Working time reductions and monopsony power

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Job market paper

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Abstract

I use newly digitized micro datasets to evaluate one of the first-ever labor regulations in Belgium: a maximum 9-hour workday in coal mines in 1910. On average, hourly wages and employment increased. However, these effects were size-dependent: hourly wages decreased in small firms, while all employment gains were concentrated in large firms. I argue that these results are inconsistent with three common assumptions: (i) workers choose hours, (ii) competitive wages, and (iii) a Cobb-Douglas technology in jobs and hours. I rationalize these results in a directed search model where firms with heterogeneous TFP post vacancies, hours, and wages while internalizing workers' leisure preferences. Monopsony power leads to long hours. When hours are capped, a firm either increases wages to substitute lost hours with new hires, or cuts wages to restore markdowns. Which mechanism dominates depends on firm size, even holding monopsony power constant. Welfare analysis with sufficient statistics suggests that the 1910 reform improved workers' welfare.

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1 Introduction

Today, some workers would like to work less at their current wage rate (Jarosch et al., 2025; Lachowska et al., 2023; Mas & Pallais, 2017). Historically, governments responded to such workers' requests by imposing caps on daily, weekly, and yearly working hours. To date, working time regulations are key determinants of hours worked within countries (Bick et al., 2022; Gethin & Saez, 2025). Moreover, these regulations are highly heterogeneous across countries: for example, France first mandated two weeks of paid vacation in 1936 and guarantees five weeks today, whereas the United States does not have any nationwide mandate on paid time off.[1]

Despite their prevalence, the empirical identification of the pure effects of working time reductions is challenging for at least two reasons. First, most reforms on hours are confounded by simultaneous tax and/or wage policies: the French 35-hour workweek in 2000 was voted along with compensatory payroll tax cuts (Chemin & Wasmer, 2009), while the 1930s US workweek restrictions were accompanied by wage floors (Fishback et al., 2024). Second, their aggregate scope makes it difficult to find micro-level evidence, and identification often relies on comparing macro groups like regions or industries (Gunnesmo & Hansen, 2025; Hunt, 1999).[2]

This paper develops an empirically informed framework to study how hours, wages, and employment are jointly determined and how they respond to government-mandated working time reductions. I evaluate the Belgian 1910 law that imposed a maximum 9-hour workday in the coal mine industry. This empirical context features two key advantages. First, because this policy was among the first labor regulations in the country, there is no confounding tax reform or wage regulation. Second, because the law only applied to underground coal workers but not aboveground coal workers, I leverage identifying variation both across firms and within firms across occupations.

I collected qualitative and quantitative evidence to assess the effects of this reform. On the quantitative side, I digitized and assembled novel administrative datasets from archival sources covering the near-universe of coal mines in the country from 1903 to 1913. These datasets contain detailed firm-level information on yearly production, employment, and the wage bill, as well as within-firm occupation-level information on hours worked and wages. Clearly, the reform had a sizable bite: the cap on daily hours was binding for 82% of underground workers who had to reduce their daily schedule

[1] Altonji and Oldham (2003) and Altonji and Usui (2007) provide descriptive facts on paid time off.

[2] Other papers where wage regulations also played an important role in working time reductions include Asai et al. (2024), Bengtsson and Molinder (2017), Costa (2000), Crépon and Kramarz (2002), and Goux et al. (2014). Other papers where identification relies on comparing macro-groups include Batut et al. (2023), Chemin and Wasmer (2009), and Fishback et al. (2024).

by 10% on average. On the qualitative side, a parliamentary commission interviewed hundreds of workers and dozens of business owners. These interviews reveal a clear labor conflict: all business owners opposed the reform while all workers supported it, with some workers even willing to accept pay cuts for shorter workdays.

At the firm-level, I use an event-study design and compare post-reform outcomes of firms with different scheduling practices before the reform. I show that treated firms substituted lost hours with additional workers: the reform increased their headcount employment by 45 workers (3.4%) on average relative to control firms. Importantly, all of these employment gains are found in (treated) underground occupations, with no spillover effect to (untreated) aboveground occupations. Moreover, all of these employment gains are driven by relatively large firms: small firms did not substitute lost hours with new hires. I do not find any statistically significant effects on firms' profits, investment, production, and prices.

Within firms, I leverage variation in the mandated daily hours reduction across occupations in an event-study design where aboveground workers serve as control. I find an elasticity of daily earnings to a mandated reduction of daily hours of -0.28, which implies that the reform reduced daily earnings by 2.8% on average. Because earnings decreased less than hours worked, hourly wages must have increased on average. However, I show that this average effect masks an important heterogeneity: hourly wages decreased in small firms but increased in large firms. The elasticity of hourly wages to a mandated reduction in daily hours is -1.1 for workers employed in firms in the bottom third of the firm size distribution, but $+0.65$ in the top two thirds of the firm size distribution. Overall, these reduced-form findings suggest that firm size matters: employment and hourly wages increased in large firms, but employment did not increase and hourly wages decreased in small firms.

The second part of the paper argues that these results are inconsistent with two standard assumptions of labor models: (i) workers choose hours worked, (ii) wages are set by perfect competition.

First, if workers choose hours worked (as in neoclassical labor supply theory), the marginal utility of reducing hours is nonpositive, which contradicts qualitative evidence highlighting workers' unanimous support for the reform. By contrast, I show that whenever firms set hours internalizing workers' utility (as in the hedonic labor supply theory), the marginal utility of reducing hours is positive in equilibrium, and workers would like to work less at the given wage rate. Intuitively, firms increase hours beyond the utility-maximizing schedule because it raises output without violating workers' participation constraint. Hence, profit-maximizing hours are longer than utility-maximizing hours.

Second, in a perfectly competitive labor market, hourly wages are equal to the per-worker marginal product of an hour and decreasing returns per hour imply that a working time reduction must increase equilibrium hourly wages. Because I find hourly wage cuts in some firms, perfect competition is unlikely, which is consistent with Delabastita and Rubens (2025) who documented extensive monopsony power in 1900s Belgian coal mines. I show that when firms have monopsony power, they react to the reform by cutting hourly wages. Hence, the wage effect of the same working time reduction has opposite signs depending on the competition structure of the labor market.

Based on these observations, the last part of the paper develops a directed search model[3] where firms (i) post hours and (ii) enjoy some monopsony power. Consistent with the empirical context of coal mines, I assume that all firms share the same technology but differ in TFP, which can reflect geological factors. Because firms need both jobs and hours to produce, heterogeneous TFP leads them to different hours and headcount employment (i.e. size) choices. Workers' leisure-consumption trade-off governs their participation and application behaviors which is internalized by firms when posting vacancies, hours worked, and hourly wages. As in Vergara (2025), because a wage increase attracts applicants but matching frictions may not convert them into employees, the labor supply curve observed by the firm is not infinitely elastic and this endogenizes some monopsony power in equilibrium. In turn, the model explains how hours, wages, and employment are determined depending on firms' technology, productivity, labor market power, and workers' preferences. I derive two central analytical results.

First, Proposition 1 characterizes the conditions under which contracts feature *long hours* in the eyes of workers. On the one hand, technology matters: workers would like to work less at the equilibrium wage rate as soon as technology is such that the marginal product of an hour dominates the marginal product of a job. This is likely to happen in empirical settings where workers' on-the-job experience matters: marginally increasing hours worked by existing, experienced workers increases output more than the marginal hire. On the other hand, monopsony power also leads to long hours contracts: a larger markdown on earnings is achieved by setting both longer hours and lower hourly wages.

Second, Proposition 2 pins down the determinants of the effects of a working time reduction on hourly wages and employment. When jobs and hours are substitutable in the production function, hiring workers compensates for the lost hours, which pushes

[3] Key references for directed search models include Acemoglu and Shimer (1999), Eeckhout and Kircher (2010a, 2018), Guerrieri et al. (2010), Kircher (2009), Moen (1997), and Wright et al. (2021). While matching frictions were added to hedonic wages by Hwang et al. (1998) and Lang and Majumdar (2004), they assumed random search rather than directed search. Eeckhout et al. (2024) studied the importance of firm size in shaping sorting between firms and workers and wage inequality within- and across-firms.

hourly wages up- a *substitutability* effect. However, when the production function is concave, reducing employment through lower hourly wages increases the marginal product of a job - a *concavity* effect. Interestingly, even if firms offer the same contract, enjoy the same monopsony power, and have the same technology, wage effects may differ by firm size because the strength of the substitutability and concavity effects depends on pre-reform headcount employment.

In particular, I argue analytically and numerically that a Cobb-Douglas technology over jobs and hours is unable to rationalize size-dependent wage responses to a working time reduction because that reform changes the marginal product of a job in a way that is constant across firm sizes. By contrast, a CES production function with an elasticity of substitution between jobs and hours above 1 can rationalize the reduced-form empirical findings.[4] In that case, large firms need many hires to compensate for the lost hours, while small firms prefer to cut hourly wages to restore their markdown.

Finally, the directed search model is useful in assessing the net welfare effects of the reform. Given the adverse effects on earnings but positive effects on leisure and employment, the effect on aggregate welfare is ambiguous *a priori*. I derive sufficient statistics to assess utilitarian welfare[5] and show that any utility function concave in consumption leads to the conclusion that workers' welfare improved. This is less likely to happen in settings where workers choose hours or where jobs and hours are more complementary in production.

These findings in historical context are also helpful to inform policy-making today. First, working time reductions are likely to have heterogeneous effects in labor markets: firm size matters even when controlling for technology, monopsony power, and contract terms. Second, although monopsony power leads to long hours, working time reductions may be a blunt tool to fight monopsony power, as some wages may fall. Third, occupations where jobs and hours are complements in the production function are unlikely to benefit from these policies. For example, this is the case when a new colleague increases the workload of other colleagues, like in models of strategic complementarity (Milgrom & Roberts, 1990) or firms as communication networks (Bolton & Dewatripont, 1994; Garicano, 2000).

[4]This mirrors Carry (2024) who studies a *minimum* workweek policy in modern-day France and also documents an imperfect substitutability between jobs and hours.

[5]Interestingly, welfare may be assessed without assumptions on production or on the degree of monopsony power in labor markets, which is known to vary significantly across contexts and industries (Azar et al., 2022; Card, 2022).

Contributions to the literature

By building an empirically-informed model of the codetermination of wages, employment and hours worked in imperfectly competitive settings, the paper contributes to three strands of literature.

Policy evaluation of working time regulations Whether working time reductions create any jobs has been a long-standing debate in the literature[6]: some papers documented positive employment effects (Fishback et al., 2024; Gunnesmo & Hansen, 2025) while others found negative or zero effects (Asai et al., 2024; Chemin & Wasmer, 2009; Crépon & Kramarz, 2002; Hunt, 1999). As discussed above, the empirical setup of the present paper features a double advantage compared to these papers: I leverage identifying variation at a micro level, and wages are neither regulated nor nominally rigid. On the theory side, Marimon and Zilibotti (2000) and Rocheteau (2002)[7] model wage-hour determination as the outcome of bargaining while the present model has contract posting which has been found more relevant than bargaining empirically for low-wage jobs (Caldwell & Harmon, 2019; Hall & Krueger, 2012; Lachowska et al., 2022). The present paper contributes to this literature by being the first to demonstrate empirically and theoretically that the key parameters governing the employment and wage effects of working hours regulations are (i) firms' labor market power, (ii) firms' size, and (iii) the substitutability of jobs and hours. Incidentally, these results may be used to evaluate other labor policies.[8]

Determinants of long hours There is evidence that some workers would like to work less at their wage rates (Jarosch et al., 2025; Labanca & Pozzoli, 2022, 2023; Lachowska et al., 2023). The model of Rosen (1974, 1986) rationalizes this fact and the present paper generalizes this model to the case where hours, wages, and employment are simultaneously co-determined, potentially in imperfect competition. Chetty et al. (2011) endogenizes a distribution of hours when workers have heterogeneous preferences but assumes perfectly elastic labor demand. Carry (2024) and Fishback et al. (2024) endogenizes a distribution of hours with structural assumptions on technology and utility. By contrast, the present paper pins down when long hours contracts arise for general preferences and technology, as well as how monopsony power influences the determination of hours.

[6] See Calmfors (1985) and Drèze (1986) for early discussions.

[7] Other related papers include Cahuc and Granier (1997), Fagnart et al. (2023), Lang and Majumdar (2004), Osuna and Rıos-Rull (2003), and Willington and Navarro (2015).

[8] Di Nola et al. (2023), Gandhi and Ruffini (2022), Jardim et al. (2022), and Kim et al. (2023) documented that minimum wage hikes lead to longer hours, which can be explained by monopsony power. By contrast, Gravoueille (2023) showed that an increase in low-earners wage subsidies led to an increase in hours worked but a decrease in wage rates and this negative wage-hour covariance is consistent with competitive hourly wages. Overtime policies studied by Quach (2022, 2025) are a combination of wage and hours regulations.

Amenities The literature has focused on positive questions[9] such as the relationship of amenities with earnings and productivity (Mas & Pallais, 2017, 2020; Ouimet & Tate, 2023; Sockin, 2022; Sorkin, 2018), monopsony power (Lamadon et al., 2022), workers' preferences (Maestas et al., 2023; Wiswall & Zafar, 2018) [10], job search (Hall & Mueller, 2018), and minimum wages (Clemens, 2021; Clemens et al., 2018; Dube et al., 2022). However, the normative aspects of regulating amenities have not been addressed, except by Nekoei (2023) who suggests that mandating amenities can improve efficiency if there is adverse selection à la Akerlof. My paper contributes to this literature by deriving sufficient statistics for welfare evaluation of any policy affecting wages, hours or amenities, and employment in a general equilibrium environment with heterogeneity, matching frictions, and monopsony power.

Section 2 presents a reduced-form empirical evaluation of the Belgian coal mines maximum workday introduced in 1910. Section 3 discusses claims (i), (ii) and (iii) through toy models that contrast the effects of working time reductions depending on who sets hours and wages as well as the elasticity of substitution between jobs and hours. Section 4 introduces the directed search model, describes analytically the determinants of long hours and of the wage effects of hours regulation, and quantifies welfare effects. Section 5 concludes.

2 Reduced-form policy evaluation

2.1 Institutional context

At the time of the reform, Belgium's coal industry was mature and the coal-producing provinces were among the highest GDP per capita regions in Europe (Rosés & Wolf, 2021). As the first country to industrialize on the European continent, Belgium relied heavily on coal extraction to provide manufacturing industries with cheap energy (Mokyr, 1976; Philips & Buyst, 2020).

The policy under study is the first major piece of labor regulation affecting prime-age males in the country.[11] Meanwhile, neighboring countries already had some form of working time regulations in the mining industry: for example, France had a maximum

[9] See Lavetti (2023) for a recent review.

[10] Volpe (2024) quantifies sorting and monopsony power in an empirical framework that allows for heterogeneity in workers' preferences, skills, and firms' technology.

[11] Earlier regulations were only targeted to female and child labor. In the mining industry, underground labor was prohibited for women younger than 21 and male children below 12 from 1892 onward (Annales des Mines, 1907). The 1910 reform was among the first policies to break the *Laissez-faire* tradition on which Belgium was built, which consisted in low tariffs and few regulations (Abbeloos, 2008).

workday of 10 hours in 1900 and 8 hours in 1905.[12] Compared to their foreign competitors, Belgian coal mines were relying more on manual labor and less on mechanized extraction while wages were lower (Denoël, 1909). They also exhibited a smaller mortality risk (Leboutte, 1991) despite longer workdays (Cousot, 1908).

