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Claudio Labanca
Monash University

Dario Pozzoli
Copenhagen Business School and IZA

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IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

Hours Constraints and Wage Differentials across Firms*

Although constraints on hours worked at the firm-level are viewed as an important determinant of firm wages, little direct evidence exists to support this view. In this paper, we use linked employer-employee data on hours worked in Denmark to measure hours constraints and to investigate how these constraints relate to firm wages. We show that firms with stricter constraints pay higher firm-specific wages and that these premiums are concentrated in more productive firms. Starting from these findings we discuss a framework in which hours constraints are motivated by the productivity gains derived from having a more cooperative production process, leading more productive firms to constrain hours and to pay compensating wage differentials.

JEL Classification: J31, J33

Keywords: wage differentials, hours constraints, cooperation

Corresponding author:
Dario Pozzoli
Department of Economics
Copenhagen Business School
Porcelaenshaven 16 A
DK-2000 Frederiksberg
Denmark
E-mail: dp.eco@cbs.dk

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1 Introduction

The traditional labor supply model assumes that workers can freely choose how many hours to work. In this model workers receive a constant wage rate that is independent of hours worked. Numerous studies, however, have questioned this assumption (e.g. Abowd and Ashenfelter, 1981; Altonji and Paxson, 1992; Aaronson and French, 2004; Rogerson, 2011). In this literature hours constraints imposed by employers on employees are often seen as a fundamental factor limiting the ability of workers to work their desired hours (e.g. Chetty et al., 2011), leading to compensating wage differentials (e.g. Altonji and Paxson, 1988; Dickens and Lundberg, 1993). Due to the limited availability of data on hours worked within firms, however, little direct evidence exists on the relationship between hours constraints and firm wages.

In this paper, we use linked employer-employee data from Denmark to measure hours constraints at the firm level and to study how these constraints relate to firm wages. The distinctive features of the Danish data, which allow us to link hours constraints to a number of other firm and worker characteristics, provide an opportunity to study this relationship in light of other factors that are known to affect firm wages. As part of this analysis and motivated by existing evidence showing that more productive firms pay higher wages (e.g. Dunne et al., 2004), we then explore how the relationship between firm wages and hours constraints varies across differently productive firms. Based on the results of this analysis, we finally discuss a framework and a potential mechanism linking hours constraints, wages and firm productivity.

We base the empirical analysis on Danish administrative data. Denmark is a particularly fitting setting for our study. The unique features of the Danish data, in fact, allow us to link the number of hours worked to a large set of other individual and firm characteristics. Furthermore, compared to other European countries, Denmark has a relatively flexible labor market in which employers have considerable discretion in setting wages and hours (Botero et al., 2004).

We measure firm-level constraints on hours using the standard deviation of the average hours worked across coworkers with different skills who, based on survey data, display heterogenous labor supply preferences. Lower values of this standard deviation indicate a limited ability of workers with heterogenous desired hours to work their preferred number of hours and, therefore, stricter hours constraints. Consistent with the fact that hours worked are set by employers in firms with strict constraints, we observe that workers who move from firms with looser constraints (higher standard deviation) to firms with stricter constraints (lower standard deviation) tend to work a number of hours that is closer to the firm average in firms with stricter constraints, and the opposite trend is seen for workers moving in the reverse direction. In line with this evidence, in Labanca and Pozzoli (2021) we use the same measure of hours constraints and find that hours worked in high-constraint firms are unresponsive to variations in workers' preferences due to tax rate changes.

With this measure of constraints in hands, we then turn to the analysis of how the degree of constraints at a firm relates to wage rates paid to workers. We start this analysis by analyzing the relationship between average firm wages and hours constraints. Then, to account for the fact that workforce characteristics might correlate with hours constraints and firm wages, we estimate firm-specific wage premiums as the firm fixed effects from a regression of hourly wages on individual, firm fixed effects and time-varying characteristics (Abowd et al., 1999). In line with the theory of compensating differentials, we find a strong and positive association between the firm component of wages and the degree of hours constraints in a firm.

This relationship is robust to an extensive set of firm characteristics that are known to affect wage inequality across firms, such as firm size (Mueller et al., 2017), the firm's export status (e.g., Helpman et al., 2017), the skill and gender composition of the workforce (Card et al., 2016, Song et al., 2019), the average number of hours worked in the firm, the unionization rate (e.g., Dickens, 1986), and overtime premiums (Cardoso et al., 2012).

We estimate that an increase of 1 standard deviation in the degree of hours constraints at a firm is associated with an increase of 9.6% in the average firm-component of wages. In the same specification, the magnitude of the relationship between hours constraints and firm wages is similar to the premium associated with exporting firms and greater in magnitude than the premium associated with firm size or physical capital per employee. The relationship between firm wages and hours constraints remains significant within sectors with approximately half of the magnitude being explained by differences across sectors and the other half being explained by differences across firms within sectors.

Next, we explore how the wage premium associated with hours constraints varies across differently productive firms. Existing studies, in fact, show evidence of a positive correlation between wage and productivity differentials across firms (e.g., Faggio et al., 2010) as well as a positive relationship between the degree of hours constraints and firm productivity (Labanca and Pozzoli, 2021). This evidence, combined with our findings of wage premiums from hours constraints, suggests a potential link among hours constraints, firm wages and productivity.

We find that the relationship between wages and hours constraints becomes insignificant after controlling for measures of firm productivity, which indicates that the wage premiums due to hours constraints concentrate in more productive firms. In particular, we estimate that hours constraints can explain between 6% and 9% of the wage inequality across firms within the same sector that is due to productivity and that is not explained by other factors commonly associated with wage premiums at the firm. These findings suggest that a relevant part of the unexplained correlation between the firm component of wages and productivity may reflect wage differentials for stricter hours constraints in more productive firms.

We conceptualize the link between firm productivity, hours constraints and wages in a framework in which firms differing in productivity employ workers with heterogeneous desired work hours. In this framework, firms can choose whether to constrain hours. Stricter constraints enhance productivity but require the hours worked to be the same across heterogeneous coworkers. In this framework we show that more productive firms choose to constrain hours and to pay compensating wage differentials for imposing sub-optimal hours.

This framework assumes, consistent with the empirical evidence, that the degree of hours constraints of a firm is positively associated with firm productivity. In the final part of the paper we explore one potential mechanism to explain this fact. Specifically, we postulate that stricter constraints on hours are motivated by a more cooperative production process that demands a greater degree of interaction among coworkers. This greater need for interaction may require heterogenous coworkers to work a more similar number of hours, thus leading firms to impose stricter constraints on hours worked. At the same time, a greater cooperation among coworkers has been shown to enhance workers productivity (e.g., Hamilton et al., 2003), linking constraints on hours to firm productivity. In line with this interpretation, we observe that firms with a high degree of hours constraints score high on measures of the importance of cooperation among coworkers, which are obtained from survey data.

This study contributes to multiple strands of the literature. First, it contributes to the literature on the effects of hours constraints (e.g., Ham, 1982; Kahn and Lang, 1991; Altonji and Paxson, 1988; Dickens and Lundberg, 1993; Rogerson, 2011; Chetty et al., 2011). Within this literature, constraints on hours at the firm level are viewed as an important determinant of hours worked and wages. Using data on hours worked within firms, we provide new firm-level evidence on the effects through which hours constraints are related to firm wages. In doing so, our results shed light on existing evidence at more aggregate levels. Siow (1990), for instance, found evidence of higher wages in industry–occupations with less volatile hours. More recently, Erosa et al. (2017) document that hourly wages decline when moving from occupations with low to high dispersion of hours. Our finding of higher wages in firms that impose stricter constraints provides one mechanism to explain the link between dispersion of hours and hourly wages. Our analysis of wages complements recent evidence showing that constraints on working hours at the firm level are an important determinant of hours worked (Labanca and Pozzoli, 2021).

Second, it contributes to the literature on wage and productivity differentials across firms (e.g., Dunne et al., 2004; Faggio et al., 2010; Barth et al., 2016; Card et al., 2018). Specifically, we offer a look inside firms by modeling and empirically quantifying the importance of constraints on hours as a rationale that leads more productive firms to pay higher wages. In this respect, our results suggest a possible mechanism in line with the recent findings on compensating differentials as a relevant source of wage inequality across firms (Taber and Vejlin, 2016; Sorkin, 2018; Lamadon et al., 2019). Relative to the literature on compensating differentials from less-desirable hours, our results emphasize the importance of considering the hours worked relative to those of other workers in the firm as a way to capture disamenities from hours at the workplace (e.g., Lewis, 1969; Rosen, 1986; Abowd and Ashenfelter, 1981; Goldin and Katz, 2016; Mas and Pallais, 2017; Erosa et al., 2021).[1]

The remainder of the paper is organized as follows. Section 2 describes the data and the

[1] To the extent that stricter hours constraints facilitate a greater overlap of workers at the workplace, our finding of higher wages in firms that constrain hours of workers with different skills, complements the work of Cubas et al. (2019) who document a positive correlation between occupation-level wages and the concentration of work schedules among workers with similar skills.

institutional setting. Section 3 introduces the measure of hours constraints. Section 4 presents the analysis on hours constraints and firm wages. Section 5 presents the analysis of hours constraints and wages across differently productive firms, which also includes a discussion of the theoretical framework. Finally, Section 6 concludes the paper.

2 Institutional framework and data sources

We base the empirical analysis on a panel of Danish workers. In this section, we describe the main features of the Danish labor market and the main sources of our data.

