	1,715	11.2
28	machinery and equipment, n.e.c.	849	5.54
29; 30	motor vehicles, trailers and semi-trailers; other transport equipment	1,058	6.91
31; 32	manufacturing nec	927	6.05
53; 61-63; 79	supporting and auxiliary transport activities; post and telecommunications; computer and related activities	2,332	15.23
60; 64	financial intermediation except insurance and pension funding	883	5.77
68; 72-74; 77	real estate activities; renting of machinery and equipment; computer and related activities; research and development; other business activities	2,833	18.5
Total		15,316	

Figure 2: Distribution of wage dispersion across countries with different minimum number of sampled employees (3–10).