The policy was signed into law by the King on December 31, 1909 and imposed that a workday for underground workers could not exceed 9 hours and 30 minutes from January 1, 1911 and 9 hours from January 1, 1912.[13] Importantly, the law did not regulate the schedules of aboveground workers.[14] Before this, there were no regulations on daily schedules.

Two institutional features are worth pointing out. First, there is no confounding policy at the same time: there was no labor income taxation and barely any other labor regulations. This contrasts with modern-day reforms on working time where these policies are typically coupled with support measures such as payroll tax reductions, rendering identification of the pure impact of working time reductions tedious. Second, there was no downward wage rigidity at the time. Figure 1 shows that wages display a striking cyclicality both in nominal and real terms for the average firm.[15]

2.2 Data

I use administrative data retrieved from archival sources. The coal mining industry was closely scrutinized by the government for several reasons. First, coal mines were subject to a corporate tax (composed of a fixed fee and a linear rate), although it only raised a modest amount: 1.5 million BEF in 1903 i.e. 0.3% of the state's revenue (Chamber of Representatives of Belgium, 1903). Second, coal mines were important to the state for industrial, political, social, and economic factors. More than 120,000 workers[16] were directly employed in coal mining while 37% of GDP was produced by the manufacturing sector (Buyst et al., 1995). Third, as all mineral resources belonged to the state but were

[12] In the Netherlands, the maximum workday was 8.5 hours in 1908. In Prussia, the maximum workday was 8 hours in 1905 and even limited to 6 hours in mines where temperature exceeds 28 degrees Celsius (Cousot, 1908).

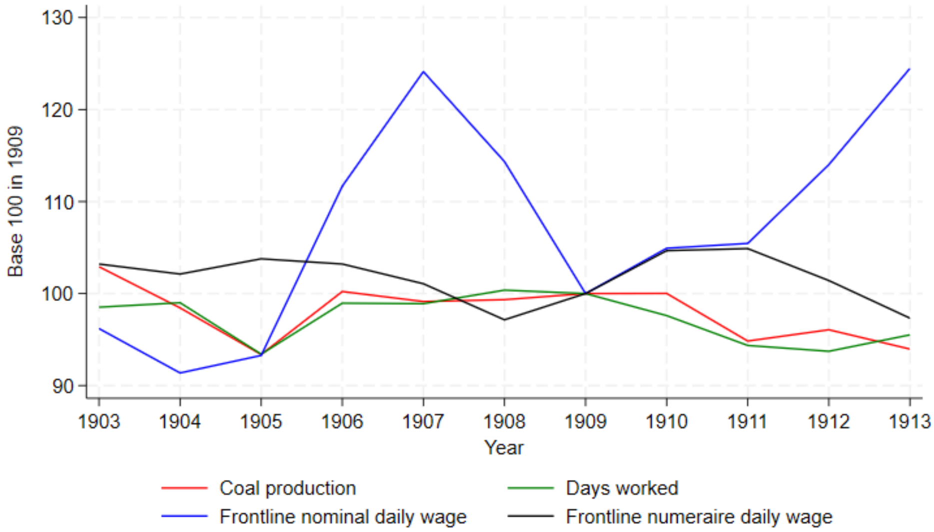
[13] Working time must be understood as *from bank to bank*, i.e. the time from the surface at the beginning of the working day to the time at the surface at the end of the working day. Hence, it includes the time in the lift as well as time needed to walk from the lift to the work station.

[14] In 1909, the cross-sectional average share of workers underground was 73.1%. Exceptions to the 9-hour limit were granted for some specific underground occupations (e.g. horseman or cagers) but these exceptions may not exceed one hour per day. Violations were subject to civil fines or criminal charges.

[15] Appendix Figure A.2 shows that this also holds for the aggregate variables. In the sample, all occupations suffer at least once a nominal wage cut over the sample period, while the unconditional probability of wage cut over the sample period is 40%.

[16] This corresponds to 11% of the industrial labor force of the country.

Figure 1: Descriptive statistics of Belgian coal mines over the business cycle, 1903-1913.



Notes: this figure plots the firms' cross-sectional average for selected outcomes for each year. It covers the universe of mines. The base year is set to 100 in 1909. Coal production is measured in tons of coal. Days worked is a variable summing all days worked in the firm in a given year. The blue line is the average daily wage for a frontline worker, expressed in nominal currency. The black line is the same variable divided by the price of output, i.e. expressed in units of numéraire.

leased for private exploitation[17], the government was keen on monitoring production.

As a result, the Mining Administration kept a consistent record of data of remarkable quality for the time. Each year, state officials[18] were sent to each mine to collect statistics on production, prices, employment, and wages. These reports were then collected by the administration to establish a firm-level panel dataset. In Appendix Figure A.1, I provide examples of a report in (a) and of the panel dataset in (b).

I digitized the panel dataset for the province of Hainaut while Delabastita and Rubens (2025) digitized the provinces of Liège and Namur. In 1910, the province of Hainaut accounted for 71% of national coal production and 67% of labor expenditures in the industry. The combination of these efforts yields a dataset covering the universe of mines in the country from 1903 to 1913.

This dataset contains firm-level information on annual coal production[19], output

[17]This tradition was inherited from the French domination of Belgium rather than the Dutch domination. The Imperial Law of April 21, 1810 promulgated by Napoleon set the basis for such leasing on minerals and served as backbone of Belgian legislation on mining. By contrast, in 1900 the Dutch government still had a monopoly on two thirds of national production.

[18]These officials were public servants with a high level of education such as mine engineers. Besides collecting statistics, these officials also had a role of policing, advising and studying the mines.

[19]Production data is detailed for various output types such as high-quality coal and low-quality coal. As documented by Delabastita and Rubens (2025), the production process is relatively homogeneous whatever the type of coal produced as well as within a geological region.

prices, input costs, headcount employment, total days worked, and the wage bill. Moreover, it also contains occupation-level information on yearly employment and daily wages both for underground workers (affected by the reform) as well as aboveground workers (not affected by the reform). However, the panel dataset does not contain information on daily working time.

I retrieved cross-sectional information on working time from parliamentary proceedings. Indeed, as one of the first pieces of labor legislation, this reform was highly controversial in Parliament[20] which initiated a parliamentary commission. From the 3000 pages of documents, I digitized a cross-sectional dataset of hours worked at the occupation level. The dataset was collected by the Mining Administration in August 1900 and published in 1907 while noting that "*the situation has barely changed since then*" (Annales des Mines, 1907, p.556).

This cross-sectional dataset covers hours worked for 9 occupations working underground, while the panel dataset only contains two types of underground occupations (frontline and non-frontline underground workers). I match the two datasets such that the resulting aggregate distribution of hours in the matched dataset resembles an aggregate distribution collected by the Mining Administration on November 29, 1907. I describe the matching procedure in Appendix A.2.1. In Figure 2, I report the distribution of hours worked in the matched dataset in green, together with the (exact) distribution of the Mining Administration in blue (Parliamentary Commission, 1908).

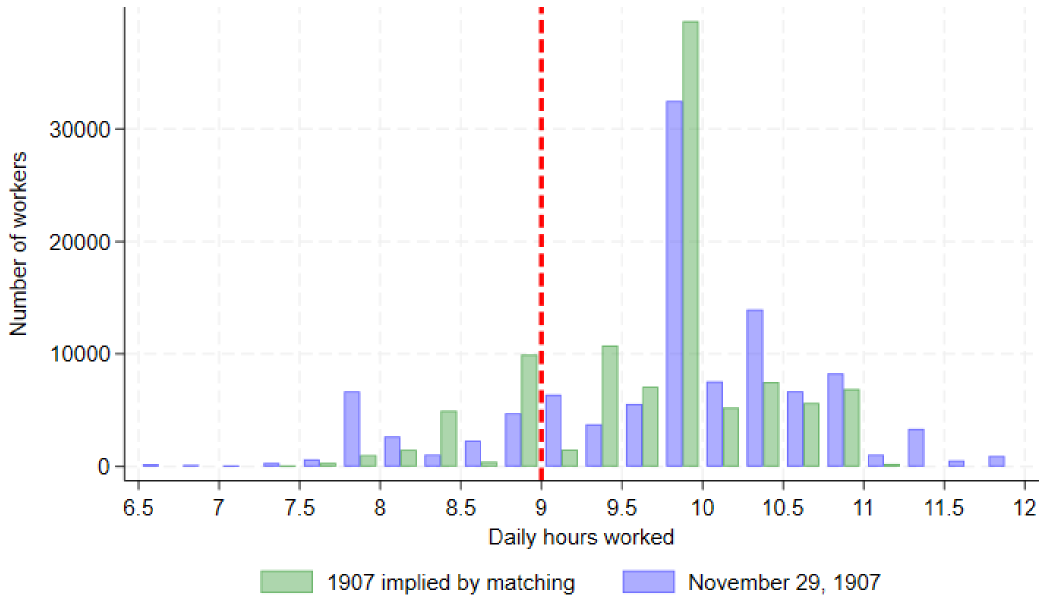
Importantly, the fraction of workers working more than 9 hours is identical in both distributions: 82% of underground workers.[21] The average working day lasts 9h46 in the green distribution and 9h49 in the blue distribution. Although the green distribution is less dispersed than the blue, the former represents an annual average.

The rest of the paper uses a balanced matched dataset, i.e. firms belong to the dataset if (i) I have information on their daily hours worked and (ii) they did not exit, did not participate in mergers, and were not acquired during the sample period. Appendix Table A.2 shows that requirement (i) is met by firms covering 96% of national production while Appendix Table A.3 shows that the balanced panel satisfying both (i) and (ii) cov-

[20]The bill was introduced by socialist M.P. Destrée in 1903. From 1884 and until World War I and despite electoral reforms toward universal suffrage, the Catholic party had an absolute majority and initially opposed the maximum workday in the coal mines, as did King Leopold II. In 1907, some Catholic MP flipped their vote and created a political crisis which culminated in the resignation of the prime minister and mine owner Count de Smet de Nayer (Neuville, 1981). The new government initiated a Parliamentary Commission. Documents contain interviews of workers and mines owners but also technical reports from academics in economics and engineering.

[21]While geology seems to play a role as workdays are longer in Mons than in Liège geological regions (Vandervelde, 1911), there also exists within-region variation.

Figure 2: Aggregate distribution of hours worked underground in the dataset (green) versus on November 29, 1907 (blue).



Notes. In green: implied distribution of hours worked by underground workers in 1907 by my dataset matching. In blue: (exact) distribution of hours worked by underground workers on November 29, 1907 (Parliamentary Commission, 1908).

ers around 86% of the industry's production and employment and contains 99 firms. In Appendix Table A.4, I show that the occurrence of mergers, acquisitions, or firm exits are relatively balanced between treated and control groups both before and after the reform.

Finally, the reform allowed for deviations to the 9-hour rule for exceptional circumstances (such as urgent safety work) provided that the deviations were recorded and reported to the Mining Administration, thereby providing information on enforcement of the reform. Aggregate statistics reveal that the volume of overtime hours amounted to 143,868 hours and 157,274 hours in 1912 and 1913 respectively, which represents 0.058% and 0.064% respectively of the aggregate volume of hours of 1909. This corresponds to 1h45 and 1h53 per underground worker per year, i.e. 21 and 23 seconds per day, respectively. Moreover, the number of complaints filed by workers for employers' non-compliance is positive but negligible.[22] In the remainder of the paper, I assume perfect compliance with the legal thresholds for post-reform hours worked.

Besides datasets, these archival sources also provide qualitative information on the context of the reform. From firm owners' interviews, we learn that (i) all of them op-

[22]For the provinces of Liège and Namur, there were 15 complaints over 1912-1914 for non-compliance filed to the Administration, out of which 14 have been deemed inadmissible. Most complaints were filed by "*persons outside the mines*".

posed the reform and (ii) hours worked per occupation were stable over time, set by the managers[23], displayed publicly at the mine's entrance, and determined by firms' geological conditions and customs. From workers' interviews, we see that all of them were in favor of the reform holding wages constant, and some even if wages were cut while others opposed wage cuts (Parliamentary Commission, 1909).

2.3 Reduced-form estimates

2.3.1 Firm level

The first empirical strategy leverages variation in pre-reform scheduling practices across firms. The regressor of interest will be the share of a firm's underground daily hours volume in 1909 that it needs to cut to comply with the 9-hour daily cap. More formally, I define vol_reduction_j as

$$\text{vol\_reduction}_j = \frac{\sum_{o \in \text{underground}} \max\{h_{o,j,1909} - 9, 0\} \times N_{o,j,1909}}{\sum_{o \in \text{underground}} h_{o,j,1909} \times N_{o,j,1909}} \times 100$$

where $h_{o,j,1909}$ and $N_{o,j,t}$ are the daily hours worked and headcount employment of occupation o in firm j in 1909. If no underground occupation works more than 9 hours per day, a firm's vol_reduction_j is equal to 0 and it will be part of the control group, while all firms with positive values belong to the treated group. The average vol_reduction_j among treated firms is 9.06 with a standard deviation of 3.4. In Table 1, I report summary statistics for pre-treatment values of treated and control firms.

Unsurprisingly, treated firms produce differently than control firms: the former are on average twice bigger than the latter in terms of headcount employment and rely relatively more on non-frontline underground employment. However, per-worker variables are remarkably similar in both groups. Moreover, profits and wages display a similar mean and dispersion in both treated and control groups.

The main firm-level outcome of interest is employment. Our main specification is a standard event-study design where we regress an outcome $y_{j,t}$ in levels on firm fixed effects μ_j and time fixed effects as well as year dummies interacted with vol_reduction_j.

$$y_{j,t} = \beta_0 + \sum_{k \neq 1909} \beta_k \times \text{vol\_reduction}_j \times \mathbf{1}_{t=k} + \mu_j + \text{TimeFE} + \epsilon_{j,t} \tag{1}$$

where $\epsilon_{j,t}$ is the error term. Standard errors for estimated coefficients will be clustered at the firm level. The omitted year is set to 1909 which is the last full year before the

[23] In particular, all underground workers had to take a lift to go in and out of the mine. This was the same lift as the one used to extract coal output, which creates a bottleneck in the production chain that is resolved by managers' scheduling.

Table 1: Summary statistics for control and treated firms, averages over 1903-1909.

	Control firms	**Treated firms**
Profits, units of numéraire	9,813.91	9,024.95
	(21,312.46)	(25,661.59)
TFP	1.129	1.092
	(0.303)	(0.129)
Labor share	0.558	0.521
	(0.124)	(0.064)
Total days worked	**198,967**	**391,174**
	(342,923)	**(276,198)**
Headcount employment	**660**	**1,309**
	(1,143)	**(921)**
Share underground employment	**0.780**	**0.733**
	(0.063)	**(0.056)**
Share frontline among underground	**0.334**	**0.244**
	(0.158)	**(0.047)**
Share of self-consumed production	**0.043**	**0.098**
	(0.039)	**(0.046)**
Yearly days worked per worker	294.51	298.75
	(15.16)	(7.09)
Daily product per worker, tons	0.589	0.583
	(0.227)	(0.108)
Output, tons per m^2	0.851	0.901
	(0.214)	(0.176)
Average power of coal veins, meter	0.628	0.680
	(0.151)	(0.136)
Yearly product per frontline miner, tons	809.83	1,027.96
	(418.40)	(310.28)
Average wage per worker, units of numéraire	0.303	0.299
	(0.055)	(0.041)
Output price, current BEF	**13.56**	**14.97**
	(2.18)	(1.59)
Investment-to-sales ratio	0.092	0.109
	(0.047)	(0.052)
vol_reduction_j	0.00	9.06
	(0.00)	(3.44)
Observations	13	86

Notes: This table reports treated and control group average for selected variables with standard deviations in parentheses. A row x is in bold if the p-value of the t-test $H_0 : x_{\text{treated}} = x_{\text{control}}$ is smaller than 5%.

law was passed. All the results are presented for two sets of time fixed effects: year fixed effects control for industry-wide shocks in a given year, while province-by-year fixed effects control for region-specific shocks in a given year. The coefficients β_k are the objects of interest. Because of the definition of vol_reduction_j, β_k can conveniently be interpreted as the average effect in year k across treated firms of a 1% mandated reduction in the volume of hours. The average treatment effect on the treated (ATT) can be obtained by a simple average of the estimated coefficients $\hat{\beta}_k$ for $k > 1909$ multiplied by 9.06, i.e. the average vol_reduction_j.