2.1 The Danish labor market

Denmark is a fitting setting for our study. In fact, a soft employment protection legislation combined with a generous social safety net make of the Danish labor market one of the most flexible in the world (Botero et al., 2004). In the past, wages and working time were set at the industry level through collective bargaining, but over time, the system has undergone a decentralization process in which negotiations are much more based at the firm level.

As an effect of this process and despite the fact that approximately 70% of workers in the private sector are unionized, the wages of approximately 85% of them are negotiated directly at the worker-firm level (Hummels et al., 2014). The wage premium for workers who work overtime is usually equivalent to 50% of the normal wage for the first 3 hours in a week and 100% of the normal wage for each hour of overtime that exceeds the first 3 hours.

Regarding working time regulation, sectoral agreements usually define the normal week as 37 hours on average with no more than 8 hours of overtime work. Firms, however, have made increasing use of "opening clauses", which allow union representatives at the company to develop local regulations that can deviate from the sector-level agreements. In 2008, approximately 60% of full-time workers in the private sector were estimated to be covered by this type of local regulation (Dansk-Arbejdsgiverforening, 2012).

The relative flexibility that Danish firms have in setting hours is consistent with the substantial variation in hours worked across firms within sectors observed in the data. In Labanca and Pozzoli (2021), for instance, we document that 23% of the overall variance of total annual hours worked in Denmark is explained by cross-firm variation within the same 3-digit sector.

Further discretion in the choice of working hours comes from overtime work. Approximately 20% of salaried workers and 60% of hourly workers in our sample report at least one hour of paid overtime work. Finally, flexibility in the supply of hours derives from vacation time. Although most employees are entitled to 5 weeks of vacation per year, workers can negotiate with employers for a 6th week of vacation, allowing employers to have some discretion over the vacation hours of employees. In line with this practice, a substantial share (41%) of the variance of annual vacation hours is between-firms.

2.2 Data

We base the empirical analysis on multiple data sources. We use data on individual socioeconomic characteristics, such as tax returns, earnings and education, from the Integrated Database for Labor Market Research (IDA), which collects annual data on the entire Danish population. Data on annual hours of regular and overtime work are extracted from *Lønstatistikken* (LON). These data are reported by employers whose contributions to employees' pensions are based on hours worked and who therefore have an incentive to accurately report them (see details in Online Appendix A). Following Lachowska et al. (2018), we perform a number of tests to evaluate the quality of LON's records on hours. The results of these tests indicate that the quality of the Danish records is generally high and similar to that of other sources of administrative data on hours that are used in the literature (see Online Appendix section A.1 and Labanca and Pozzoli, 2021).

Unfortunately, not all workers in the IDA dataset can be matched to LON. For our study, however, it is particularly important to observe the hours of as many workers as possible within a firm. For this reason, we consider only firms in which the number of hours worked in a year are available for at least 95% of the workforce. Hourly wages are obtained as annual earnings over the sum of regular and overtime hours.

We use firm-level data from the Firm Statistics Register (Firmstat) and the Danish Foreign Trade Statistics Register, which provide information on firm characteristics, such as the number of employees, industry affiliation, accounting and trade data. These registers cover the totality of private firms with more than 50 full-time equivalent employees and a representative sample of smaller private firms. We match employees to employers using the Firm-Integrated Database for Labor Market Research (FIDA).[2] We focus on full-time employees who were 15 to 65 years old in the 2003–2011 period, for which data are available from all sources.[3] It is common practice to use only full-time workers in the IDA register because hours' records are more accurate for full-time workers (e.g. Hummels et al., 2014; Lund and Vejlin, 2015). However, since this restriction could come at the cost of ignoring some of the variation that is of interest to us, we also show the results obtained while considering all of the workers as a robustness check.

Table 1 reports descriptive statistics of the entire population (columns 1 and 2), the sample of the population that can be linked to data on firms and hours (columns 3 and 4), and our final sample comprising firms with available data on hours for 95% or more of the workforce (columns 5 and 6). A comparison of columns 3 and 5 suggests that our final sample, while providing better information on hours worked, does not substantially distort the composition of the population for which individual and firm records are available (see also Labanca and Pozzoli, 2021). Our final sample includes more than 400,000 employees and approximately 8,300 firms.

3 Hours constraints: Measure

Our measure of hours constraints is the standard deviation of hours worked across skill groups:

$$\sigma_{jt} = \left[\frac{1}{S_{jt}} \sum_{s=1}^{S_{jt}} \left(\tilde{h}_{sjt} - \mu_{jt} \right)^2 \right]^{1/2}, \tilde{h}_{sjt} = \frac{1}{N_{sjt}} \sum_{i=1}^{N_{sjt}} h_{isjt} \tag{1}$$

[2]FIDA links workers to firms in the employment spell of week 48 of each year. For workers who have multiple employers in this spell we focus on the primary employer. Primary employers are selected based on hours worked. This practice is standard in studies that use similar data (see, for instance, Buhai et al., 2014; Søresen and Vejlin, 2014). For workers whose spell in week 48 lasted less than 1 entire year, we use annualized hours and earnings. We refer to Online Appendix Section A for more details on the data.

[3]Following the official definition in place during the period, we define full-timers as those working more than an average of 26 weekly hours over a one-year period, representing approximately 90% of the workers in the sample.

Table 1: Descriptive statistics

	IDA Sample		IDA -Firmstat-LON sample		Final sample	
	(1)	(2)	(3)	(4)	(5)	(6)
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Workers Characteristics:						
Age	39.82	12.87	41.11	11.09	42.05	10.91
Fraction < 30 years old	0.27	0.44	0.19	0.39	0.16	0.37
Fraction > 50 years old	0.27	0.44	0.25	0.43	0.27	0.45
Fraction Males	0.50	0.50	0.66	0.47	0.70	0.46
Fraction Unionized	0.70	0.46	0.73	0.44	0.77	0.15
Fraction Hourly	0.17	0.37	0.24	0.42	0.28	0.45
Fraction Primary Educ.	0.33	0.47	0.28	0.45	0.29	0.45
Fraction Secondary Educ.	0.40	0.49	0.52	0.50	0.51	0.50
Fraction Tertiary Educ.	0.24	0.43	0.19	0.39	0.18	0.39
Hourly wage (in DKK)			187.07	141.14	183.65	124.37
Annual Labor Income (in 1000 DKK)	267.00	448.30	357.93	288.35	349.36	248.68
Total Annual Hours			1907.99	213.01	1896.19	197.24
Overtime Annual Hours			27.82	95.55	27.62	87.60
Workers by sector (% of total):						
Agriculture, forestry and fishing, mining and quarrying	2.52		0.37	6.05	0.16	4.00
Manufacturing	26.60		32.48	46.83	35.73	47.92
Construction	10.35		8.67	28.15	9.43	29.23
Electricity, gas, steam and air conditioning supply, Trade and transport	30.14		43.46	49.57	40.82	49.15
Financial and insurance, Real estate, Other business	22.95		14.82	35.53	13.71	34.39
Other services	7.44		0.2	4.46	0.15	3.92
Firms Characteristics:						
Hours Constraints					94.38	92.72
Mean Firm Size			46.59	306.38	43.94	296.35
Mean Capital per employee (1000 DKK)			423.82	6874.83	924.24	42406.7
Mean Value Added per employee (1000 DKK)			431.16	2844.1	501.17	1723.95
Mean Revenues per employee (1000 DKK)			1655.39	6230.38	2104.16	8339.31
Exporters (%)			35.55	42.52	44.46	48.29
Number of observations	22,379,298		4,466,676		787,683	
Number of individuals	3,518,236		1,205,301		400,653	
Number of firms	266,196		29,111		8,817	

Notes: The table shows the mean and standard deviations for a set of variables for 3 groups of employees. In all 3 groups, we consider only workers who are between 15 and 65 years of age in the years 2003-2011. The "IDA Sample" refers to the entire Danish population. The "IDA-Firmstat-LON" sample refers to the sample of workers in IDA that can be matched to the Firmstat and LON samples. The "Final sample" is composed of all workers from IDA-Firmstat-LON who are employed in firms for which information on hours is available for at least 95% of the workforce. The data on employment by industry for the entire population are from Statistikbanken (Statistics Denmark), which does not provide standard errors around the mean values. Annual and hourly earnings, value added, capital and sales are expressed in Danish Kroner (DKK) and deflated by using the CPI index with 2000 as the base year (8 DKK $\simeq$ 1 USD in 2000). In Labanca and Pozzoli (2021), we use the same sample of workers and firms for the analysis and, for this reason, we present the same table of descriptive statistics.

where h_{isjt} is the number of annual hours worked by employee i in skill group s in firm j at time t, $\tilde{h}_{sjt}$ is the average of h_{isjt} across workers in sjt, and μ_{jt} is the average of $\tilde{h}_{sjt}$ across skill groups in firm-year jt. Finally, N_{sjt} and S_{jt} are the number of workers in sjt and the number of skill groups in jt, respectively. For consistency with the frequency of the data on hours used in the analysis, we measure σ_{jt} at an annual frequency.

This measure captures the degree to which workers with different skills at a firm are constrained to work undesired hours. To capture differences in desired hours among coworkers we group them based on skills. In fact, matching labor force survey data to our sample of administrative records we observe that desired hours substantially vary across skills, with the least skilled workers desiring to work approximately 15% fewer hours (5 weekly hours) than the most skilled workers (see online Appendix Table D.1 and Labanca and Pozzoli, 2021). These differences in desired hours across skill groups are more pronounced than differences across workers within skill groups (see Online Appendix Table D.2 and Labanca and Pozzoli, 2021).

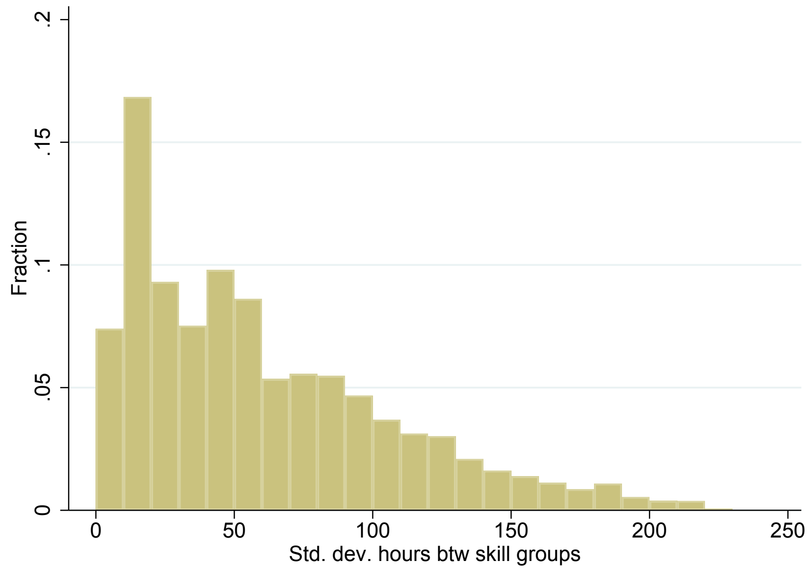
In light of this, a low value for the standard deviation indicates that coworkers with heterogeneous desired hours instead work a relatively homogenous number of hours, which in turn implies that they face stronger constraints. On the contrary, in firms in which the standard deviation is high workers with different preferences are less likely to deviate from their preferred hours, which implies that they face lower constraints.

We use two alternative definitions of skill groups. First, starting with the estimated coefficients from a firm-worker fixed-effect model of the type described in Abowd, Kramatz and Margolis (1999) (henceforth, AKM), we measure skills as the sum of the individual fixed component ($\hat{\alpha}_i$) and the time-varying component ($X_{ijt}\hat{\beta}_1$) of the hourly wages: $\widehat{s_{ijt}} = X_{ijt}\hat{\beta}_1 + \hat{\alpha}_i$ (Iranzo et al., 2008 and Irarrazabal et al., 2013). We thus assign workers in each year to one of 10 skill groups, defined as deciles of the distribution of $\widehat{s_{ijt}}$. We refer to Section 4.2 for a detailed discussion of the AKM estimation in our setting. One advantage of using this measure is that it captures both observed skills and time-invariant unobserved ability. However, we also construct an alternative measure of skills given by the intersection of the education and occupation categories obtaining similar results (see online Appendix D.3).

The measure σ_{jt} in equation (1) could capture individual preferences, rather than firm constraints, if workers with similar desired hours sort perfectly, or pervasively, across firms. In this case, however, σ_{jt} would be small or close to zero in all firms because coworkers would have equal or similar preferences on hours worked. In contrast, the distribution of σ_{jt} shows substantial variation across firms with a 90th to 10th percentile ratio of approximately 100 (see

Figure 1). In line with the hypothesis that σ_{jt} reflects firm constraints rather than individual preferences, in Labanca and Pozzoli (2021) we find that hours worked are unresponsive to changes in preferred hours in firms with strict constraints measured using σ_{jt}.

Figure 1: Distribution of hours constraints



Note: This figure presents the distribution of hours constraints measured as the standard deviation of mean hours (regular and overtime) worked across skill groups within a firm and year. We define skill groups as deciles of the distribution of $\hat{\alpha_i} + X'_{ijt}\,\hat{\beta}$ estimated from the AKM model (for details, see Online Appendix Section B). For each firm and year, we plot the value of the standard deviation of hours across skill groups weighted by firm size. Each bin in the histogram is ten hours long. To comply with the Danish micro-data usage regulation, we do not show the top 5% of the distribution because it would result in a number of observations below the allowed limit in some bins. In Labanca and Pozzoli (2021) we use the same measure of hours constraints, and therefore we show the same distribution.

One reason why this measure is unlikely to capture sorting, which is consistent with the evidence based on labor force survey data, is that workers in different skill groups generally differ in their desired hours thus limiting the scope of sorting based on hours' preferences. Frictions, as in Chetty et al. (2011), and/or compensating wage differentials can also prevent workers with similar preferences from sorting across firms.

One alternative approach to measure hours constraints would be to use the average standard deviation of hours worked within skill groups in a firm. However, since differences in desired hours across skill groups are more pronounced than differences within skill groups (see Online Appendix Table D.1 and Labanca and Pozzoli, 2021) this measure would be at greater risk of capturing sorting based on preferences. For this reason we use σ_{jt} in the baseline analysis. Then, in a robustness check, we present the results obtained while using this alternative measure.

Another possible approach to measure hours constraints would be to use the standard deviation of hours across all workers of a firm, independently of their skills. This measure, however, would mostly reflect the hours constraints faced by the most numerous skill group in the firm. In contrast, σ_{jt} in equation (1) assigns equal weight to the average hours worked in each skill group and, in doing so, it captures hours constraints faced by a wider set of workers. For this reason we use σ_{jt} in the baseline analysis. Then, in a robustness check, we present the results obtained while using the standard deviation of hours across all coworkers.

While we consider only full-time workers, ignoring part-timers may come at the cost of neglecting some of the variation in hours worked that is of interest for us. For this reason, we also construct a measure of σ_{jt} that includes part-time workers, and we present the results obtained using this alternative measure in the robustness section. However, due to the fact that the firms allowing more flexibility in the hours of full-time workers also employ relatively more part-timers (Labanca and Pozzoli, 2021), the two alternative measures are strongly correlated, and the results obtained from these measures are qualitatively the same.

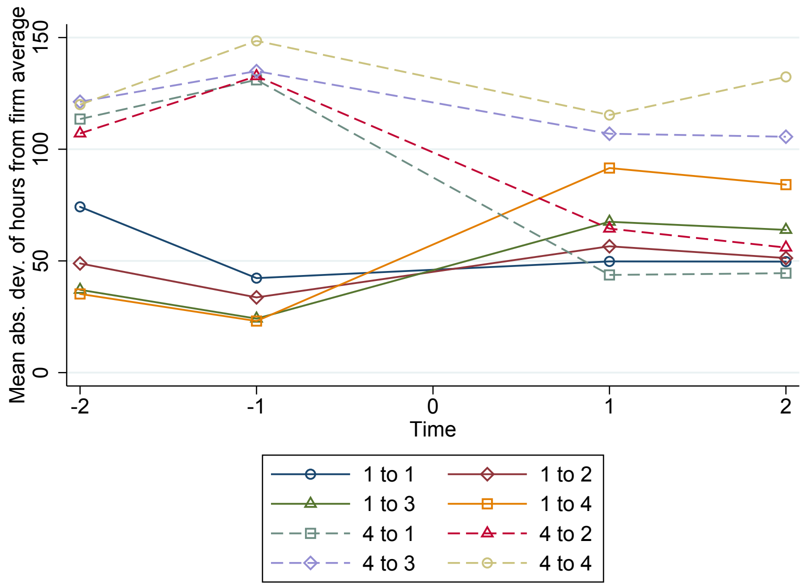
3.1 Constraints and hours worked by movers

In this section, we analyze the trends in the hours worked by workers who move across firms that, based on σ_{jt}, present different degrees of hours constraints. To the extent that this measure captures firm-level constraints on hours, we expect that the same worker would work a number of hours closer to the firm average in firms in which hours constraints are stricter relative to firms in which they are looser.

Using an event study approach similar to that used for wages in Card et al. (2013), we divide the distribution of σ_{jt} in each year into quartiles. We then assign each worker to a quartile of this distribution based on the degree of hours constraints at the firm where she/he is employed during the year. Thus, we identify movers from one firm to another, and we restrict the analysis to those who can be observed for a period of 5 years around the time of the job change. For each mover and year, we compute the mean absolute deviation of her/his working hours from the firm average.

Figure 2 presents the trend in the mean absolute deviation of hours from the firm average for movers from the 1st (i.e., most stringent constraints) or 4th (i.e., loosest constraints) quartile

Figure 2: Hours dynamics of job changers



Note: The figure plots the mean absolute deviation of hours from the firm average of job changers classified by quartile of the standard deviation of hours across skill groups (σ_{jt} in section 3). The figure is based on workers observed in the years 2003-2011 who can be tracked for 5 years around the job change. The figure shows movers from the 1st (i.e., high-constraints) or 4th (i.e., low-constraints) quartile of the distribution of the standard deviation of hours across skill groups. Online Appendix Tables D.3 shows the mean absolute deviation of hours from the firm average for movers across the other quartiles of the distribution. Hours in the first year of employment at the new firm (year zero) are excluded from the analysis because in Denmark vacation hours accumulated by a job changer at the former employer can be used at the new employer in the first year of employment. Therefore, in year zero, hours worked may not only capture the worker's supply of hours at the new employer.

of the distribution of σ_{jt}. Convincingly, we observe that working hours move closer to the firm average for workers going from firms with higher σ_{jt} to firms with lower σ_{jt}, while hours deviate more from the firm average for workers moving from a high- to a low-constraints firm.[4] The results obtained for movers from the 2nd and 3rd quartiles of the distribution of σ_{jt} are in line with the evidence presented in Figure 2 (see the Online Appendix Table D.3).[5]

[4]We find similar trends if we exclude hours worked by movers from the measure of mean firm hours and from σ_{jt}, suggesting that these trends do not reflect a mechanical relationship among hours of movers, mean hours and σ_{jt}.