This strategy is standard in the policy evaluation literature (Carry, 2024; Dube & Lindner, 2024; Harasztosi & Lindner, 2019; Saez et al., 2019). The identifying assumption is that firms with different scheduling practices before the reform would have had parallel evolution in their outcomes if the reform had not happened. This assumption could be rejected if β_k significantly differs from 0 in the years prior to the reform. All results presented below are accompanied by a statistical test that shows that one cannot reject the null hypothesis that β_k are jointly 0 before 1909.

Employment Results for regression 1 are reported in Figure 3. In panel (a), we see that a 1% mandated reduction in firms' hours volume increases employment by 5 jobs in 1911-1913. Panel (b) shows that all of these 5 jobs were underground jobs. The corresponding estimated ATT using 1909 as baseline level are $\frac{5\times 9.06}{1309} = 3.45\%$ for overall employment and $\frac{5\times 9.06}{954} = 4.75\%$ for underground employment. This suggests that firms hired treated underground workers to replace lost hours, yet there were no employment spillovers to untreated aboveground occupations.[24] In Appendix Table A.6, I obtain similar estimates in magnitude when running standard difference-in-differences regressions, yet without gains in precision.

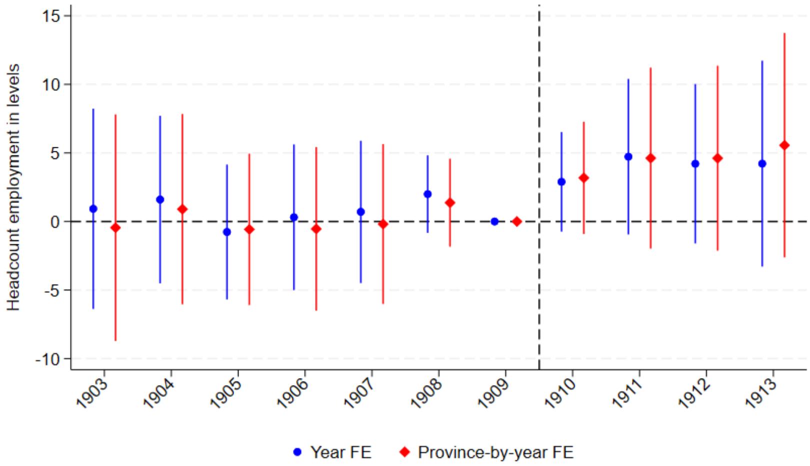
Other outcomes Although the dataset contains other outcomes, we are not able to detect any statistically significant effects on profits, output prices, output quantity, nor digging investment. I report these results in Appendix Figures A.4, A.5, A.6, A.7, respectively.

2.3.2 Occupation-level analysis

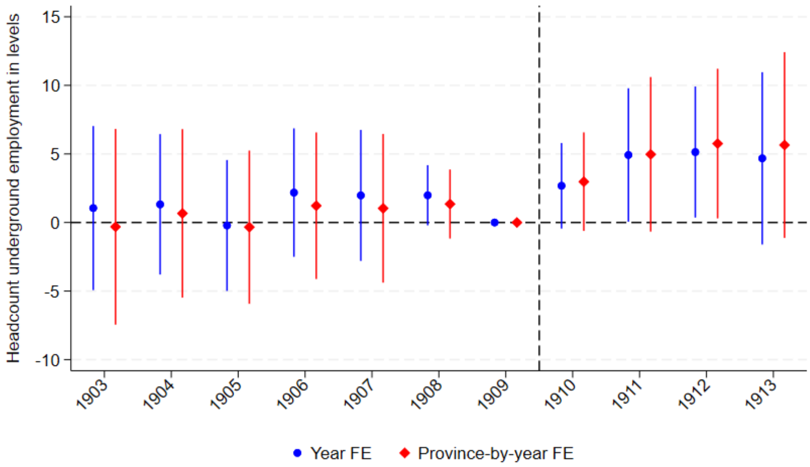
I now leverage the variation in hours worked within firm across occupations in addition to variation across firms. Again, I exploit the continuous nature of the treatment and define the regressor of interest as the fraction of daily hours that occupation o in firm j works in excess of 9 hours. Importantly, recall that aboveground workers were not

[24]By law, females under 21 years old were banned from underground occupations, which limits spillovers. Yet, they only account for 17.4% of aboveground employment in 1909 while the rest was filled by boys aged 12 to 16 (8.3 %), women older than 21 (4.7%) and males older than 16 (69.7%).

Figure 3: Event-study results for firm-level employment variables.



(a) Headcount total employment. P-values for $H_0 : \beta_k = 0 \; \forall k < 1909$ are 0.51 (blue) and 0.82 (red) while within R-squared are 0.005 and 0.008 respectively.



(b) Headcount underground employment. The p-value for testing $H_0 : \beta_k = 0 \; \forall k < 1909$ are 0.42 (blue) and 0.83 (red), respectively. The within R-squared are 0.008 and 0.012 respectively.

Notes: this figure reports β_k in regression 1 of two employment measures along with standard errors reported at the 95% confidence level. Panel (a) shows the headcount total employment, which includes underground and aboveground workers while panel (b) shows headcount underground employment. I report the p-value for testing $H_0 : \beta_k = 0 \; \forall k < 1909$ as well as the within R-squared.

affected by the workday restriction. More formally, I define $\text{h\_reduction}_{o,j}$ as

$$\text{h\_reduction}_{o,j} = \begin{cases} \frac{\max\{h_{o,j}-9,0\}}{h_{o,j}} \times 100 & \text{if } o \in \text{underground} \\ 0 & \text{if } o \notin \text{underground} \end{cases}$$

An underground occupation o in firm j is treated whenever it was working more than 9 hours before the reform, or equivalently when $\text{h\_reduction}_{o,j}$ is positive. The average $\text{h\_reduction}_{o,j}$ among treated units is 10 with a standard deviation of 3.87. Moreover, the distribution of treated and control units across firms is reported in Table 2.

Table 2: Distribution of Treated (T) and Control (C) units across occupation category and firms

o	Firm type				# treated o
Frontline underground	T	T	C	C	70
Non-frontline underground	T	C	T	C	79
Aboveground	C	C	C	C	0
# firms	63	7	16	13	99 $j \times 3$ o

Notes: the last row counts the number of firms for each possible treatment-control composition of their occupations. The last column counts the number of treated units across firms for each occupation.

Out of the 86 treated firms in the previous section, we see that 63 of them had schedules beyond the 9-hours threshold for all their underground occupations. However, 7 firms (resp. 16) had only frontline (resp. non-frontline) workers with schedules above the threshold. Each firm has 3 occupations for a total of 297 units, of which 149 units (70 frontline and 79 non-frontline) will be treated. In Table 3, we show that treated units are larger in terms of employment size and receive larger wage.[25]

The identification strategy and specification follow the same line as above *mutatis mutandis* and I regress the outcome of occupation o at firm j in year t on year dummies interacted with the exposure variable $\text{h\_reduction}_{o,j}$:

$$y_{o,j,t} = \beta_0 + \sum_{k \neq 1909} \beta_k * \text{h\_reduction}_{o,j} * \mathbf{1}_{k=t} + \mu_{o,j} + \nu_{o,t} + \epsilon_{j,t} \quad (2)$$

where fixed effects $\mu_{o,j}$ control for time-invariant unit-specific characteristics, $\nu_{o,t}$ control for occupation-specific aggregate shocks (such as weather affecting aboveground but not underground workers)[26] and $\epsilon_{j,t}$ are standard errors clustered at the firm level.

[25]I report the firm-level statistics analog to Table 1 for this new treated and control (o, j) units in Appendix Table A.5.

[26]In the remainder, I assume that hours worked l for (untreated) aboveground workers are unaffected by the reform, which is supported qualitatively by managers' interviews.

Table 3: Summary statistics for control and treated units (o, j), averaged over 1903-1909.

	Control units	**Treated units**
Earnings$_{o,j}$, units of numéraire	**0.258**	**0.345**
	(0.076)	**(0.054)**
Earnings$_{o,j}$, efficiency units	**0.133**	**0.217**
	(0.083)	**(0.102)**
Headcount employment$_{o,j}$	**324**	**491**
	(363)	**(445)**
h_reduction$_{o,j}$	**0.00**	**9.999**
	(0.00)	**(3.874)**
Observations	148	149

Notes: This table reports treated and control group average for selected variables with standard deviations in parentheses. A row x is in bold if the p-value of the t-test $H_0 : x_{\text{treated}} = x_{\text{control}}$ is smaller than 5%.

One object of interest is the effect of the reform on hourly wages, denoted by w. In the data, we observe net earnings $(1 - \tau)wl$, the firm-specific withholding rate τ[27], as well as hours worked l given perfect compliance. Hence, I will present logarithms of outcomes to capitalize on the useful identity that decomposes ATT:

$$\ln w = \ln(1 - \tau)wl - \ln l - \ln(1 - \tau) \tag{3}$$

In Figure 4, I report the results of regression 2 for the three variables on the right-hand side of equation 3.[28]

Panel (a) shows the results for the full sample. One finds a negative effect on earnings: the average treatment effect on the treated is -2.8% and the associated elasticity of daily earnings to a 1% mandated reduction in daily hours amounts to -0.28. Because this elasticity is larger than -1 and $(1 - \tau)$ is unaffected by the reform, by equation 3, this implies that the average treatment effect on hourly wage is positive.

However, panels (b) and (c) show that the effect is completely different depending on the size of firms. In panel (b), we see that a 1% mandated reduction of hours worked reduces earnings by 2.1% for treated workers in small firms. Given that the net-of-tax rate is stable, this implies that the elasticity of hourly wages to a mandated reduction of daily hours is -1.1. By contrast, the ATT for daily earnings in big firms is estimated to be -0.05% which implies that the elasticity of hourly wages to a mandated reduction of

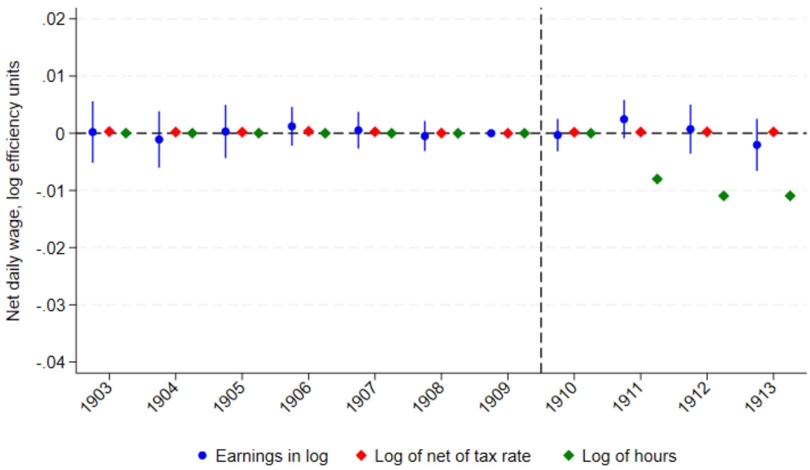
[27]Although there were no payroll taxes, some employers organized firm-specific withholding policies which had two purposes: fines for workers' misconduct or employer-provided life (or sometimes old-age) insurance. The majority of firms have a 0 withholding rate, and it never exceeds 3% in the sample.

[28]In Appendix Figure A.8, I show the results for $\ln w$ and $\ln(1 - \tau)wl$ for completeness. In Appendix Table A.7, I show that the results are consistent with difference-in-differences estimates.

Figure 4: Event-study results for components of net daily wage in efficiency units.

(a) Full sample. P-value for $H_0 : \beta_k = 0 \ \forall k < 1909$: 0.39. Within R-squared: 0.007.

(b) Subsample of units in small firms (bottom third of the size distribution). P-value for $H_0 : \beta_k = 0 \ \forall k < 1909$: 0.15. Within R-squared: 0.054.



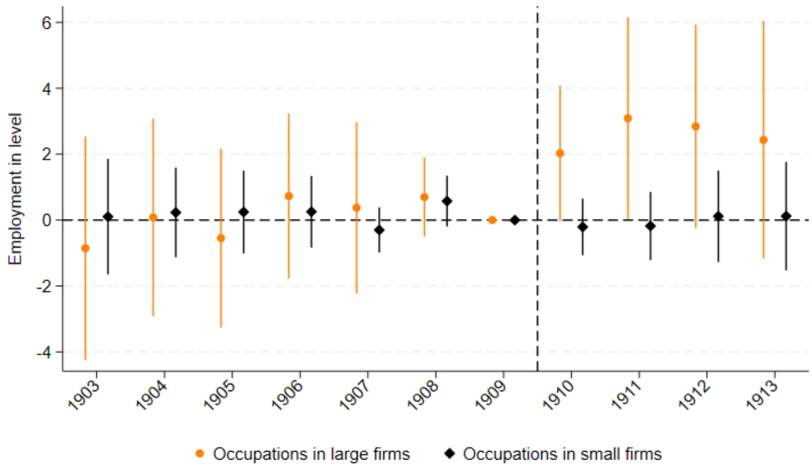
(c) Subsample of units in big firms (top 66% of the size distribution). P-value for $H_0 : \beta_k = 0 \ \forall k < 1909$: 0.76. Within R-squared: 0.002.

Notes: this figure reports β_k in regression 2 for the right-hand side variables of equation 3 along with standard errors at the 95% confidence level. I report the p-value for testing $H_0 : \beta_k = 0 \ \forall k < 1909$ as well as the within R-squared for the blue regression only.

daily hours is +0.65.[29] Hence, hourly wages increased in large firms but decreased in small firms.

With respect to employment outcomes, the occupation-level analysis confirms the positive average effect documented in the firm-level analysis in Figure 3. Moreover, there is also an interesting heterogeneous response by firm size in this case. In Figure 5, I report the results of running equation 2 when the dependent variable is the level (not the log) of employment in occupation o in firm j for small and large firms.

Figure 5: Event-study results for (o, j)-level employment for two subsamples defined by firm size.



Notes: this figure reports β_k in regression 2 of employment (in levels) along with standard errors are reported at the 95% confidence level. Results are reported for two subsamples: (o, j) in small firms (i.e. the bottom third of the firm size distribution whose associated cutoff is 550 workers) and (o, j) in big firms (its complementary set). The p-value for testing $H_0 : \beta_k = 0 \; \forall k < 1909$ is 7.53% in the orange regression and 61.43% in the black regression, while the within R-squared are 0.0053 and 0.009, respectively.

Interestingly, all the positive employment effects for underground workers come from large firms: a mandated reduction of daily hours by 1% increases employment by 2.60 units which implies an average treatment effect of $\frac{2.6\times 10}{539.1} = 4.8\%$ in large firms. By contrast, there is no differential evolution of occupation-level employment between treated and control groups in small firms.