[5]Figure 2 shows steeper variations in the mean absolute deviation of hours from the firm average (MAD) between time -2 and time -1. This is due to outliers presenting unusual MAD values in the year preceding the job change (period -1 in our graph). To minimize the concerns related to these observations, in Online Appendix Table D.3 we evaluate trends in MAD values observed at times -2 and 2, thus excluding the periods immediately before and after the job change. Then, in the last column of these Online Appendix tables, we also control for a set of individual characteristics associated with steeper changes in MAD between times -2 and -1. The main conclusions of Section 3.1 remain valid in these alternative analyses, suggesting that outliers are unlikely to be driving the main results.

4 Hours constraints and wage differentials across firms

The theory of compensating wage differentials would suggest that firms that impose stricter constraints pay higher wages to compensate for suboptimal hours (Rosen, 1986; Abowd and Ashenfelter, 1981; Altonji and Paxson, 1988). Motivated by this, in this section, we analyze the relationship between employer-specific wage premiums and hours constraints.

4.1 The empirical model

We base this analysis on an empirical model that relates the wage premium paid by firm j, $\widehat{\psi_{j(i,t)}}$, to a measure of firm j's degree of hours constraints, σ_j, controlling for a vector of controls, $\bar{Z}_j$. The equation to be estimated is as follows:

$$\widehat{\psi_{j(i,t)}} = \delta_0 + \delta_1 \sigma_j + \delta_2 \bar{Z}_j + v_j \tag{2}$$

We begin by measuring $\widehat{\psi_{j(i,t)}}$ as the average log hourly wage in a firm over the years 2003–2011. Then, to account for the fact that workforce characteristics might correlate with hours constraints and firm wages, we also measure $\widehat{\psi_{j(i,t)}}$ using the firm fixed effect from an AKM firm-worker fixed-effect model. This firm fixed effect measures the fixed component of the wage that is specific to a firm once we control for individual fixed and time-varying characteristics. In the next section, we describe the details of the AKM estimation and discuss the plausibility of the AKM assumptions in our setting.

The term σ_j in equation (2) is the average of σ_{jt} from equation (1) over the years 2003–2011. Based on this, low values of σ_j indicate stricter constraints on hours, and the opposite is true for high values of σ_j. The existence of compensating differentials would imply that δ_1, the coefficient attached to σ_j, is negative.

To control for other firm characteristics that may confound the effects of the hours constraints on firm wages, we include in equation (2) an extensive set of average firm controls ($\bar{Z}_j$). Among these controls, we include detailed geographic and industry fixed effects, controls for the composition of the workforce of a firm both in terms of gender and ability, and other firm characteristics such as firm size, exporter status or unionization rate, all of which have been found to correlate with wage differentials across firms. In order to account for potential bias in the estimation of the standard errors in equation (2) that may derive from limited mobility in AKM regression models (Abowd et al., 2003, Andrews et al., 2008), we also present the results of a robustness check in which we estimate standard errors based on the leave-out estimator of Kline et al. (2020).

One may worry that a negative correlation between hours constraints and firm wages might be driven by institutional factors. In particular, workers in high-paying firms may work longer hours, and in doing so, they may bunch at 37 hours, which is the upper limit imposed on the average number of hours by most collective labor agreements. For a similar reason, if workers in high-paying firms are more likely to work overtime, higher wages may reflect statutory overtime premiums rather than compensating wage differentials. To take these factors into account, first, in all the specifications, we control for the average number of hours worked. Then, in a set of robustness checks, we explicitly explore these potential concerns by excluding firms that bunch at 37 hours and by considering only the earnings from regular hours.

While the richness of the data at hand allows us to control for a large number of confounding factors, the effects obtained from equation (2) may still suffer from omitted variable bias. As a way to assess the sensitivity of our results to omitted variables, in the robustness section, we perform a set of tests of the type proposed in Oster (2019). While the results of these tests are reassuring, in the absence of an exogenous variation in firm hours constraints, our estimates are not to be considered as causal. However, due to the limited evidence that exists on the relationship between hours constraints and wages at the firm level, we regard this analysis as an important step towards understanding a relevant economic phenomenon.

4.2 The firm component of wages

We estimate the average wage premium paid by a firm to all workers as the firm fixed effect in the following regression model:

$$ln\, \mathrm{w_{ijt}} = \alpha_i + \psi_{j(i,t)} + \beta_1\, X_{ijt} + r_{ijt} \tag{3}$$

where $\mathrm{w_{ijt}}$ is the gross hourly wage earned by individual i in firm j in year t. X_{ijt} is a vector of time-varying controls, while α_i controls for individual fixed effects.[6] The variable of primary interest to us is the firm fixed effect $\psi_{j(i,t)}$, which measures the fixed component of the wage that is specific to firm j once we control for individual fixed and time-varying characteristics.

Equation (3) is similar to the model used in AKM and several other studies. However, unlike most other studies, we observe hours worked and, therefore, we use hourly wages rather than annual or monthly earnings as a dependent variable. Furthermore, we consider both male and female workers since hours constraints involve all coworkers in a firm regardless of their gender.

The AKM wage decomposition rests on the assumption of exogenous worker mobility conditional on observables. Following Card et al. (2013), we present a number of tests performed with the aim of investigating the plausibility of this assumption. The results of these tests suggest that endogenous mobility is unlikely to be an issue in our setting (see Online Appendix B).

4.3 Results

Table 2 presents the results obtained from estimating equation (2). To compare the coefficients attached to different regressors, we standardize all variables. Column 1 shows that higher constraints in a firm are associated with higher average wages. Column 2 reports the coefficients estimated while using the firm component of wages from the AKM decomposition as the dependent variable in equation (2). In this specification, the coefficient on hours constraints has the same sign and significance as in column 1, while the magnitude of the correlation decreases. This finding is consistent with the fact that part of the correlation in column 1 may depend on workforce characteristics that are better controlled for when using the AKM-based measure

[6]Following Card et al. (2013), we include in X_{ijt} a set of interactions between year dummies and educational attainment, as well as interaction terms between quadratic and cubic terms in age and educational attainment. In addition, we also control for firm characteristics that change over time such as value added, sales, capital per employee, exporter status and the share of hourly workers. These additional firm controls isolate the average wage premium paid by a firm from temporary fluctuations due to firm-level shocks. The results obtained when we only include individual characteristics are noisier but still in line with the baseline regression and are shown in the robustness section. We estimate this regression on all workers and firms for which data on hourly wages, individual and firm characteristics are available (column 2 in Table 1).

of average firm wages. Based on this, in the specifications that follow, we use the AKM-based measure to the extent that it results in more conservative estimates.

Existing studies have shown that wage differentials across firms correlate with a number of other firm characteristics, some of which may confound the estimated correlation between hours constraints and wages. Thus, in column 3, we control for firm size and exporter status to account for the fact that large firms and exporters pay higher wages (e.g., Mueller et al., 2017, Helpman et al., 2017, Macis and Schivardi, 2016). We also include region fixed effects to control for geographic differences in pay, and we control for the share of female workers in the firm because females are more likely to sort into low-paying firms or to bargain for lower wages (Card et al., 2016). Additionally, we control for the share of unionized workers as a way to capture rents from unions (Dickens, 1986) and for the average number of hours worked to control for compensating differentials due to long hours (e.g., Goldin and Katz, 2016).

In column 3, we add further controls for the skill composition of a firm's workforce. In fact, recent studies show that the sorting of more able workers into better-paying firms is important in determining wage inequality between firms (e.g., Song et al., 2019). We control for the skill composition of the workforce in two ways. First, we include controls for the share of workers in each skill group. Then, to account for the fact that workers in the same skill group might differ across unobserved dimensions, we also control for the average values of the individual fixed effects ($\hat{\alpha}_i$) from the AKM regression in each quartile of the firm distribution of $\hat{\alpha}_i$. These have been used as measures of unobserved workforce ability in the literature (Bender et al., 2018).

The results in column 3 are reassuring as the coefficient attached to the measure of hours constraints retains its sign and significance. The magnitude of the coefficient in this specification is such that a one-standard-deviation (95 hours per year) increase in hours constraints is associated with an increase equivalent to 9.6% of the average firm-component of wages.[7]

To gain a further understanding of the importance of hours constraints for firm wages, we can compare the coefficient of hours constraints to the coefficients estimated for other firm characteristics that are commonly associated with higher wages. This comparison indicates that the

[7]This finding is obtained by multiplying the coefficient (0.061) by the standard deviation of the firm component of wages (0.26); this gives a 0.01586 log wage increase, which corresponds to 9.6% of the average firm-component of wages (-0.165).