Overall, these results are consistent with a story where the reform increased employment and wages in large firms, but decreased wages and kept employment stable in small firms. Qualitative evidence suggested that all workers were willing to work less before the reform. The remainder of the paper uses these insights to derive consequences for models of the labor market and welfare analysis. In particular, I will argue that the

[29]The fact that the implied hours elasticity to the reform differs from -1 comes from the fact that hours are not reduced in 1910.

empirical evidence is inconsistent with (i) workers choosing hours worked, (ii) perfect competition in the labor market, and (iii) jobs and hours entering multiplicatively in production.

3 Toy models: who chooses what?

In this section, I build toy models in general equilibrium of the codetermination of wages and hours to support claims (i) and (ii), setting aside the determination of employment for now. We are interested in understanding the effects of working time reductions depending on *who chooses what*, i.e. who sets hours worked (firms or workers) and who sets hourly wages (perfect competition or monopsonistic firms).

A firm produces using only hours, denoted by l, through a production function $F(l)$ which is assumed to be increasing and concave. Hours are bounded above by a natural constraint normalized to 1, such that the government must choose a legal maximum $\bar{l}$ in the interval $[0, 1]$. The labor contract specifies a quantity of hours worked l at a unit price w and the firm's profits $F(l) - wl$ must be nonnegative for it to participate.

Workers have a utility function $u(c, l)$ that is increasing in consumption c and decreasing in hours worked $l \in [0, 1]$. They have an outside option to the labor contract that gives a reservation utility u_r. When working, their consumption is equal to their earnings $c = wl$. Interestingly, the marginal utility of an extra hour $\frac{du(\cdot)}{dl} = wu'_c + u'_l$ has an ambiguous sign: at low hours, workers would like to work more at the wage rate w because the positive consumption effect dominates the negative leisure effect, while this is reversed for long hours. For regularity, I assume that the workers' preferred schedule is neither 0 nor 1[30].

I have two main objects of interest. First, I will sign the marginal utility of an extra hour $\frac{\partial u(\cdot)}{\partial l}$ before the introduction of the policy $\bar{l}$. When it is negative, workers would like to work less at the given wage rate such that they would welcome a working time reduction with rigid wages. Second, I study how the introduction of a small binding working time reduction $\bar{l} < l$ affects equilibrium wage rates.

The theoretical predictions depend on the definition of strategy sets: who chooses hours and who chooses wages? I will consider four different models. In model 1, workers choose hours to maximize utility and wage rates are competitive. In model 2, workers choose hours but the firm sets wage rates. In model 3, the firm sets hours to maximize profits but wage rates are competitive. In model 4, the firm sets both hours and wage rates. Models 1 and 2 use the neoclassical theory of labor supply while models 3 and

[30]Formally, I impose that for any w we have a $l^* \in (0, 1)$ such that $\frac{\partial u(wl^*, l^*)}{\partial l} = 0$.

4 use the hedonic theory of labor supply. Models 1 and 3 correspond to perfectly competitive wages while models 2 and 4 correspond to monopsonistic wages. These models are illustrated in Figure 6.

In model 1, workers choose hours to maximize utility such that one must have that $l = \arg\max u(wl, l)$ for any given w and $l \in [0, \bar{l}]$. Hence, it must be that the marginal utility of working an extra hour is nonnegative $\frac{\partial u(\cdot)}{\partial l} \geq 0$ in equilibrium and equal to 0 in interior solutions. Because wage rates are competitive, workers are paid at their marginal product and $w = F'(l)$. Concavity in the production function implies that the marginal product is decreasing in hours such that a binding working time reduction must increase $F'(l)$ and hence equilibrium wage rates $dw \geq 0$.

In model 2, workers set again hours such that $\frac{\partial u(\cdot)}{\partial l} \geq 0$. However, the firm sets monopsonistic wage rates to maximize profits internalizing the neoclassical labor supply $l(w)$ which associates workers' choice of hours to each wage level. This gives rise to the standard Robinson (1933) monopsony equation $F'(l) - w = \frac{l}{l'(w)}$ where $l'(w)$ is the derivative of the labor supply function. When $l(w)$ is increasing[31], a working time reduction must necessarily be associated with a decrease in equilibrium wage rates $dw \leq 0$.

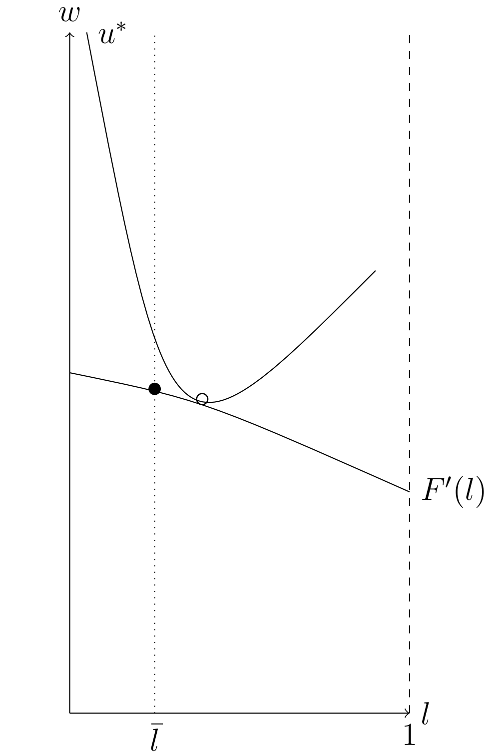
In model 3, the firm chooses hours to maximize profits and wages are competitive $w = F'(l)$ such that the optimal schedule solves $l = \arg\max F(l) - lF'(l)$. Because $F(\cdot)$ is concave, this objective increases in l such that the solution is a corner solution: hours will be set at their largest admissible value, that is $l = \bar{l} \leq 1$. When workers have no leisure and $l = 1$, they will welcome a working time reduction such that $\frac{\partial u(\cdot)}{\partial l} \leq 0$. Here again, because $F'(l)$ is decreasing in hours, a working time reduction increases wage rates in equilibrium $dw \geq 0$.

Finally, in model 4, firms choose both wage rates and hours to maximize profits. Equivalently, the firm chooses the profit-maximizing contract on the workers' reservation indifference curve u_r. Necessarily, this is a contract with long hours and low wage rates such that the marginal utility of an extra hour at that wage rate is negative $\frac{\partial u(\cdot)}{\partial l} \leq 0$ and workers would welcome a working time reduction. However, in equilibrium they must remain on the same indifference curve u_r, such that the utility gains generated by the policy on leisure will be fully compensated by a loss in wage rates, such that $dw < 0$.

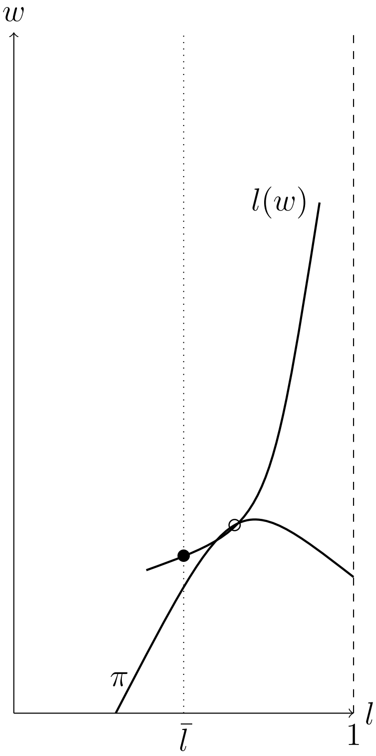
In Table 4, I summarize the theoretical predictions on $\frac{\partial u(\cdot)}{\partial l}$ and dw for the four models. The main results of this section can be summarized as follows. First, if wages are

[31] The fact that $l(w)$ is increasing implies that the substitution effect dominates the income effect in the Slutsky equation of workers. This guarantees that workers are paid below their marginal product $w < F'(l)$ which is a widely-documented empirical fact by the monopsony literature (see Card (2022) e.g.).

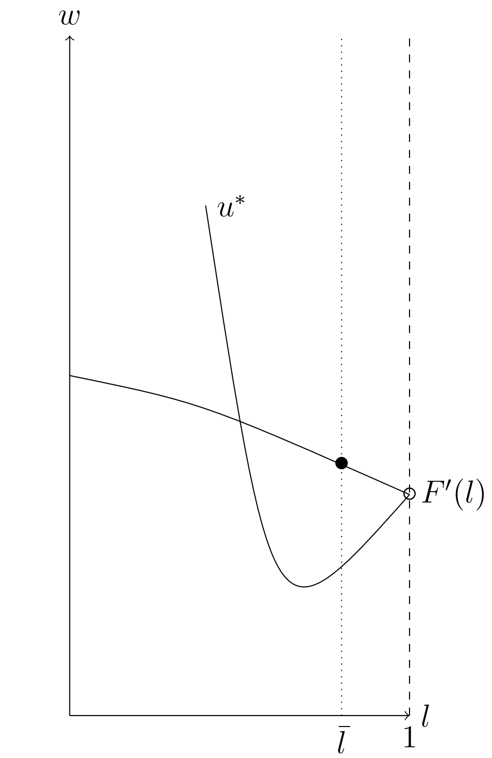
Figure 6: Equilibrium before (○) and after (•) a small binding working time reduction $\bar{l} < l$.



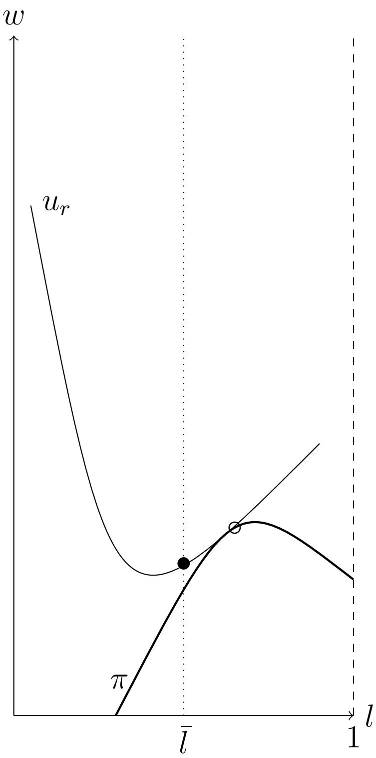
(a) Model 1: workers choose hours, competitive wage rates



(b) Model 2: workers choose hours, firm chooses wage rates



(c) Model 3: firm chooses hours, competitive wage rates



(d) Model 4: firms choose hours and wage rates

Notes: $F'(l)$ denotes the marginal product of an hour, u_r denotes the reservation utility and u^* is the maximum utility, π is the iso-profit, and $l(w)$ is the labor supply curve.

rigid, workers are more likely to be favorable to government-mandated working time reductions when firms set hours.[32] Second, the very same working time reduction increases competitive wage rates but decreases monopsonistic wage rates[33].

Table 4: Summary of theoretical predictions in the four different models.

Who sets l ? Who sets w ?	Utility-maximizing l Competitive w *Model 1*	 Firm sets w *Model 2*	Profit-maximizing l Competitive w *Model 3*	 Firm sets w *Model 4*
Marginal utility of l	$\frac{\partial u(\cdot)}{\partial l} \geq 0$	$\frac{\partial u(\cdot)}{\partial l} \geq 0$	$\frac{\partial u(\cdot)}{\partial l} \leq 0$	$\frac{\partial u(\cdot)}{\partial l} \leq 0$
Equilibrium after $\bar{l} < l$	$dw \geq 0$	$dw \leq 0$	$dw \geq 0$	$dw \leq 0$

Which model can rationalize our empirical findings in section 2? Because workers unanimously supported the reform, the marginal utility of an extra hour must have been negative, which is inconsistent with models 1 and 2 where workers choose hours. I conclude that firms must set hours to rationalize our results. This is consistent with qualitative evidence on firms' organization: because all workers and output use the same lift to go in an out the mine, managers need to organize schedules for ordered production.

Now, wages increased in large firms, which is inconsistent with model 3, while they decreased in small firms, which is inconsistent with model 4. However, in our empirical context, it is unlikely that small and large firms face different competition structures as they were sometimes located next to one another geographically.[34] Moreover, Delabastita and Rubens (2025) documented widespread monopsony power in the same empirical context. Hence, I will assume from now on that firms have some monopsony power.

Rather, one should remember that these toy models do not consider employment and use only hours in the production function $F(l)$. Equivalently, results would be identical in a model where jobs N and hours l enter the production function as $F(N, l) = NF(l) - Nwl$. In that case, the demand for N is perfectly inelastic and employment is unaffected by the reform in Models 1 to 4, which is rejected by our findings of section 2. The next section build a model where firms' demand for N displays some finite elasticity.

[32]It would be easy to show that models 1 and 2 imply that working time reductions are inefficient while models 3 and 4 give a redistributive role to working time reductions. Welfare when production includes employment is less obvious (and therefore more interesting) because working time reductions affect not only the quality but also the quantity of jobs. I come back to this issue in section 4.

[33]Interestingly, the Roosevelt administration introduced the minimum wage alongside a working time reduction, see Fishback et al. (2024).

[34]There is no consensus on whether larger firms have more monopsony power: Jarosch et al. (2024) found evidence supporting this when estimating a model with Austrian data while Volpe (2024) found evidence against this with Norwegian data in a model where workers have heterogeneous tastes.

4 General model of employment, hours and wages

Based on the arguments of section 3, in order to rationalize the empirical results, we need a model where employment matters and (i) firms set hours, and (ii) there may be some monopsony power. This section builds that model which features directed search à la Moen (1997) and monopsony power like in Vergara (2025).[35] Firms post[36] hours, wages, and vacancies while workers' leisure-consumption tradeoff governs both their participation and application decisions. In turn, the model explains the joint determination of hours, wages, and employment depending on technology, productivity, preferences, and labor market power.

I use this model to assess (a) the determinants of long hours, (b) the determinants of the effects of working time reductions, (c) the production functions $F(N,l)$ that are consistent with the reduced-form results of section 2, and (d) the welfare effects of the reform.

4.1 Directed search model

Labor market Consider a set of measure L of workers who are each endowed with a unit of time.[37] Firms are posting vacancies with a pair $m = (w_m, l_m)$ of wage rate and hours worked. All vacancies v_m at a given pair m form a submarket and there may be potentially many submarkets. Workers are applying to one vacancy among the various submarkets m and the number of applicants for a given submarket is denoted by a_m.

Matching There is a technology $\mathcal{M}(a_m, v_m)$ matching applicants and vacancies in a submarket. I assume that it is constant returns to scale.[38] As a result, one can compute the job-finding probability as

$$p_m = \frac{\mathcal{M}(a_m, v_m)}{a_m} = \mathcal{M}(1, \theta_m) = p(\theta_m)$$

where $\theta_m = \frac{v_m}{a_m}$ is the submarket tightness. Similarly, the job-filling probability is

$$q_m = \frac{\mathcal{M}(a_m, v_m)}{v_m} = \mathcal{M}(\frac{1}{\theta_m}, 1) = q(\theta_m)$$

[35] The key difference with Vergara (2025) is the presence of leisure in workers' utility and hours worked, in addition to jobs in production.

[36] There is a long literature exploring the relevance of posting in labor market. For example, Eeckhout and Kircher (2010b) showed that price posting (sorting workers types ex-ante) emerges as an equilibrium trading mechanism rather than auctions (screening workers types ex-post) when the meeting technology is sufficiently rival. A review can be found in Wright et al. (2021).

[37] All the analysis in this section could be carried out in a model where workers have heterogeneous types as long as firms observe it and the labor market is segmented.

[38] See Hall and Schulhofer-Wohl (2018) and Petrongolo and Pissarides (2001) for empirical evidence on the matching function.

and $q_m = p(\theta_m) \times \frac{1}{\theta_m}$. As is standard, it is further assumed that the matching technology is twice continuously differentiable, increasing and concave. Hence, the tighter submarket, the higher will be the job-finding probability $\frac{\partial p(\theta_m)}{\partial \theta_m} > 0$ and the lower will be the job-filling rate $\frac{\partial q(\theta_m)}{\partial \theta_m} < 0$.

Workers Each worker decides whether or not to enter the labor market. Workers are only heterogeneous in their disutility of participation, denoted by d and drawn from a cdf $G(\cdot)$.[39] They have preferences over consumption and leisure represented by an ordinal utility function $u(c, l)$. The government grants some benefits B to all nonemployed agents, be they inactive or unemployed.[40] I assume that each worker may only apply to one submarket, such that the expected utility of participating to the labor market for a worker of disutility of participation d reads

$$\max_m \left\{ p_m u(w_m l_m, l_m) + (1 - p_m) u(B, 0) \right\} - d$$

An individual worker applies by taking p_m as given but the aggregate behavior of all workers will pin down p_m. Hence, in equilibrium, it must be that all agents have the same expected utility[41] (net of their d) that I will denote by $\bar{U}$.[42] However, the fact that all workers of the same type enjoy the same expected utility ex-ante does not imply that they all enjoy the same ex-post utility.

The key mechanism of the model is already visible here: a worker prefers submarkets that pays higher income $w_m l_m$ for lower hours worked l_m but their tightness θ_m will be lower. In other words, as elsewhere in competitive search models, there is a tradeoff between favorable terms of trade and probability of trade. Observe that this equation also defines the level of tightness θ_m on the equilibrium path. In particular, we have equilibrium tightness as an implicit function of three variables $\theta(\underset{-}{w_m}, \underset{+-}{l_m}, \underset{+}{\bar{U}})$: in a given submarket, larger wages and higher expected utility attract more applicants and increase tightness. Longer hours may attract or repel applicants depending on their leisure preferences.

A worker of type d participates if and only if $\bar{U} \geq d + u(B, 0)$ such that the total

[39] This ensures that the extensive elasticity of labor supply is finite.

[40] This formulation supposes that inactives are entitled to the same benefit coverage B than unemployed, which is realistic in the 1910's coal mines. For the value of nonemployment versus unemployment, see Jäger et al. (2020).

[41] Proof: assume it is not the case such that m' yields higher expected utility than m. Then some agents will move towards m', which decreases $\theta_{m'}$ and decreases $p_{m'}$ in turn. This marginally reduces $U(m')$. The process continues until $U(m) = U(m')$.

[42] This is called the *market utility* (Wright et al., 2021).

number of participants is given by $G(\bar{U} - u(B, 0)) \times L$.[43]

Firms All firms face perfect competition in the single output market whose homogeneous good is set as the numéraire.[44] Firms are only heterogeneous in their total factor of productivity ψ_j.[45] They share the same production technology[46] $F(N, l)$ whose inputs are jobs $N = qv$ and hours worked per worker l. Firms internalize workers' decisions such that their job-filling probabilities $\tilde{q}_m$ are implicitly defined by the application behavior with $\tilde{q}_m = q(\theta(\underset{-}{w_m}, \underset{+-}{l_m}, \underset{+}{\bar{U}})$. Conditional on entering the labor market, a firm maximizes expected profit by choosing the number of vacancies v_m^j to post in each submarket m along with the associated wage-hours (w_m^j, l_m^j):

$$\pi(\psi_j) = \max_{\forall m: w_m^j, l_m^j, v_m^j} \int_m \psi_j F(\tilde{q}_m v_m^j, l_m^j) - \tilde{q}_m v_m^j w_m^j l_m^j - k(v_m^j) dm$$

where $k(v_m^j) = k_m v_m$ is a linearly increasing cost of vacancy posting. Because firms face a cost of creating vacancies independently of the hours worked in that vacancy, it is *ex-post* more costly to hire two workers each working half-time rather than one full-time worker, *ceteris paribus*. However, *ex-ante* the probability that vacancies will be filled might differ between short-hours and long-hours contracts.[47]

Firms' entry A set of measure K contains capitalists who are heterogeneous in productivity ψ_j drawn from a compact set $[\underline{\psi}, \bar{\psi}]$. A capitalist enters the labor market if and only if their expected profit is greater than a fixed cost denoted by x. Because the profit function is monotonically increasing in ψ_j, there exists a decisive ψ^* such that $\pi(\psi^*) - x = 0$. All capitalists with $\psi_j < \psi^*$ abstain from entering the labor market and remain inactive while all with $\psi_j \geq \psi^*$ participate.

Economy, allocation and equilibrium The directed search economy e is a set of vNM agents of measure L with leisure preferences $\succsim$ and disutility of participation d drawn from a cdf G, as well as a set K of firms with productivity ψ_j, the vacancy posting cost function $k(\cdot)$, the entry cost x and the production function $F(\cdot)$ and the matching

[43]We can mention current endeavors in the literature to estimate $G(\cdot)$, that is to compute workers' outside options (Caldwell & Danieli, 2024; Caldwell & Harmon, 2019; Caldwell & Oehlsen, 2018; Jäger et al., 2020, 2022, 2023).

[44]The assumption of perfect competition is consistent with our result in Figure A.5 where we show no effect of the reform on output prices

[45]The analysis in this section would be unchanged if ψ_j was assumed to be the productivity of the match between firms and workers, both of them having heterogeneous skills, as long as the skill-matching function exhibits supermodularity which implies positive assortative matching. See Eeckhout and Kircher (2010a, 2018) for a rigorous treatment.

[46]It is assumed that production is increasing in both inputs and it is concave in N.

[47]See Carry (2024) for empirical evidence of such imperfect substitutability the French case.

function $\mathcal{M}$.

$$e = \left\{L, \succsim, G, \{\psi_j\}_{\forall j \in K}, k, x, F(\cdot), \mathcal{M}\right\}$$

Definition 1. *An allocation is a* ***competitive search equilibrium*** *for e if it is characterized by the market utility $\bar{U}$, the zero-profit firm ψ^*, applications a_m, vacancies $v_m = \sum v_m^j$ in each submarket $m = (w_m, l_m)$ as well as a mapping $P(\cdot)$ from productivity to submarkets such that*

1. ***Firms are expected profit maximizers****:*
   The tuples (v_m^j, w_m^j, l_m^j) solve the FOC of firms of type ψ_j taking ψ^* and $\bar{U}$ as given

$$\begin{aligned}
v_m^j: &\quad \tilde{q}_m(\psi_j F'_N - w_m l_m) \le k_m && \textit{with equality if } v_m^j > 0 \quad (4)\\
w_m: &\quad \tilde{q}'_{m,w}(\psi_j F'_N - w_m l_m) \le \tilde{q}_m l_m && \textit{with equality if } w_m > 0 \quad (5)\\
l_m: &\quad v_m^j \tilde{q}'_{m,l}(\psi_j F'_N - w_m l_m) + \psi_j F'_l \ge \tilde{q}_m v_m^j w_m && \textit{with equality if } l_m < \bar{l} \quad (6)
\end{aligned}$$

   where $\bar{l} \le 1$ the legal maximum workweek, and the partial variation of tightness with respect to wages and hours worked are denoted by $\tilde{q}'_{m,w} = \frac{\partial \tilde{q}_m}{\partial w}$ and $\tilde{q}'_{m,l} = \frac{\partial \tilde{q}_m}{\partial l}$. The superscript j for w_m^j and l_m^j is omitted for brevity because all firms active in the same submarket must post the same terms of trade by definition of a submarket.

2. ***Firm's entry constraints are satisfied****:*

$$\psi^* \textit{ solves } \pi(\psi^*) = x \qquad \textit{taking } \bar{U} \textit{ given} \tag{7}$$

3. ***Across-submarket equilibrium conditions are satisfied****:*
   Applications in a submarket ensure that all submarkets yield market utility

$$a_m \textit{ solves } \bar{U} = p_m u(w_m l_m, l_m) + (1 - p_m) u(B, 0) \tag{8}$$

   with $p_m = p(\frac{v_m}{a_m})$, taking ψ^*, v_m, l_m, w_m as given for $m \in [P(\psi^*), P(\bar{\psi})]$

4. ***Workers' participation constraint is satisfied:***

$$\bar{U} \textit{ solves } \int_{P(\psi^*)}^{P(\bar{\psi})} a_m dm = G(\bar{U} - u(B, 0)) \times L \textit{ taking } \psi^*, u, a_m \textit{ given.} \tag{9}$$

4.2 Model properties

I now turn to the properties of the competitive search equilibrium just defined.

Firm and submarket sizes In a single submarket, one may find vacancies from several firms. Say that we find two firms $\psi_j > \psi_k$ in some given submarket (w, l) where the total number of vacancies is $v = v^k + v^j$. By equations 5 and 6 respectively, it must be that

$$\psi_j F'_N(v^j \tilde{q}, l) = \psi_k F'_N(v^k \tilde{q}, l)$$
$$\frac{1}{v_j}\psi_j F'_l(v^j \tilde{q}, l) = \frac{1}{v_k}\psi_k F'_l(v^k \tilde{q}, l)$$

In other words, the marginal product of jobs must be equal for both firms, and their relative number of posted vacancies must be proportional to their relative marginal product of hours. As a consequence, their marginal rate of technical substitution must be equal. Observe that this also implies that if two firms coexist in the same submarket $\psi_j > \psi_k$, their employment level must be $N_j > N_k$ to respect equation 5.

Conversely, can a single firm post vacancies in several submarkets in equilibrium? Observe that production is separable in submarkets, such that the model assumes away potential complementarities between submarkets in production. In general, firms may post vacancies in several submarkets, i.e. equation 4 may be saturated for many m in the sense that nothing prevents or guarantees it. Because firms need two labor inputs to produce, they must necessarily have $N > 0$ and $l > 0$ in at least one submarket to be active. In that sense, this model endogenizes a distribution of firm size.[48]

Monopsony power Although search is competitive, the labor market remuneration might not be. Indeed, this model produces an earnings markdown and workers are paid below their marginal product. If the submarket-specific wage elasticity of labor supply is $\epsilon^w_m = \frac{\partial \tilde{q}_m v_m}{\partial w_m}\frac{w_m}{\tilde{q}_m v_m}$, then equation 5 reads

$$\frac{\psi_j F'_N - w_m l_m}{w_m l_m} = \frac{1}{\epsilon^w_m}$$

which is the original Robinson (1933) markdown equation: the earnings markdown is inversely proportional to the submarket-specific elasticity of labor supply. It is noteworthy that the present model has two sources of monopsony power.[49] First, because disutilities of participation are heterogeneous, the wage elasticity of labor supply is finite. Second, there is monopsony power because of matching frictions. Indeed, observe that when matching frictions increase, ϵ^w_m decrease and the earnings markdown increase.

Importantly, observe that two firms of unequal productivity $\psi_j > \psi_k$ active in the same submarket m such that $\psi_j F'_N = \psi_k F'_N$ must have the same monopsony power in

[48] One cannot really call this *large firms* in the sense of Eeckhout and Kircher (2018) because that implies that several types of workers are employed in the same firm in equilibrium. In the present paper, workers are homogeneous conditional on their disutility of participation.

[49] Berger et al. (2024) quantifies the empirical importance of several determinants of monopsony power including preferences and search frictions. Azar and Marinescu (2024) review the literature.

that submarket. Hence, heterogeneous firms may offer identical contracts and enjoy the same monopsony power in that contract. However, a direct implication of the envelope theorem is that firms with higher productivity must have higher profits such that the sum across submarkets of a firm's monopsony power increases with ψ.

Double monopsony Given that this model features two inputs, we can note that not only the remuneration of jobs but also the remuneration of hours worked can be marked down relative to their marginal productivity. Indeed, by equations 5 and 6 we have in interior solutions

$$\frac{\psi_j F_l' - w_m N_m^j}{w_m N_m^j} = -\frac{l_m \tilde{q}_{m,l}'}{w_m \tilde{q}_{m,w}'}$$

where the left-hand side measures the markdown on the hours input and the right-hand side is proportional to workers' marginal rate of substitution between hours and wages.

This expression transparently links workers' leisure preferences with the markdown on hours worked. When workers are calling for a working time reduction, one gets $\tilde{q}_{m,l} < 0$, the right-hand side is positive and the marginal cost of an hour Nw is marked down relative to its marginal product $\psi F_l'$.

Hence, an increase in workers' taste for leisure has real effects in the labor market. Although it does not affect labor supply in levels because workers do not choose hours, it affects labor supply elasticities. As a result, the firm reacts by modifying w_m and l_m according to equations 5 and 6. By the hours markdown equation, we know that hours markdown must increase, which can be achieved by decreasing w or l. These two monopsony equations allow us to derive the next proposition.

Proposition 1. *In interior solutions, workers in submarket m would like to work less at their current wage rate if and only if*

$$\tilde{q}_{m,l}' \leq 0 \iff \frac{\epsilon_m^w}{1+\epsilon_m^w} \leq \frac{l_m F_l'}{N_m F_N'}$$

Proposition 1 is useful because it gives the technological and preference conditions to find long hours. With respect to technology, long hours arise when the output elasticity of hours lF_l' dominates the output elasticity of hires NF_N'.[50] This seems relevant in settings with experience effects: marginally increasing hours of existing experienced workers yields more output than marginal increasing the size of the workforce.[51] Intuitively, when hours are more productive than jobs, firms will set long schedules. With

[50] For evidence that $lF_l' < 1$, see Collewet and Sauermann (2017) for a contemporary setting and Pencavel (2015) for a World Ward I context.

[51] Coal mining in Belgium was an occupation where on-the-job experience was an important determinant of productivity given the irregular nature of coal veins (Denoël, 1909).

respect to preferences and matching frictions, long hours arise when ϵ^w is small and monopsony power (on jobs) is large. This is the same channel as in Model 4 in section 3: a larger monopsony power leads to longer hours and lower hourly wages.

When jobs and hours enter multiplicatively in production (i.e. $F(Nl)$) such that $\frac{l_m F_l'}{N_m F_N'} = 1$, observe that (i) one finds contracts with long hours as soon as there is monopsony power and ϵ_m^w is finite, and (ii) in the perfectly competitive limit $\frac{\epsilon_m^w}{1+\epsilon_m^w} \to 1$, we get $\tilde{q}'_{m,l} \to 0$ such that workers' marginal utility of working an extra hour is 0. In that case, the equilibrium is equivalent to the standard model where workers choose hours as in Model 1 in section 2. This suggests that our model where firms set hours nests models where workers choose hours.

Contract dispersion and sorting The model produces wage dispersion among (observably) identical workers[52] which is a long-standing finding of empirical labor studies (see Card et al. (2018)) because there is a continuum of submarkets in equilibrium. It is naturally interesting to study how heterogeneous firms are sorting in the contract space. Taking the total derivative of equation 4 in a particular submarket away from corner solutions one gets

$$dv \underbrace{(\tilde{q}^2 \psi F_N'')}_{<0 \text{ if } F_N'' \leq 0} + dw \underbrace{(\tilde{q}_w'(\psi F_N' - wl) - \tilde{q}l + \tilde{q}v\tilde{q}_w'\psi F_N'')}_{<0 \text{ by equation 5 if } F_N'' \leq 0} + dl \left(\gamma_l \right) + d\psi \underbrace{(\tilde{q}F_N')}_{>0} = 0$$

where indices are omitted for brevity. Hence, a firm with higher productivity ψ_j will post higher wages and more vacancies, thereby having a larger headcount employment in each submarket. With respect to hours worked, the coefficient γ_l multiplying dl is difficult to sign in the general case as it depends on the firms' size and inputs complementarity. Besides, this equation governs the within-firm correlations between endogenous variables when one sets $d\psi = 0$. In particular, it must be that vacancies and hourly wage covary positively within-firm. A complete analysis of sorting patterns à la Eeckhout et al. (2024) or Volpe (2024) is beyond the scope of the present paper.