Table 2: Hours constraints and wage differentials across firms

	(1) Firm Mean Wage	(2) Firm F.E.	(3) Firm F.E.	(4) Firm F.E.	(5) Firm F.E.	(6) Firm F.E.
Std dev. btw skill groups	-0.153***	-0.088***	-0.064***	-0.054***	-0.033**	-0.034**
	(0.023)	(0.018)	(0.019)	(0.015)	(0.014)	(0.015)
Firm size			0.015	0.015	0.010	0.025***
			(0.011)	(0.010)	(0.006)	(0.009)
Exporter status			0.055***	0.056***	0.027*	0.017
			(0.019)	(0.019)	(0.016)	(0.016)
Union. Rate			0.023	0.031*	0.032	0.034*
			(0.018)	(0.017)	(0.019)	(0.019)
Female Share			-0.147***	-0.188***	-0.127***	-0.116***
			(0.037)	(0.036)	(0.026)	(0.027)
Average Hours			0.148	0.071	-0.043	-0.056
			(0.096)	(0.107)	(0.101)	(0.101)
log(Cap/empl)			0.027*	0.029**	0.035***	0.043***
			(0.014)	(0.014)	(0.012)	(0.012)
Region f.e.	NO	NO	YES	YES	YES	YES
Additional Controls	NO	NO	YES	YES	YES	YES
1 digit Sector f.e.	NO	NO	NO	YES	NO	NO
2 digits Sector f.e.	NO	NO	NO	NO	YES	NO
3 digits Sector f.e.	NO	NO	NO	NO	NO	YES
Mean dep. variable	5.153	-0.165	-0.165	-0.165	-0.165	-0.165
Std. dev. dep. variable	0.318	0.218	0.218	0.218	0.218	0.218
Mean SD Hours btw skills	94.685	94.685	94.685	94.685	94.685	94.685
Part. R-sq SD Hours	0.023	0.008	0.004	0.003	0.001	0.001
Part. R-sq VA and Sales	0.134	0.025	0.027	0.027	0.015	0.013
Coordination Share	0.174	0.298	0.144	0.094	0.055	0.063
R-sq	0.023	0.008	0.283	0.290	0.321	0.329
N	7478	7478	7478	7478	7478	7478

Notes: In this table, we report the results of estimating equation (2). All regressions report standardized coefficients. In column (1), the dependent variable is the firm's mean wage. In columns (2)-(6), the dependent variable is the firm fixed effect from the AKM model (3). The variable "Std dev. hours btw skill groups" in the table refers to our measure of hours constraints, which is the standard deviation of the average total (regular and overtime) hours worked across skill groups within a firm (Section 5.2). Skill groups are defined as deciles of the distribution of $\hat{\alpha_i} + \hat{\beta} X_{ijt}$ from the AKM model (3). The exporter dummy is defined as the modal exporter status (i.e., zero for not exporting, one for exporting) between 2003 and 2011. "Region f.e." refers to the following region dummies: Capital Region of Denmark; Central Denmark Region; North Denmark Region; Region Zealand; and Region of Southern Denmark. "Additional Controls" refers to a vector of controls for the share of workers in each skill group, a vector that contains the average value of the individual fixed effects $\hat{\alpha_i}$ in each quartile of the distribution of $\hat{\alpha_i}$ within a firm and the average hours squared. "Coordination Share" is derived as the ratio of "Part. R-sq SD Hours" and "Part. R-sq VA and TFP" (see section 5). "Part. R-sq VA and TFP" is from Table D.6. Value added and TFP are obtained as described in Online Appendix A.3. Standard errors are clustered at the 2-digit industry level. *, ** and *** indicate significance at the 10-, 5- and 1-percent levels, respectively.

relationship between wages and hours constraints is greater in magnitude than the association between wages and firm size or capital per employee, and it is comparable in magnitude to the premium associated with working at an exporting firm.

In line with other studies, we find no evidence of a significant relationship between firm-wages and average hours (Card et al., 2016). This result, combined with the finding of a significant and negative relationship between firm wages and hours constraints, highlights the importance of measuring relative hours in a firm to capture disamenities from working time.

The relationship between the firm component of wages and the degree of hours constraints remains significant within 1-, 2- or 3-digit sectors (columns 4 to 6 in Table 2). Based on our estimates, approximately half of the relationship between hours constraints and firm wages is explained by differences across sectors, with the other half being explained by differences across firms within sectors.

Overall, these findings indicate that the degree of hours constraints is an important predictor of between-firm wage inequality. The sign of the correlation is consistent with the existence of compensating wage differentials in high-constraints firms. This interpretation of the results is in line with other existing studies that, using a different approach, identify compensating differentials as a relevant source of wage inequality across firms (e.g., Taber and Vejlin, 2016; Sorkin, 2018). However, if sizable search frictions exist, this correlation may also capture rent sharing at high-constraints firms. While we cannot rule this out, the fact that, at least within sectors, we observe a relatively small and insignificant relation between the degree of hours constraints and the average worker tenure at the firm would suggest that frictions are less likely to play a major role in this setting (see Online Appendix Table D.4).

4.4 Robustness checks

In Table 3 we show a set of robustness checks for the results presented in the most detailed specification of column (6) in Table 2. In column 1 we consider earnings and hours constraints from normal hours only, thus excluding overtime, while in column 2 we exclude firms that bunch at 37 hours (average hours between 36.5 and 37.5). In these specifications the relation between the firm component of wages and hours constraints remains negative and of similar magnitude, suggesting that institutional factors are unlikely to drive our results.

In columns 3 to 5 we show the results obtained from using the set of alternative measures of hours constraints that we discuss in Section 3. Specifically, in column 3 we use the standard deviation across all workers; in column 4, we consider part-time workers in the measure of hours constraints; in column 5, we use the average standard deviation of hours within skills groups in a firm. In column 6, we use the median absolute deviation of hours across skill groups to reduce the concerns from having outliers in hours worked. Reassuringly, the relationship between firm

Table 3: Hours constraints and wage differentials: robustness check

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Var.:	Firm F.E.	Firm F.E.	Firm F.E.	Firm F.E.	Firm F.E.	Firm F.E.	Hourly Wage
Std dev. btw skill groups		-0.055***		-0.043***			-0.0310***
		(0.016)		(0.010)			(0.006)
Stand. Dev. Normal Hours	-0.037**						
	(0.014)						
Std. dev. hours (overall)			-0.071***				
			(0.015)				
Stand. Dev. w/i skill groups					-0.040**		
					(0.016)		
Median abs. dev. btw skill groups						-0.048***	
						(0.017)	
Firm size	0.025***	0.015	0.033***	0.025***	0.031***	0.025***	0.045***
	(0.009)	(0.011)	(0.009)	(0.009)	(0.008)	(0.009)	(0.006)
Exporter status	0.017	0.007	0.020	0.022*	0.020	0.016	0.006
	(0.016)	(0.024)	(0.017)	(0.013)	(0.017)	(0.016)	(0.0043)
Union. Rate	0.033*	0.055***	0.036*	0.036**	0.029	0.035*	0.015***
	(0.019)	(0.017)	(0.019)	(0.015)	(0.019)	(0.019)	(0.005)
Female Share	-0.115***	-0.139***	-0.115***	-0.109***	-0.116***	-0.117***	0.036***
	(0.027)	(0.028)	(0.028)	(0.026)	(0.028)	(0.027)	(0.0081)
Average Hours	-0.060	-0.071	-0.076	-0.124	-0.061	-0.073	0.093***
	(0.100)	(0.113)	(0.099)	(0.089)	(0.103)	(0.102)	(0.018)
log(Cap/empl)	0.043***	0.059***	0.041***	0.039***	0.038***	0.043***	0.093***
	(0.012)	(0.013)	(0.012)	(0.013)	(0.012)	(0.012)	(0.014)
3 digits Sector f.e.	YES	YES	YES	YES	YES	YES	NO
Av. Hours b/w 36.5 and 37.5	YES	NO	YES	YES	YES	YES	YES
Part-time workers	NO	NO	NO	YES	NO	NO	NO
KSS leave-one–out estimation	NO	NO	NO	NO	NO	NO	YES
R-sq	0.329	0.367	0.332	0.351	0.332	0.330	0.752
N	7462	4510	7478	7731	7345	7478	508082

Notes: In this table, we report a set of robustness checks of the results presented in column (6) of Table 2. All regressions report standardized coefficients. The dependent variable in column (1) is based on wage rates from regular hours only. "Std Dev. Hours btw Skill Groups" in the table refers to the standard deviation of the average total (regular and overtime) hours worked across skill groups within a firm (Section 3). "Std. Dev. Normal hours" is the standard deviation of the regular hours worked across skill groups within a firm. "Stand. Dev. w/i skill groups" refers to the standard deviation of the average total (regular and overtime) hours worked within skill groups within a firm. The "Median Abs. Dev." is the median absolute deviation of median hours (regular and overtime) across skill groups within a firm. Skill groups are defined as deciles of the distribution of $\hat{\alpha_i} + \hat{\beta} X_{ijt}$ from the AKM model (3). All specifications include additional controls for the share of workers in each skill group, a vector containing the average value of the individual fixed effects $\hat{\alpha_i}$ in each quartile of the distribution of $\hat{\alpha_i}$ within a firm and average hours squared. Column (1) to (6) we also control for region fixed effects. We refer to the footnote of Table 2 for more details on the construction of the other variables that are part of the table. Standard errors in column (1) to (6) are clustered at the 2-digit industry level. Standard errors in column (7) are based on the Kline et al. (2020) (KSS) leave-one-out estimator. *, ** and *** indicate significance at the 10, 5 and 1 percent levels.

wages and hours constraints in these specifications remains significant and of similar magnitude.

In column 7, we test the robustness of our baseline results against the potential bias to standard errors that may arise from the limited mobility in AKM models. We do so by using the leave-out estimator introduced in Kline et al. (2020) (KSS). Specifically, we present the results obtained by projecting the pooled firm effects from the leave-one-out sample onto the measure of hours constraints and a set of controls for worker and firm characteristics.[8] In this estimation model, standard errors are based on the KSS estimator, which provides asymptotically valid confidence intervals. The results in column 7 indicate that the relationship between firm wages and hours constraints remains significant, suggesting that limited mobility is unlikely to change the conclusions of the analysis in this setting.

In Table 4, we assess the sensitivity of the baseline results to unobserved variables using Oster (2019)'s approach. This method allows to test for the sensitivity of the estimated effects to omitted variable bias under the assumption that the relationship between the treatment and unobservables can be recovered from the relationship between the treatment and the observables. Following this approach, in column (1) we report the baseline effect of hours constraints on firm wages from column 6 of Table 2. This effect serves as a lower bound for the *identified set* of the treatment effect of hours constraints on wages which is presented in column (2). We obtain this set by assuming an equal degree of selection based on observed and unobserved variables, which is usually seen as an appropriate upper bound for selection on unobservables (Altonji et al., 2011; Oster, 2019). Reassuringly the identified set does not contain zero, indicating that even if we allow for a considerable level of selection on unobservables, the relationship of interest is unlikely to go to zero or to change sign.[9]

Table 4: Robustness check: selection on unobservables

	Controlled effect	**Identified set if $\delta = 1$**	**δ for effect$= 0$**
	(1)	(2)	(3)
Std dev. hours btw skill groups	-0.034	[-0.034; -0.016]	1.719
$\tilde{R}$	0.329		
$R2_{max}$		0.428	0.428

Notes: In this table, we report a set of robustness checks of the results presented in column 6 of Table 2. In column 1, we present the effects of column 6 in Table 2. In column 2, we present the identified set obtained from Oster (2019)'s approach by assuming an equal degree of selection on observables and unobservables (i.e., $\delta = 1$ in Oster, 2019's notation) and $R_{max} = 0.428$. R_{max} in the table refers to the R-squared from an hypothetical regression of the outcome on treatment and both observed and unobserved controls. $\tilde{R}$ refers to the R-squared in our most detailed specification of column 6 in Table 3. In columns 2 and 3, we assume $R_{max} = 1.3 \times \tilde{R}$. Oster (2019) proposes this cutoff for R_{max}, as it allows at least 90% of randomized results to survive in a random sample of articles from top journals.

[8] In this specification we include firm and worker controls that are part of the AKM model of equation (3) and the time-varying firm controls that are part of equation (2). This leaves out industry and region fixed effects, which are time invariant and would, therefore, be absorbed by the firm fixed effect in the leave-out procedure.

[9] In Table 4 we assume that the R-squared from a hypothetical regression of the outcome on treatment and both observed and unobserved controls (i.e. R_{max} in Oster, 2019's notation) is equal to 0.428. This is 1.3 times larger than the R-squared in our most detailed specification of column 6 in Table 3 (i.e. $\tilde{R}$ in Oster, 2019). In doing so, we follow Oster (2019) who proposes $R_{max} = 1.3 \times \tilde{R}$ as a reasonable cutoff value because it allows at least 90% of randomized results to survive in a random sample of articles from top journals.

To further investigate this aspect, in column (3) we estimate the degree of selection on unobserved relative to observed variables necessary to obtain a null effect of hours constraints on firm wages. We obtain a ratio of approximately 1.7 which is well above the value of 1 usually seen as an upper bound for selection on unobservables. Overall, the results in Table 4 indicate that, under the assumptions implied by Oster (2019)'s approach, omitted variable bias is unlikely to change the main conclusions of the analysis.

In Online Appendix Table D.7, we present an additional set of results obtained by adapting the approach proposed by Lavetti and Schmutte (2018) to estimate compensating wage differentials from hours constraints. Reassuringly, this approach delivers qualitatively similar results.

5 Constraints on hours, wages and firm productivity

Existing studies show, on the one hand, evidence of a positive correlation between wage and productivity differentials across firms (e.g., Dunne et al., 2004; Faggio et al., 2010) and, on the other hand, evidence of a positive relationship between the degree of hours constraints and firm productivity (see Labanca and Pozzoli, 2021). Motivated by this evidence, in the following section, we analyze the importance of hours constraints in explaining the variation in pay across differently productive firms. In Section 5.2, we then discuss a framework to conceptualize the link between hours constraints, productivity and wage differentials.

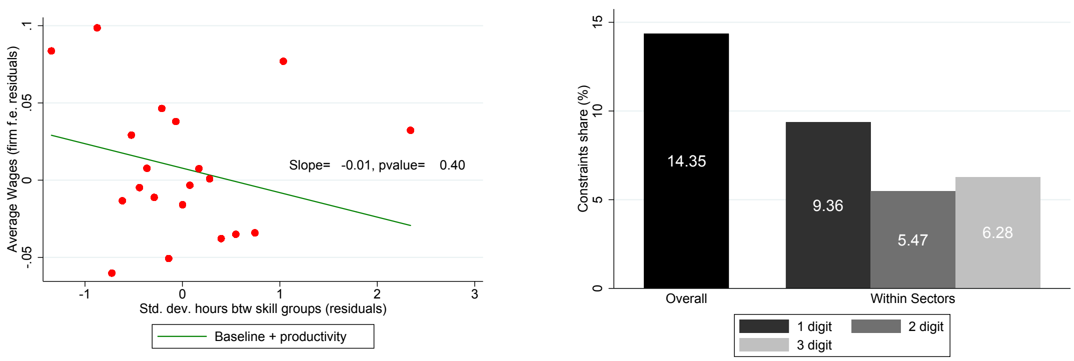
5.1 Hours constraints and wage premiums in differently productive firms

Panel (a) in Figure 3 shows that, once we introduce measures of firm productivity in the baseline specification, the coefficient of hours constraints decreases and becomes insignificant. This indicates that that the premium associated with hours constraints concentrates in more productive firms.[10]

[10]In the regression of Panel (a) of Figure 3, we use value added per employee as a measure of firm productivity and we instrument it using total factor productivity to reduce the concerns of measurement error in measuring firm productivity.

To measure the share of the correlation between wages and productivity that can be predicted by the degree of hours constraints, we first estimate equation (2) while omitting σ_j and including total factor productivity (TFP) and value added per employee as measures of firm productivity. From this alternative specification of equation (2), we obtain the partial R-squared associated with value added and TFP. Then, we measure the predictive power of hours constraints as the ratio of the partial R-squared associated with σ_j from equation (2) and the partial R-squared associated with value added and TFP. We refer to this ratio as the *constraints share*. This measure rests on the assumption, which is consistent with the evidence of Panel (a) in Figure 3, that hours constraints affect wages only through productivity.

Figure 3: Hours constraints, productivity and firm wages



(a) Hours constraints, wages and productivity (b) Constraints share

Notes: Panel A plots the residual firm component of wages and the residual standard deviation of hours between skill groups once we control for all other firm characteristics included in column 7 of the Online Appendix Table 3. The line results from a linear regression of the y-variable on the x-variable. The term "Slope" refers to the slope of the line, and "p-value" refers to the p-value of the slope. Firms are grouped into 20 bins, with each bin containing the same number of firms. Firm productivity is measured as value added per employee, which is instrumented using total factor productivity to reduce the measurement error derived from using value added as a measure of firm productivity. The full regression behind Panel A is shown in Online Appendix Table D.5. Panel B shows the "coordination share" (see details in section 5). The regressions behind Panel B are presented in Table 2 and Online Appendix Table D.6.

Panel (b) in Figure 3 shows the results of this analysis. We estimate a constraints share of approximately 14% across all firms and of 9% (6%) among firms in the same 1-digit (3-digit) industry. This estimation suggests that hours constraints predict a considerable share of the variation of firm wages that is linked to productivity differentials and that cannot be explained by other factors that are known to affect wages and productivity.

5.2 *Conceptual framework*

The evidence so far indicates that more productive firms impose stricter constraints on hours worked and pay higher wages. Motivated by this, in this section, we propose a model in which firms endogenously choose whether to restrict the range of hours available to their employees in exchange for productivity gains. Then, we examine how this choice affects wages. Finally, we discuss a mechanism to explain the link between hours constraints and productivity gains.

5.2.1 Workers

We assume that there are two types i of workers, N_H workers with high skill ($i = H$) and N_L workers with low skill ($i = L$). Workers have preferences over a continuum of consumption goods $\omega \in \Omega$ and leisure ℓ_i of the following type (Dixit and Stiglitz, 1977; Prescott, 2004):

$$U\left(Q_i, \ell_i\right) = \log\left[\int_{\omega\in\Omega} q_i(\omega)^{\frac{\sigma-1}{\sigma}}\, d\omega\right]^{\frac{\sigma}{\sigma-1}} + \eta\, v\left(\ell_i\right), \tag{4}$$

where $(Q_i)^{(\sigma-1)/\sigma} \equiv \int_{\omega\in\mathbf{\Omega}} q_i(\omega)^{(\sigma-1)/\sigma} \mathrm{d}\omega$ is the (exponentiated) consumption index for a worker of skill i, and $\sigma > 1$ is the elasticity of substitution between any two goods. We assume that the taste parameter η is positive and that the utility of leisure $v(\ell_i)$ is increasing and concave with $v'(\ell_i) > 0$ and $v''(\ell_i) < 0$.

Workers can take employment in either the non-constrained or constrained labor market. In the non-constrained labor market, workers face equilibrium wages w_i^* and pick their optimal hours $h_i^* = 1 - \ell_i^*$, allowing for an optimal consumption level Q_i^* with individual product demand $q_i^*(\omega)$, and resulting in a utility level $U_i^* \equiv U(Q_i^*, h_i^*)$ (see details in the Online Appendix C.1).