4.3 Wage effects of a working time reduction

All general equilibrium effects on wages can be analyzed using solely firms' first-order conditions, as they encompass workers' reactions. Importantly, the reform has effects in all submarkets, whether or not the reform is binding in that submarket. In treated submarkets, the reform (i) reduces the quantity of hours that can be used for production and (ii) attracts applications from other submarkets. In control submarkets, the

[52]It escapes the Diamond (1971) paradox of homogeneous contract in search models by allowing heterogeneous firms' productivities.

reform has effects because it diverts applicants towards treated submarkets. This workers' application behavior is the only channel of spillovers across submarkets, as I assumed production to be separable across them. In this section, I consider the wage effects in treated submarkets and relegate those in control submarkets to Appendix B.1.[53]

Treated submarkets To fix ideas, I assume that aggregate participation responses are negligible[54] such that $\theta_m(w_m, l_m, \bar{U}) = \theta_m(w_m, l_m)$. Consider firms active in treated submarkets where $l_m > 9$ and a small reform that reduces working time $d(1-\bar{l}) > 0$. Taking the total derivative of equation 4, one gets

$$\frac{dl}{d(1-\bar{l})}\left(\tilde{q}_l'(\psi F_N' - wl + \psi N^j F_N'') + \tilde{q}\psi F_{N,l}'' - \tilde{q}w\right) = dv^j\left(-\tilde{q}^2\psi F_N''\right) + dw\left(-\tilde{q}_w' N^j \psi_j F_N''\right)$$

The left-hand side describes the effect of the reform on firms while the right-hand side captures their reactions. When workers are calling for a working time reduction $\tilde{q}_l' < 0$, sufficient conditions for wages to increase $dw \geq 0$ are $\psi F_N' - wl + N^j \psi F_N'' \geq 0$ and $\tilde{q}\psi F_{N,l}'' - qw \leq 0$ and inequality signs are flipped for $dw \leq 0$. Using the first-order condition 5, we can rewrite these sufficient conditions in a proposition.

Proposition 2. *If treated workers are calling for a working time reduction $\tilde{q}_l' \leq 0$, the wage effects in a given* ***treated*** *submarket m for firm j are governed by the following sufficient conditions:*

$$\textit{If } \frac{1}{1+\epsilon^w} \geq \frac{-N^j F_N''}{F_N'} \qquad \textit{and } \frac{\epsilon^w}{1+\epsilon^w} \geq \frac{lF_{N,l}''}{F_N'} \implies dw \geq 0$$
$$\textit{If } \frac{1}{1+\epsilon^w} \leq \frac{-N^j F_N''}{F_N'} \qquad \textit{and } \frac{\epsilon^w}{1+\epsilon^w} \leq \frac{lF_{N,l}''}{F_N'} \implies dw \leq 0$$

Determinants of wage effects Proposition 2 highlights the driving forces for the wage effects in terms of structural parameters on both sides of the market. Technology matters on the right-hand side of these inequalities, but labor supply elasticity ϵ^w matters for the left-hand side, which is itself determined by preferences and matching frictions.

With respect to technology, the key elements are the *change* of the marginal product of labor with respect to jobs $\frac{d\ln F_N'}{d\ln N} = \frac{-N^j F_N''}{F_N'}$ and hours $\frac{d\ln F_N'}{d\ln l} = \frac{-lF_{N,l}''}{F_N'}$. When production is sufficiently concave, $-F_N''$ is large and wages are likely to decrease because cutting wages implies that the workers' exodus increases significantly the marginal product of a

[53] I show that the sufficient conditions for wage increase (resp. cuts) in treated submarket lead to wage cuts (resp. increase) in control submarkets. As a result, the sufficient conditions for wage increase in treated submarkets also describe whether the difference-in-differences is positive between treated and control.

[54] This makes sense because the participation effects are scaled by the density of inframarginal workers $g(\bar{U} - u(B, 0))$, which may be small in our setting because the vast majority of local workforce was employed by the local mine.

job. When production displays a strong gross complementarity between jobs and hours worked, $\frac{lF''_{N,l}}{F'_N}$ is large which pushes wage rates downward. Intuitively, when hours complements jobs in production, the firm does not want to compensate the working time reduction by hiring and will cut hourly wage. By contrast, when inputs are substitutes, $\frac{lF''_{N,l}}{F'_N}$ is small which pushes hourly wages up as an incentive for workers to join the firm to substitute for lost hours.

When monopsony power is large, ϵ^w is small and it has ambiguous effect on equilibrium wages. First, $\frac{\epsilon^w}{1+\epsilon^w}$ is small such that we are more likely to be in the case where wage decreases. This is the same channel as in Model 4 of section 3: when firms have monopsony power, they compensate the constraint on their hours worked by cutting hourly wages. However, a large monopsony power also implies that $\frac{1}{1+\epsilon^w}$ is large which gives an opposite upward force to wages. Indeed, a large monopsony power implies that when workers join the firm, the markdown levied on them dominates the negative effect on the firms' marginal product of job, which encourages wage increases for hiring purposes.

Heterogeneous effects by size I now assess which labor production functions $F(N,l)$ can rationalize the empirical findings of section 2 where wages decrease in small firms but increase in large firms. If I were to assume that small and large firms have different production functions, the result would be immediate using Proposition 2. Rather, I will assume that all firms have the same $F(N,l)$, which seems consistent with the coal mining context. In particular, consider two firms are active in the very same treated submarkets yet have different sizes due to unequal ψ_j. Importantly, because they are in the same submarket, they face the same labor supply elasticity ϵ^w and derive the same markdowns on both inputs. However, an identical working time reduction may have heterogeneous impact on these two firms because the *change* in marginal product of labor induced by the hours regulation and incoming applicants may differ by size depending on $F(N,l)$.

Consider a Cobb-Douglas production function $F(N,l) = N^\alpha l^\beta$ à la Feldstein (1967). In that case, the ratios of interest in Proposition 2 read :

$$\frac{-NF''_N}{F_N} = 1-\alpha \qquad \frac{lF''_{N,l}}{F_N} = \beta$$

These ratios are not varying with firm size, which suggests that the wage effects of working time reductions is independent of firm's size, and only depend on output elasticities α, β and the submarket-specific labor supply elasticity[55].

[55]One can rationalize the coexistence of wage cuts and long hours by assuming $\alpha < 1 \leq \beta$, but this prevents from observing wage increases in large firms.

Consider a general CES $F(N,l) = [\alpha N^{\rho} + \beta l^{\rho}]^{1/\rho}$. One can show that the ratios of Proposition 2 are now

$$\frac{-NF''_N}{F_N} = (1-\rho)\frac{\beta l^{\rho}}{\alpha N^{\rho} + \beta l^{\rho}} = \frac{lF''_{N,l}}{F_N}$$

as long as $\rho \neq 0$. In that case, the wage effects of a working time reduction may depend on N. This is true even if these two firms have the same production function parameters α, β, ρ and are active in the same submarket (w, l). In particular, whenever ρ is positive, one is more likely to find $dw < 0$ for small N and $dw > 0$ for large N, which is precisely what we documented empirically. This comes from the two opposing technological forces: the substitution effect and the concavity effect. In large firms, the gains in marginal product from firing workers are small while they are large in small firms.

These intuitions for the Cobb-Douglas and CES cases are derived using Proposition 2 which only gives sufficient conditions. To verify them, I simulate the wage effects of working time reductions as a function of firm size N and elasticity of substitution $(1-\rho)^{-1}$, using the necessary and sufficient conditions, i.e. the total derivative of equation 4. I set the value of the labor supply elasticity $\epsilon_w = 10.172$ which is taken from Delabastita and Rubens (2025). I also set $l = 10$ hours and $\frac{\beta}{\alpha} = 2$ and consider only values that are consistent with long hours contracts using Proposition 1. Results are presented in Figure 7 while details are given in Appendix B.2.

Figure 7: Simulation of the wage effects of the reform for CES values of ρ and employment size N

Notes : This is computed using the total derivative of equation 4 for a CES production function holding v constant. I set $l = 10$ hours, as well as $\beta/\alpha = 2$. I add a constraint that workers would like to work less $\tilde{q}'_l \leq 0$ using Proposition 1. The Cobb-Douglas production function arises when $\rho = 0$.

This simulation confirms that the reduced-form results are inconsistent with a Cobb-

Douglas production technology. It is shown here with $\frac{\beta}{\alpha} = 2$ to ensure that the marginal product of an hour dominates the marginal product of a job and workers would like to work less (through Proposition 1), but similar inconsistencies are found even when $\frac{\beta}{\alpha}$ equals 1. Intuitively, in the Cobb-Douglas case, a working time reduction changes the marginal product of a job in a way that is constant across firm size.

This simulation also shows that whenever ρ is small and inputs are complements, firms will cut hourly wages. Moreover, small firms also cut hourly wages for any level of substitutability between inputs. Indeed, in very small firms, cutting hourly wages increases the marginal product of a job by a relatively large amount which allows to restore markdowns. Yet, when ρ is mildly positive and inputs are imperfect substitutes, large firms will raise hourly wages after a working time reduction in order to increase headcount employment to compensate for the lost hours. For the parameter values of the numerical simulations, it seems that a value of ρ around 0.2 can rationalize the coexistence of wage cuts in small submarkets (below 200 workers) and wage hikes in large firms (above 200). This corresponds to a Hicksian elasticity of substitution between jobs and hours of 1.25, i.e. a 1% decrease in the marginal rate of technical substitution increases the $\frac{N}{l}$ ratio by 1.25 %.

Importantly, I note that these results do not come from a different production functions between large and small firms, nor from a difference in monopsony power. Simply put, when jobs and hours are imperfect substitutes, the larger firm needs to attract many workers to compensate for lost hours and hence increases wage rates. In the meantime, the smaller firm prefers to cut hourly wages and see some workers leaving, as this significantly increases its marginal product of N.

4.4 Welfare analysis

Now that we know that the competitive search equilibrium can replicate positive empirical findings, we can study its normative implications. Interestingly, welfare effects of the policy are ambiguous here because the negative effects on earnings may be offset by positive effects on leisure and employment. In this section, I quantify the welfare effects of the Belgian 1910 coal mine reform using the directed search model.

As discussed above, the market utility $\bar{U}$ summarizes workers' ex-ante welfare and features a trade-off between jobs quantity and job quality. I now express it in terms of sufficient statistics as in Vergara (2025). Recall that for each submarket m we have

$$\begin{aligned} \bar{U} &= p_m u(w_m l_m, l_m) + (1 - p_m) u(B, 0) \\ a_m[\bar{U} - u(B, 0)] &= N_m[u(w_m l_m, l_m) - u(B, 0)] \end{aligned}$$

where $N_m = p_m \times a_m$ is the number of workers employed in submarket m. Integrating over submarkets yields

$$\begin{aligned}
[\bar{U} - u(B,0)] \int_m a_m dm &= \int_m N_m[u(w_m l_m, l_m) - u(B,0)]dm \\
\bar{U} - u(B,0) &= \frac{\int_m N_m[u(w_m l_m, l_m) - u(B,0)]dm}{G(\bar{U} - u(B,0)) \times L}
\end{aligned}$$

where the last equation is obtained using equation 9. The denominator is simply the total number of workers participating to the labor market and the numerator is a weighted sum of utilities across submarkets whose weights are the submarkets' employment size N_m. This ratio is simply giving the average utility among active workers. To see this, observe that the last equation can be written as

$$\begin{aligned}
\bar{U} - u(B,0) &= \frac{\int_m N_m dm}{G(\bar{U} - u(B,0)) \times L} \frac{\int_m N_m[u(w_m l_m, l_m) - u(B,0)]dm}{\int_m N_m dm} \\
&= \mu \mathbb{E}_m[u(w_m l_m, l_m) - u(B,0)]
\end{aligned}$$

where μ is the employment rate and $\mathbb{E}_m[u(w_m l_m, l_m)]$ is the average utility of a job among workers. Let me normalize $u(B,0) = u(0,0) = 0$. It is straightforward to show the following result.

Proposition 3. *A small working time reduction*[56] $d(1-\bar{l}) > 0$ *has a positive impact on ex-ante welfare* $\frac{d\bar{U}}{d(1-\bar{l})} > 0$ *if and only if*

$$\eta^N + \eta^u > 0$$

where η^N *is the percentage change in employment rate due to the reform and* η^u *is the percentage change in workers' average (ex-post) utility.*

Taking the total derivative of $u(c,l)$ with respect to $(1-\bar{l})$ we can write the percentage change in utility η^u as a function of the percentage change in consumption and leisure:

$$\begin{aligned}
\frac{du}{d(1-\bar{l})} &= u'_c \frac{dc}{d(1-\bar{l})} + u'_l \frac{dl}{d(1-\bar{l})} \\
\eta^u = \frac{(1-\bar{l})}{u} \frac{du}{d(1-\bar{l})} &= \frac{cu'_c}{u} \frac{(1-\bar{l})}{c} \frac{dc}{d(1-\bar{l})} + \frac{lu'_l}{u} \frac{(1-\bar{l})}{l} \frac{dl}{d(1-\bar{l})} = \zeta^u_c \eta^c + \zeta^u_l \eta^l
\end{aligned}$$

[56] In order to enforce such reforms, governments must observe hours and hence contract (w,l) which contrasts with the typical assumption in public finance since Mirrlees (1971) that only income is observed. If governments observe (w,l), why don't they use lump-sum transfers to decentralize any first-best allocation rather than using the maximum workweek? In this model, we may reconcile the second-best environment of Mirrlees (1971) with an information set that contains w and l. Indeed, two different firms may offer in the same contract. Hence, when observing the contract, the government may still be unable to observe the identity of firms, hence the second fundamental theorem of welfare economics may not be used.

where η^c and η^l are the percentage change in consumption and hours worked while ζ_c^u and ζ_l^u are the elasticity of the utility function to consumption and hours respectively.

These sufficient statistics are strikingly simple. One can assess welfare effects of the reform simply by observing the average treatment effect of the reform on employment, earnings and leisure and postulating a cardinal utility function.[57] In particular, it does not require taking any stance on the production side nor the extent of imperfect competition in the labor market, which is known to vary significantly across contexts and industries (Azar et al., 2022; Card et al., 2018).[58] Despite the heterogeneity in the model and in the empirical results, only ATE, i.e. average effects, are needed to compute utilitarian welfare.[59]

The estimates derived in section 2 may be used to compute the welfare effects using these sufficient statistics. However, they are ATT, not ATE. As a result, I apply the welfare analysis only on treated workers. Recall that the ATT are -2.8% for daily earnings and -6.7% for daily hours worked. Assuming away application reaction to the reform[60], we estimate η^N to 4.75%, i.e the ATT on underground employment. One obtains that the reform improved welfare if

$$4.75\% + \frac{cu'_c}{u}(-2.8\%) + \frac{lu'_l}{u}(-6.7\%) > 0$$

Given that u'_l is negative, the last term is helping the inequality to be satisfied. A conservative sufficient condition for the inequality to be satisfied is that

$$4.75\% + \frac{cu'_c}{u}(-2.8\%) > 0 \iff \frac{cu'_c}{u} \leq 1.7$$

That the elasticity of utility to consumption is smaller than 1 is a consequence of concavity in consumption when $u(0,0) = 0$ and is delivered by standard functional forms. I conclude that this reform increased treated workers' welfare.