By contrast, workers employed in the constrained labor market must work for a prescribed number of hours $\hat{h}$ regardless of their skill level. In the constrained market, firms offer skill-specific hourly wages $\hat{\mathrm{w}}_H$ and $\hat{\mathrm{w}}_L$ that are discussed in the next subsection. Workers in this segment consume $\hat{Q}_i$ and $\hat{q}_i(\omega)$, resulting in utility $\hat{U}_i \equiv U(\hat{Q}_i, \hat{h}_i)$. The overall labor market for each skill group clears such that $N_i^* + \hat{N}_i = N_i$ for equilibrium wages w_i^* and $\hat{\mathrm{w}}_i$.

5.2.2 The wage-hour function

We assume perfect worker mobility between firms in the non-constrained and constrained segments of the labor market. One implication of this assumption is that, in equilibrium, a constrained labor market can co-exist with a non-constrained labor market only if workers are indifferent between employment in the two market segments. The indifference condition for each type-i worker between the constrained and non-constrained labor market segments is

$$U\left(\frac{\hat{\mathrm{w}}_{\mathrm{i}}}{P}\,\hat{h} + \frac{\bar{\pi}}{P},\,\hat{h}\right) = U\left(\frac{\mathrm{w}_{\mathrm{i}}^{*}}{P}\,h_i^* + \frac{\bar{\pi}}{P}, h_i^*\right), \tag{5}$$

where $P^{\sigma-1} \equiv \int_{\omega\in\boldsymbol{\Omega}} p(\omega)^{-(\sigma-1)}\,\mathrm{d}\omega$ is the (exponentiated) price index, and $\bar{\pi} \equiv \int_{\omega\in\boldsymbol{\Omega}} \pi(\omega)\mathrm{d}\omega/(N_H + N_L)$ represents the equal distribution of firm profits as dividends. This condition implicitly defines the wage rates $\hat{\mathrm{w}}_i$ for each type-i worker as a function of the hours worked $\hat{h}$. We refer to this function $\hat{\mathrm{w}}_i(\hat{h})$, which has $\mathrm{w_i}^*$ as a parameter, as the *wage-hour function.*[11]

Regarding the properties of this function, under standard regularity conditions on the shape of the utility function, it can be shown that $\hat{\mathrm{w}}_i'(\hat{h}) < 0$ if $\hat{h} < h_i^*$. In this case, a marginal increase in $\hat{h}$ shortens the distance between $\hat{h}$ and h_i^*, thus requiring less extra compensation to make the worker indifferent between working $\hat{h}$ and working h_i^*. Similarly, $\hat{\mathrm{w}}_i'(\hat{h}) > 0$ if $\hat{h} > h_i^*$, whereas if $\hat{h} = h_i^*$, no extra compensation is needed, and thus, $\hat{\mathrm{w}}_i'(\hat{h}) = 0$. Additionally, it can be shown that $\hat{\mathrm{w}}''(\hat{h}) > 0$ (Online Appendix C.2). Therefore, the resulting wage-hour function is U-shaped with its minimum at the equilibrium wage w_i^*, where hours $\hat{h} = h_i^*$.[12]

The economic insight behind this function is that firms in the constrained market need to offer higher wages to both skill groups when the constrained hours differ from the optimal hours.

5.2.3 Firms

There is a continuum of firms in which each firm produces a different variety ω of consumption goods under monopolistic competition. Every firm produces with a constant-returns-to-scale technology $q(\omega) = \gamma\,\phi\,G(n_H h_H, n_L h_L)$, where ϕ is a productivity parameter that differs from

[11] The concept of a wage-hour function of the type described here is not new in the literature; see, for instance, Abowd and Ashenfelter (1981); Altonji and Paxson (1988).

[12] As we show in Online Appendix C.2, there are conditions on the curvature of the leisure preferences or economy-wide productivity that ensure that $\hat{\mathrm{w}}''(\hat{h})$ is positive.

firm to firm under some probability distribution (similar to Melitz, 2003), γ is a Hicks neutral productivity shifter that varies with hours constraints, and $G(\cdot,\cdot)$ is the production function. The firm employs n_H high-skilled and n_L low-skilled workers.

In what follows, we denote by $G_H(\cdot,\cdot)$ the first derivative of $G(\cdot,\cdot)$ with respect to its argument $(n_H h_H)$ and by $G_L(\cdot,\cdot)$ the first derivative with respect to $(n_L h_L)$. For simplicity, we do not allow for market entry (Chaney, 2008). However, firms can choose whether to operate in the non-constrained or in the constrained labor market. In the non-constrained labor market, $\gamma = 1$, such that firms produce with productivity ϕ. In the constrained labor market, $\gamma = \hat{\gamma} > 1$, meaning that firms can raise their productivity to $\hat{\gamma}\phi$ but must pay a fixed cost $\hat{F}$ to impose hours constraints. The fixed costs of hours constraints can be thought of as the costs of infrastructure, such as office space, conference rooms, and scheduling software, that is needed to sustain a production in which coworkers work a similar number of hours. Consistent with this assumption, in Section 5.2.7 we discuss evidence suggesting that hours constraints are associated with greater interaction among coworkers at the workplace. The assumption of higher productivity at constrained firms is consistent with the positive association between firm productivity and the degree of hours constraints that is observed across Danish firms (see also Section 5.2.7 and Labanca and Pozzoli, 2021).

5.2.4 Non-constrained labor market

In the non-constrained labor market, firms take equilibrium wages w_i^* and workers' preferred hours h_i^* as given. Thus, they choose the number of high- and low-skilled workers that minimize costs, which leads to the following first-order conditions:

$$\frac{G_H(n_H^* h_H^*, n_L^* h_L^*)}{G_L(n_H^* h_H^*, n_L^* h_L^*)} = \frac{\mathrm{w}_\mathrm{H}^*}{\mathrm{w}_\mathrm{L}^*}.$$

We assume that $G_H(\cdot,\cdot) > G_L(\cdot,\cdot)$, such that $\mathrm{w}_\mathrm{H}^* > \mathrm{w}_\mathrm{L}^*$ and $h_L^* \neq h_H^*$, with $h_L^* < h_H^*$ if the substitution effect prevails and the opposite if the income effect prevails.

5.2.5 Constrained labor market

Firms in the constrained labor market offer contracts for a single number of hours $\hat{h}$ that workers of all skill levels must accept but offer skill-specific wages along the wage-hours function $\hat{\mathrm{w}}_i(\hat{h})$

such that each type-i worker is indifferent between employment in the constrained or non-constrained labor market. This scenario results in the following cost minimization problem:

$$\hat{C}(\omega) \equiv \min_{n_H, n_L, h} \hat{\mathrm{w}}_{\mathrm{H}}\, n_H\, h + \hat{\mathrm{w}}_{\mathrm{L}}\, n_L\, h \qquad \text{s.t.} \quad h\, G(n_H, n_L) \geq q^*(\omega)/(\hat{\gamma}\phi)$$

$$\text{and} \quad U\left(h\frac{\hat{\mathrm{w}}_i}{P} + \frac{\bar{\pi}}{P}, h\right) = U(Q_i^*, h_i^*)$$

$$\text{for } i = H, L.$$

From this, the first-order condition that implicitly defines $\hat{h}$ is (see Online Appendix C.3)

$$\hat{n}_H\, \hat{\mathrm{w}}_{\mathrm{H}}'(\hat{h}) \;=\; -\hat{n}_L\, \hat{\mathrm{w}}_{\mathrm{L}}'(\hat{h}). \tag{6}$$

Condition (6) has several implications. First, it implies that optimal hours $\hat{h}$ are between h_L^* and h_H^*. In fact, since $h_H^* \neq h_L^*$, $\hat{h}$ cannot be equal to either h_L^* or h_H^*. Furthermore, if $\hat{h}$ is greater than h_L^* and h_H^*, then $\hat{\mathrm{w}}_H' > 0$ and $\hat{\mathrm{w}}_L' > 0$, and thus, (6) cannot be satisfied. For a similar reason, $\hat{h}$ cannot be smaller than h_L^* or h_H^* to satisfy (6). Second, (6) establishes that optimal hours are such that the marginal costs of increasing hours in constrained firms equal the marginal benefits. To understand this point, let us consider the case in which high-skilled workers desire to work more than low-skilled workers ($h_H^* > h_L^*$). For any choice of constrained hours $h_L^* < \hat{h} < h_H^*$, a marginal increase in $\hat{h}$ moves them closer to h_H^*. Therefore, this situation results in lower wage premiums paid to high-skilled workers and, in turn, wage bill savings in the amount of $\hat{n}_H\, \hat{\mathrm{w}}_{\mathrm{H}}'$. However, the same increase in hours moves $\hat{h}$ further away from h_L^*, resulting in higher wages paid to low-skilled workers and therefore a higher wage bill in the amount of $\hat{n}_L\, \hat{\mathrm{w}}_{\mathrm{L}}'$. At the optimum, the savings from marginally higher hours equal the costs. Finally, (6) implies that $\hat{h}$ is set closer to the desired hours of the larger group of workers in the firm.[13]

Based on (6), both high- and low-skilled workers in constrained firms work suboptimal hours and are therefore compensated with wage premiums. We therefore have the following:

Proposition 1 *Firms that constrain work time at a common number of hours for both skill groups pay higher hourly wages than non-constrained firms, which take the supply of work hours as given.*

[13] A greater $\hat{n}_i$ in (6) raises the marginal costs of increasing $\hat{h}$ if $\hat{h} > h_i^*$ or decreases the marginal benefits of increasing $\hat{h}$ if $\hat{h} < h_i^*$, which implies that $\hat{h}$ moves closer to h_i^* as $\hat{n}_i$ increases.

5.2.6 Endogenous market segmentation

We now establish the conditions for the existence of the constrained labor market segment in equilibrium. A firm will optimally choose to enter the constrained labor market if and only if the profits from imposing constraints on hours exceed the profits from being non-constrained. It can be shown that under the assumption of $\hat{\gamma} > \hat{\mu}/\mu^*$ where μ^* and $\hat{\mu}$ are minimized marginal production costs in the un-constrained and constrained segments, respectively, a firm with productivity ϕ will optimally choose to constrain hours if:

$$\phi > \frac{\sigma}{\sigma - 1} \frac{\hat{F}^{1/(\sigma-1)}}{E^{1/(\sigma-1)} P} \frac{\hat{\mu}}{\hat{\gamma} - \hat{\mu}/\mu^*} \equiv \hat{\phi}, \tag{7}$$

Intuitively, as the fixed cost $\hat{F}$ of constraining hours or the marginal cost $\hat{\mu}$ of producing in the constrained market increases, the entry threshold increases. Conversely, a less competitive market with a high overall price level P and a larger aggregate economy with higher expenditures $E(= PQ)$ facilitate entry and therefore reduce the entry threshold. The inequality would be reversed if $\hat{\gamma} < \hat{\mu}/\mu^*$, and a constrained labor market would not exist (see Online Appendix C.4 for more details on the derivation). Therefore, we can state the following:

Proposition 2 *If a firm's productivity premium resulting from constraining work hours is sufficiently large, $\hat{\gamma} > \hat{\mu}/\mu^*$, a constrained labor market co-exists with a non-constrained labor market. Firms with productivity above a unique threshold $\hat{\phi}$ constrain work time, whereas firms with productivity weakly below that threshold remain non-constrained.*

Finally, it is important to mention that in the model presented in this section, we abstract from the sorting of workers across firms based on hours preferences. In reality, workers with preferences for longer hours may sort into hours-intensive firms, and vice versa. However, to the extent that perfect sorting can be ruled out—as is the case if there exists a continuum of workers' preferences and only a limited number of firms—the predictions of the model would still be valid.

5.2.7 Cooperation-induced constraints on hours

The framework of the previous section maintains the assumption that stricter constrains on hours worked result in productivity gains. The question arise as to why firms with stricter constraints are more productive. In this section, we propose cooperation among coworkers as a possible rationale that leads firms to constrain hours while allowing them to be more productive.

In recent decades, firms have become more collaborative, with coworkers spending a greater share of their working time interacting with one another (Delarue et al., 2008; Cross and Gray, 2013). While existing studies suggest that greater cooperation is associated with improved worker productivity (e.g., Hamilton et al., 2003; Chan, 2016), cooperation may come at the cost of constraining workers' hours. Specifically, a greater need for interaction may require that coworkers work simultaneously, thus providing a more similar number of hours despite possibly different labor supply preferences. As a result, differences in the degree of internal cooperation may lead to variation in productivity and hours constraints across firms.

Consistent with this line of argument, we observe that firms that impose stricter constraints are more productive (i.e. have higher TFP, see Table 5 and Labanca and Pozzoli, 2021). To investigate whether stronger constraints are also associated with a more cooperative production process, in Table 5 we report standardized coefficients obtained from a set of regressions of hours constraints on measures of the importance of interaction among coworkers.

We start the analysis with measures of interaction based on the Survey of Adult Skill (hence, SAS). This survey covers approximately 166,000 adults aged 16-65 and it includes, among other variables, information on a range of generic skills required of individuals in their work.[14] We focus on the following two characteristics of a job: *Time cooperating with coworkers* and *Sharing work-related information*, both of which imply cooperation among coworkers. These characteristics are measured on a discrete scale ranging from 1 to 5, where 1 means that the characteristic is not important and 5 means that it is extremely important. In order to merge this information with the Danish Registers, we first take the median value of each characteristic within each 4-digit (ISCO-08) occupation and then merge them to the registers using the same occupation code. We finally take the median value of each characteristic within a firm as a measure of the importance of each characteristic.[15]

Table 5 shows a negative and statistically significant correlation between the importance of

[14]We exclude from SAS workers in the public sector, self-employed workers and students for consistency with the sample of workers and firms on which we base the measure hours constraints.

[15]We replace the average with the median when the median is missing.

Table 5: Hours constraints and cooperation among coworkers

	Stand. dev. of hours across skill groups within firms			Obs.
	(1)	(2)	(3)	
TFP	-0.131***	-0.068***	-0.066***	16265
	(0.010)	(0.011)	(0.012)	
Time cooperating with coworkers	-0.123***	-0.038***	-0.034**	9998
	(0.012)	(0.014)	(0.016)	
Sharing work-related information	-0.127***	-0.049***	-0.047***	9998
	(0.012)	(0.014)	(0.014)	
Coordination	-0.162***	-0.082***	-0.085***	13475
	(0.011)	(0.013)	(0.014)	
Negotiation	-0.312***	-0.179***	-0.175***	13499
	(0.010)	(0.014)	(0.014)	
Persuasion	-0.316***	-0.183***	-0.182***	13499
	(0.011)	(0.014)	(0.015)	
Social perceptiveness	-0.293***	-0.139***	-0.142***	13499
	(0.011)	(0.014)	(0.015)	
Blue collar workers: 90th/10th wage ratio	0.117***	0.064***	0.069***	15798
	(0.014)	(0.013)	(0.013)	
Top managers: 90th/10th wage ratio	-0.079***	-0.039***	-0.035***	12611
	(0.009)	(0.009)	(0.008)	
2 digits Sector f.e.	NO	YES	NO	
3 digits Sector f.e.	NO	NO	YES	

Notes: The table shows the standardized coefficients from the regressions of the standard deviation of hours across skill groups within firms from Section 3 on firm characteristics and a constant. Each cell in the table corresponds to a different regression. In column 2, we add industry fixed effects to the baseline regressions using the Danish industry classification DB07. The regressions are based on the firm-year observations from the firms in our final sample (Table 1) over the years 2003–2011. Total factor productivity (TFP) is obtained following Ackerberg et al. (2015). The standard errors in parentheses are clustered at the firm level. * p<0.10, ** p<0.05, *** p<0.01.

these job characteristics and the standard deviation of hours across skill groups. That is, in firms in which hours constraints are weak, the importance of the interaction among coworkers is also low.[16]

Consistent with the fact that cooperation is important in high-constraint firms, Labanca and Pozzoli (2021) also document that firms with stricter hours constraints are less likely to employ part-time workers. One possible explanation that is consistent with the above evidence is that hiring part-timers may be viewed less favorably in high-constraint firms. Part-time workers, in fact, may not be available for as many hours as full-time coworkers would need in order to be most productive in highly cooperative workplaces.

[16] In Labanca and Pozzoli (2021) we obtain similar results when we use measures of team work, contact and communication from O*NET

Next, we analyze how hours constraints correlate with the importance of social skills in a firm. To the extent that hours constraints are stricter in firms in which the interaction among coworkers is stronger, we would expect social skills to be more intensively used in firms with stricter constraints. We perform this analysis using O*NET data. This is a survey that provides information on occupation-specific descriptors such as work style or work content. For each descriptor, O*NET provides a measure of its importance in each of the occupations surveyed. We match this information to Danish registers based on occupation. We select the 4 descriptors in O*NET that are used in the literature to measure social skill intensity (Deming, 2017). The descriptors are as follows: *Coordination*; *Negotiation*; *Persuasion*; and *Social perceptiveness*.[17] The measure capturing the importance of each descriptor in O*NET ranges between 1 and 100. We take the median score across coworkers in each year as a measure of the importance of each factor in a specific firm and year. Table 5 shows that in firms with strict constraints on hours, the importance of social skills is high.

If stricter constraints on hours worked improve the cooperation among coworkers, then these constraints can be thought of as decreasing the costs of communication in a firm. In hierarchical organizations such as those described in Garicano and Rossi-Hansberg (2006), this decrease in communication costs may lead to more problems being solved at the top of the firm hierarchy and, thus, to decreased wage inequality among blue collar workers and increased wage inequality among managers and between managers and blue-collar workers. Consistent with this hypothesis, we find that strict constraints in a firm are associated with a lower 90th–10th wage ratio among blue collar workers, a greater 90th–10th ratio among top managers, and a greater ratio of the average wage of managers to the average wage of blue collar workers.

Overall, these findings are consistent with the tenet that stricter hours constraints are associated with a greater degree of cooperation within a firm, providing one mechanism linking hours constraints and productivity gains. The discussion so far, however, leaves open the question as to what ultimately drives different degrees of cooperation and hours constraints across firms. In Labanca and Pozzoli (2021), we show evidence consistent with the fact that,

[17] O*NET gives the following definitions for these four descriptors. (i) Coordination: "adjusting actions in relation to others' actions"; (ii) negotiation: "bringing others together and trying to reconcile differences"; (iii) persuasion: "persuading others to change their minds or behavior"; (iv) social perceptiveness: "being aware of others' reactions and understanding why they react as they do."

at least in the short-run, hours constraints are driven by a firm's technology of production.

6 Conclusion

This paper analyzes the relationship among constraints on hours worked, firm wages and productivity. Our findings indicate that stricter constraints on hours worked in a firm are associated with higher wages. We also find that the degree of hours constraints explains a considerable share of the wage differentials across firms that are due to firm productivity and that are not explained by other factors commonly linked to firm-wage inequality. Future work might investigate the relationship between hours constraints and other dimensions of wage inequality that are often linked to employers, such as the gender wage gap.

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