A key question for policymakers is: would these positive effects for workers also hold

[57]One could have picked Boppart and Krusell (2020) utility function who show in a structural macro exercise that the functional form consistent with labor supply dynamics over the past century takes the form of $u(w,l) = w\ l\phi(l\ c^{\frac{\nu}{1-\nu}})$ with ϕ a decreasing function, where $\nu \in (0,1)$ is such that if productivity grows by g, then hours decrease at a rate g^ν and consumption increase at a rate $c^{1-\nu}$. However, 1910 mine workers were unlikely to use the preferences that lead to the decline in hours worked over the century that succeeds them.

[58]I note that these elasticities must be understood as macro-elasticities in the sense of Landais et al. (2018), i.e. incorporating all general equilibrium effects.

[59]Given that workers are identical ex-ante, there is no reason to given them heterogeneous welfare weights for an ex-ante welfarist planner. An ex-post planner would ignore employment effects and focus only on leisure-consumption. An intermediate solution has been proposed by Fleurbaey (2010).

[60]Observe that $\eta^N = \frac{d\mu}{d\bar{l}}\frac{\bar{l}}{\mu} = \frac{dN}{d\bar{l}}\frac{\bar{l}}{N} - \frac{dA}{d\bar{l}}\frac{\bar{l}}{A}$ where A is the number of applicants. Assuming the latter term to be equal to 0 pushes η^N upwards.

today? I have argued that working time reductions are unlikely to be favorable to workers when they are able to choose their own hours because there are no utility gains from the extra leisure. Moreover, in industries where hours and jobs are more complementary, the welfare effects on employment and wages are likely to be negative. Finally, monopsony power plays an ambiguous role in the desirability of working time reductions for workers' welfare. On the one hand, monopsony power leads to longer hours such that the welfare gains in leisure might be sizable. On the other hand, monopsony power may lead firms to wage cuts and negative employment effects to restore their markdowns after the reform.

5 Conclusion

The paper has studied theoretically and empirically the effects of working time reductions on wages, employment, and welfare. The normative framework is able to study the welfare effects of any policy affecting wages, hours, and employment. The empirical application uncovered size-dependent responses to the first-ever working time reduction in Belgium: in large firms, hourly wages and employment increased, while in small firms, hourly wages decreased and there was no employment effect. I argued that the results are in contradiction with (i) workers choosing hours (ii) competitive wages and (iii) jobs and hours entering multiplicatively in production. I built a model to show how preferences, technology, and labor market power explains the prevalence of long hours contracts and the effects of working hour regulations.

The policy recommendations are twofold. First, working time reductions are likely to have negative effects on workers' welfare in industries where (i) they are able to choose their hours and (ii) there is production complementarity between jobs and hours. Second, even though monopsony power leads to long hours, government-mandated hour reductions are a blunt tool to fight monopsony power, which may lead to wage cut and hurt workers' welfare if not accompanied by wage regulations.

There are several ways in which this line of research can be extended. First, the interaction with taxes is of obvious interest for public economists. Second, the characterization of optimal policy and efficiency has been left aside. Interestingly, claim (iii) implies a market failure even in perfect competition, as there is only one price (wage rates) to trade two different goods (hours and jobs), which leaves room for Pareto-improving reforms. Third, the model can be amended to allow for heterogeneous preferences for leisure, which would be relevant to discuss the desirability of gendered holidays or retirement policies. Fourth, the (counter)cyclicality of working time regulations could be interesting to relate to the literature on short-time work (Giupponi & Landais, 2023). Fifth, the model may have macro implications for the aggregation of labor inputs in the neoclassical production function (Baqaee & Farhi, 2019; Feldstein, 1967) or the decomposition of the fall in hours over the course of development (Boppart & Krusell, 2020; Pencavel, 2016) from preferences, market power, and technology factors.

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A Empirical appendix

A.1 Data collection

A.2 Construction of variables

A.2.1 Hours worked

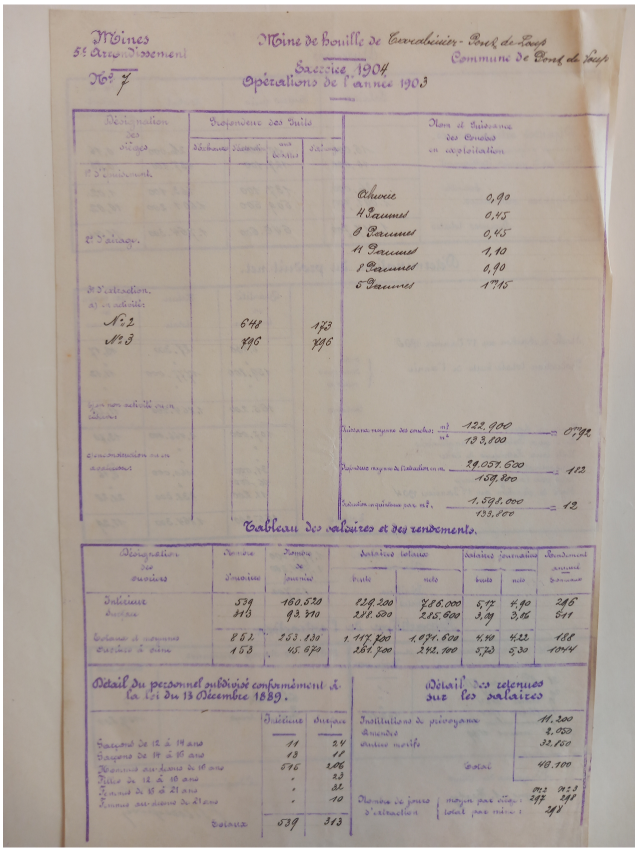
The panel dataset contains information on three occupations: frontline underground workers, non-frontline underground workers as well as aboveground workers. However, the 1900 cross-sectional dataset on hours worked contains information on 9 underground occupations: frontline workers, first transport workers, dirt diggers, stone diggers, second transport workers, path-makers, horseman, backfillers, and lift keepers.

I assign frontline workers' hours to the panel frontline workers. For non-frontline underground workers, I assign a weighted average of the cross-sectional occupations. Weights are 0.45 on hours of *Coupeurs de voies*, 0.45 on *Remblayeurs* hours, and 0.1 on *Bouveleurs* hours. There are no missing values for *Bouveleurs*. When either *Coupeurs de voies* or *Remblayeurs* is missing, I assign a weight of 0.9 to the non-missing value.

These weights were chosen such that the resulting probability distribution of hours worked in the matched dataset is reasonably close to an exact aggregate distribution of hours worked retrieved from Parliamentary Commission (1908). The Mining Administration computed that aggregate distribution for hours worked on November 29, 1907, which I report in panel (b) of Figure 2 along with the implied distribution of my dataset in panel (a).

Despite the fact that cross-sectional information on hours worked underlying panel (a) were collected in 1900, we observe a strikingly close implied distribution of hours in 1907 to the one . The average hours worked in panel (a) is 9.73 while it is 9.81 in panel (b). Crucially, the proportion of workers working more than 9 hours is 82.22% in panel (a) and 82.76% in panel (b). The modes of both distribution are the interval [9.75,10).

Although both distribution are close, they differ notably at extreme values (which is the consequence of taking a weighted average of occupations). With respect to observations below 9 hours, this has no consequences for our estimations because the intensity of hours does not matter in the control group. With respect to hours worked above 10 hours, this could be affecting the results for continuous treatment specifications. However, the green distribution is on a yearly basis while the blue distribution is specific to a given date. The Mining Administration notes while providing the blue distribution that *[t]he chosen day is the Friday of the week preceding the feast of Saint Barbara; it is one of the days of the year when the number of workers is highest and daily production reaches*



Mines
5e Arrondissement
N° 7

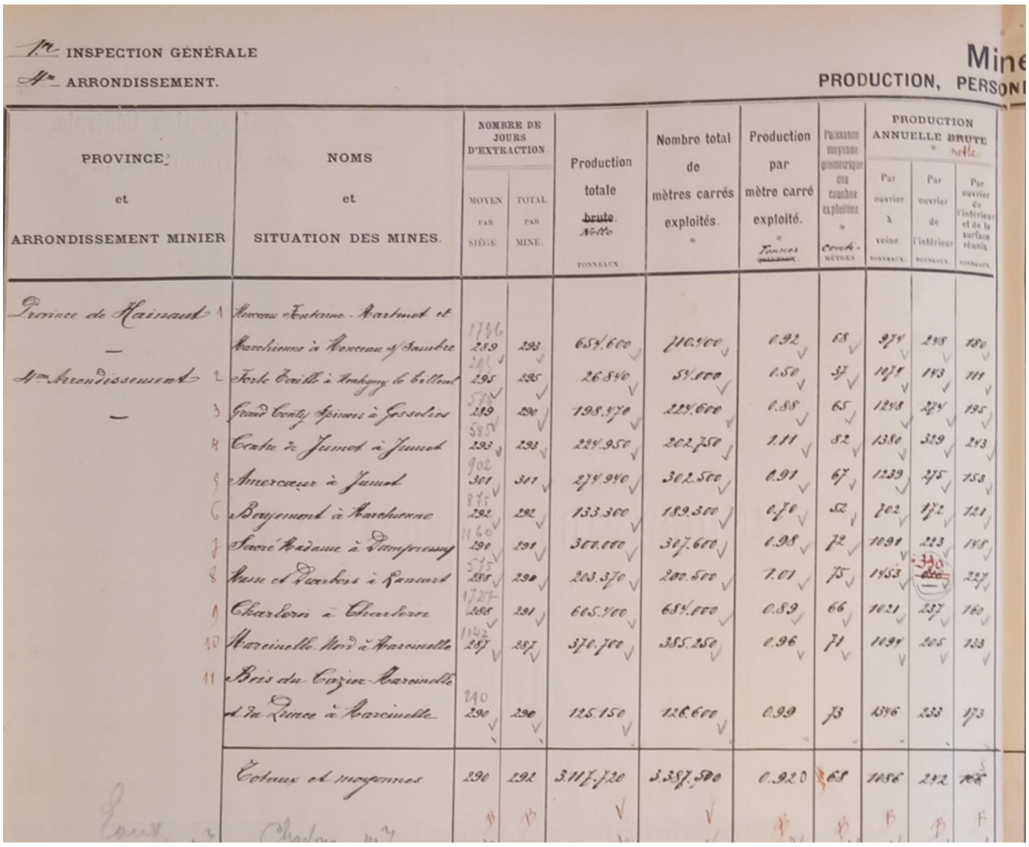
Mine de houille de Carabinier - Pont de Loup
Commune de Pont de Loup
Exercice 1904
Opérations de l'année 1903

Tableau des salaires et des rendements.

Détail du personnel subdivisé conformément à la loi du 13 Décembre 1889.

Détail des retenues sur les salaires

(a) A report for the mine *Carabinier-Pont du Loup* in 1903.



1re INSPECTION GÉNÉRALE
4me ARRONDISSEMENT.

Mine[s]
PRODUCTION, PERSON[NEL]

PROVINCE et ARRONDISSEMENT MINIER		NOMS et SITUATION DES MINES.	NOMBRE DE JOURS D'EXTRACTION: MOYEN PAR SIÈGE	NOMBRE DE JOURS D'EXTRACTION: TOTAL PAR MINE.	Production totale ~~brute~~. Nette (TONNEAUX)	Nombre total de mètres carrés exploités.	Production par mètre carré exploité. (Tonnes)	Puissance moyenne géométrique des couches exploitées (Centi-MÈTRES)	PRODUCTION ANNUELLE ~~BRUTE~~ nette: Par ouvrier à veine. (TONNEAUX)	PRODUCTION ANNUELLE ~~BRUTE~~ nette: Par ouvrier de l'intérieur (TONNEAUX)	PRODUCTION ANNUELLE ~~BRUTE~~ nette: Par ouvrier de l'intérieur et de la surface réunis. (TONNEAUX)
Province de Hainaut	1	Monceau Fontaine - Martinet et Marchienne à Monceau s/ Sambre	289	293	654.600	710.500	0.92	68	974	258	180
— 4me Arrondissement	2	Forte Taille à Montigny le Tilleul	295	295	26.840	54.000	0.50	37	1074	143	111
—	3	Grand Conty Spinois à Gosselies	289	290	198.570	224.600	0.88	65	1248	274	195
	4	Centre de Jumet à Jumet	293	293	224.950	202.750	1.11	82	1380	329	243
	5	Amercœur à Jumet	301	317	274.940	302.500	0.91	67	1239	275	153
	6	Bayemont à Marchienne	292	292	133.300	189.300	0.70	52	702	172	121
	7	Sacré Madame à Dampremy	290	291	300.000	307.600	0.98	72	1091	223	148
	8	Masse et Diarbois à Ransart	288	290	203.370	200.500	1.01	75	1453	340	227
	9	Charleroi à Charleroi	288	291	605.400	684.000	0.89	66	1021	237	160
	10	Marcinelle Nord à Marcinelle	287	287	370.700	385.250	0.96	71	1094	205	133
	11	Bois du Cazier-Marcinelle et du Prince à Marcinelle	290	290	125.150	126.600	0.99	73	1396	233	173
		Totaux et moyennes	290	292	3.117.720	3.387.500	0.920	68	1086	242	166

(b) A slice of the panel dataset which shows some outcomes for the 4th arrondissement in the province of Hainaut in 1913.

Figure A.1: Pictures of the data collection *its peak.* (page v., Parliamentary Commission (1908)). Both remarks suggest that the hours worked in the matched dataset can be trusted.

A.2.2 Profits

I construct profits as the difference between total revenue and total expenses. Total revenue is computed as the sum of sales and the change in stock of coal evaluated at the firm's market price. The variable is expressed in real terms by deflating with the price of output, such that profits are measured in tons of coal.

A.2.3 Earnings

In the occupation-level dataset, I define daily earnings in efficiency units as follows. To obtain a real measure of wages, I deflate the daily gross wage by the output price. To convert it in efficiency units, I divide the real wage by the average daily production of a worker.

$$(1-\tau_{o,j,t})wl^{E}_{o,j,t} = \frac{\dfrac{\text{Daily net wage in current BEF}_{o,j,t}}{\text{Sales price in current BEF}_{j,t}}}{\dfrac{\text{Yearly production per person}_{o,j,t}}{\text{Average days worked per worker in year}_{j,t}}}$$

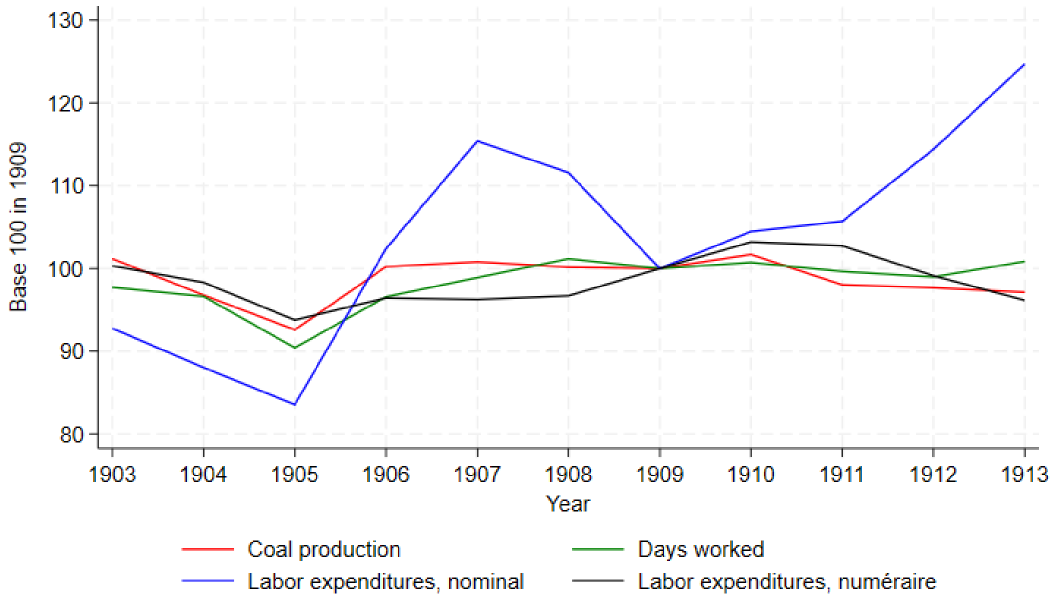
All wage results reported in the paper use net earnings. Although there was no labor income taxation at the time, a worker could see a gap between his wage and take-home pay because of firm-organized policies such as fines for misconduct or employer-provided amenities (housing, life insurance). As shown in the main text, firm-organized withholding did not react to the reform.

A.3 Additional empirical context

Figure A.2 complements Figure 1 from the main text. It shows how aggregate variables evolves over the business cycle. Here as well, we see no downward wage rigidity both in nominal and real terms.

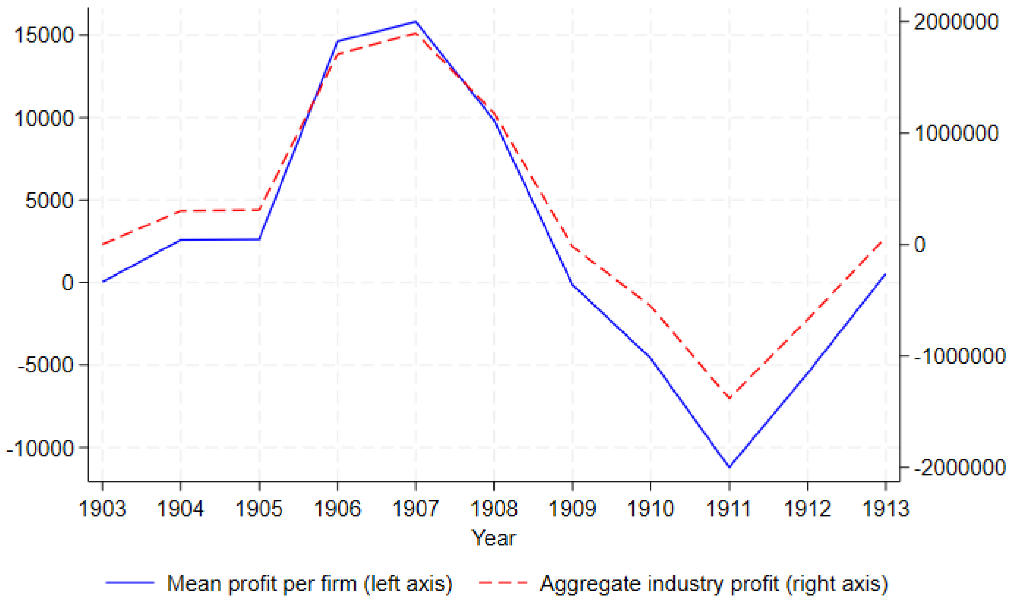
Table A.1 reports summary statistics for this cross-sectional data on hours worked by geological region.

Figure A.2: Descriptive statistics of Belgian coal mines over the business cycle, 1903-1913.



Notes: this figure plots the evolution of the aggregates (summed over firms) for selected outcomes, computed over the universe of mines. The base year is set to 100 in 1909. Coal production is measured in tons of coal. Days worked is a variable summing all days worked across firms in a given year. The blue line is the total labor expenditures across firms, expressed in nominal currency. The black line is the same variable divided by the price of output, i.e. expressed in units of numéraire.

Figure A.3: Profits in tons of coal over the business cycle for the average firm and the industry



Hours	**Mons**	**Centre**	**Charleroi**	**Namur**	**Liège**	**Total**
$(7.5, 9]$	2	2	0	5	30	39
$(9, 9.5]$	2	0	4	1	9	16
$(9.5, 10)$	1	0	0	0	2	3
$[10, 12]$	13	8	31	5	4	61
Total	18	10	35	11	40	114

Table A.1: Firm-level average daily hours worked for frontline workers before the reform, by geological region.

Table A.2: Unbalanced sample selection

Year	Matched	Population	Share of Covered (%)	
			Output	Days Worked
1903	114	124	99.51	99.33
1904	113	122	99.24	98.98
1905	112	121	99.26	98.74
1906	111	122	98.70	98.53
1907	111	125	98.37	98.11
1908	111	126	98.30	98.23
1909	111	125	98.16	98.03
1910	110	129	97.73	97.47
1911	110	132	97.44	97.12
1912	109	132	96.95	96.57
1913	108	132	96.86	96.17

Notes: unbalanced sample with information on hours worked versus the total number of firms in the country (*Population*) by year. The last three columns report the share of total output and days worked captured by the matched sample.

Table A.3: Balanced sample selection

Year	Balanced sample	Population	Share of Covered (%) Output	Days Worked
1903	99	124	86.80	86.68
1904	99	122	86.65	86.16
1905	99	121	86.63	86.12
1906	99	122	86.39	85.88
1907	99	125	87.05	86.09
1908	99	126	86.82	86.46
1909	99	125	86.89	86.66
1910	99	129	86.26	86.13
1911	99	132	86.07	85.99
1912	99	132	85.57	85.56
1913	99	132	85.74	85.33

Notes: balanced sample with information on hours worked versus the total number of firms in the country (*Population*) by year. The last three columns report the share of total output and days worked captured by the matched sample.

Year	**Merger or acquisition**		**Exits**	
	Treated	Control	Treated	Control
1903				
1904		1	1	
1905	1			
1906	1			
1907				
1908				
1909			1	
1910	1			
1911			1	1
1912	1	1		
1913		1		

Table A.4: Count of mergers & acquisitions and firm exits per year. A firm exit is defined as a zero coal production in the calendar year. Control or treatment status is counted on the consolidated entity after merger or acquisition.

Observe that there are 7 events of mergers and acquisitions in Table A.4 while there are only 6 fewer firms in 1913 than in 1903 in Table A.2. This comes from the fact that one firm, *Charbonnages de Haine Saint Pierre, La Hestre et Houssu*, was divided in 2 parts merged with two different firms in 1912: the *Houssu* merged with *Ressaix* while the *Haine-Saint-Piere et La Hestre* merged with *Mariemont*.

Table A.5: Summary statistics of firm-level variables for control and treated units (o, j) in 1903-1909.

	Control units	Treated units
Profits, units of numéraire	8,999.66	9,256.57
	(24,673.12)	(25,309.15)
TFP	1.111	1.093
	(0.190)	(0.130)
Labor share	0.602	0.598
	(0.050)	(0.043)
Total days worked	**327,758**	**403,856**
	(302,805)	**(272,987)**
Headcount employment	**1,094**	**1,353**
	(1,011)	**(908)**
Share underground employment	**0.751**	**0.727**
	(0.059)	**(0.055)**
Share frontline among underground	**0.267**	**0.244**
	(0.098)	**(0.044)**
Share of self-consumed production	**0.083**	**0.099**
	(0.052)	**(0.044)**
Yearly days worked per worker	298.31	298.08
	(9.98)	(6.90)
Daily product per worker, tons	0.586	0.582
	(0.147)	(0.106)
Output, tons per m^2	0.885	0.904
	(0.193)	(0.167)
Average power of coal veins, meter	0.662	0.684
	(0.143)	(0.132)
Yearly product per frontline miner, tons	**809.83**	**1,027.96**
	(418.40)	**(310.28)**
Output price, current BEF	**14.56**	**15.00**
	(1.87)	**(1.56)**
Investment-to-sales ratio	0.102	0.110
	(0.051)	(0.051)
h_reduction_j	**0.00**	**9.998**
	(0.00)	**(3.885)**
Observations	148	149

Notes: This table reports treated and control group average for selected firm-level variables with standard deviations in parentheses. A row x is in bold if the p-value of the t-test $H_0 : x_{\text{treated}} = x_{\text{control}}$ is smaller than 5%.

A.4 Additional empirical results

A.4.1 Firm-level outcomes

Employment: static DiD In Table A.6, I provide the DiD coefficient of the following regressions

$$y_{j,t} = \beta_0 + \beta * Post1909_j * \text{Treated}_j + \mu_j + TimeFE + \epsilon_{j,t} \tag{A.1}$$

$$y_{j,t} = \beta_0 + \beta * Post1909_j * \text{vol\_reduction}_j + \mu_j + TimeFE + \epsilon_{j,t} \tag{A.2}$$

where Treated_j takes value 1 when vol_reduction_j is strictly positive, and $Post1909_j$ takes value 1 when $t > 1909$.

Table A.6: Static difference-in-differences results for employment measures

	Total employment		Underground employment	
	Year FE	Prov×Year FE	Year FE	Prov×Year FE
Regression A.1	51.42**	80.00***	43.72*	70.78***
	(25.86)	(26.18)	(23.47)	(25.00)
Regression A.2	3.427	4.470	3.540	4.634
	(3.616)	(4.066)	(2.928)	(3.315)

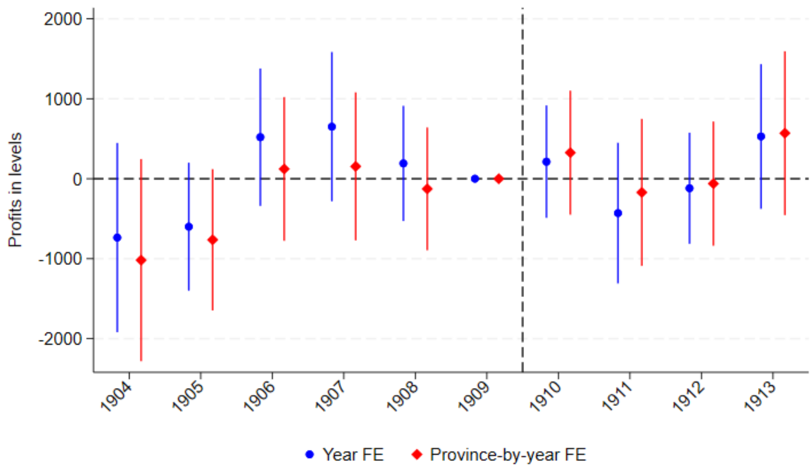
Notes: this table provides the DiD coefficients and standard errors for regressions of headcount total employment (in columns 2 and 3) and headcount underground employment (in columns 4 and 5) for two sets of time fixed effects. The first line are DiD coefficients when the regressor is a binary variable that is 1 when the firm is treated. The second line are DiD coefficient when the regressor is vol_reduction_j. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

One can see that the values for the continuous treatment specification are close to those obtained in the main text. The binary treatment gives an estimate of the ATT that ignores the heterogeneity of the intensity of the reform across treated firms.

Profits Results of regression 1 for profits are reported in Figure A.4. I do not detect any statistically significant effects on profits. The parallel trend assumption is violated by the statistical test for the regression with year fixed effects but not in the case of province-by-year fixed effects. I note that confidence intervals are very large: the confidence interval for $\hat{\beta}_{1911}$ implies an ATT included in the interval $[-\nu, +\nu]$ where ν is the cross-sectional average of profits for treated firms before the treatment. Although this absence of precision may be due to the design, it is not helped by the high volatility of profits in the dataset: the standard deviation of the year-to-year change in profits was 38,176 units of numéraire in the pre-reform period, i.e. four times larger than the mean profits. In Appendix Figure A.3, I confirm this volatility by showing the evolution of average profits per firm and industry profits over the business cycle.

I report the results for the regression equation 1 when the dependent variable is the

Figure A.4: Event-study results for firm-level profits (in units of numéraire).



Notes: this figure reports β_k in regression 1 of profits in units of numéraire along with standard errors are reported at the 95% confidence level. The p-value for testing $H_0 : \beta_k = 0\ \forall k < 1909$ are 0.0302 and 0.15 for the blue and red regressions, respectively. The within R-squared are 0.014 and 0.013, respectively.

firm's output price in Figure A.5 while Figure A.6 shows the output quantity. Panel (a) shows the outcome in levels while panel (b) shows the same outcome in logs.

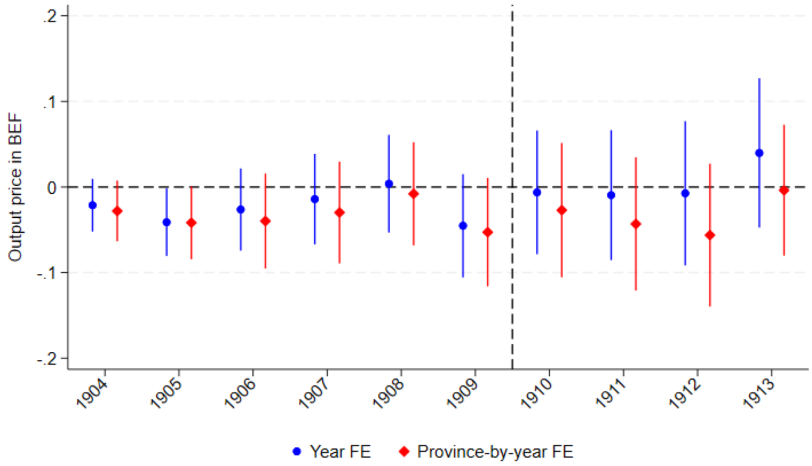
We can see that the reform has barely any effect on output prices: the point estimates are close to 0 and relatively precisely estimated. This is consistent with Delabastita and Rubens (2025) who documented that Belgian coal mines had no price-setting power in their output markets. We also obtained a zero effect on output quantities, although this effect is much less precisely estimated.

In terms of firms' investment and capital, the only information in the dataset are digging expenditures, which is somewhat crude and does not inform us on the quality and quantity of physical capital used in the mine. I report in Figure A.7 the results of regression 1 for digging investments in units of numéraire. We observe no discernible effect of the reform on this outcome.

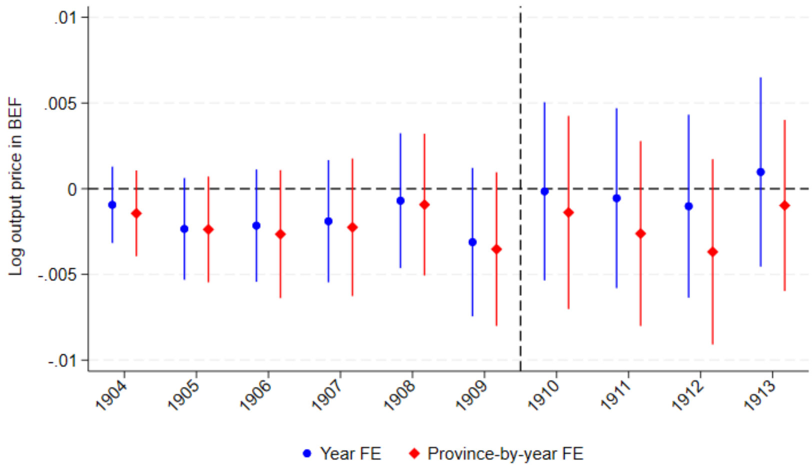
A.4.2 Occupation-level outcomes

In Table A.7 I report the static difference-in-differences (DiD) results for wage measures in log, which are obtained by running the equivalent of regressions A.1 and A.2 applied to the occupation-by-firm dataset, i.e. including occupation-by-firm fixed effects and occupation-by-year fixed effects, by analogy to main-text regression 2. The table shows that the DiD results are consistent with the story depicted above: hourly wages decreased in small firms and increased in large firms. In Figure A.8, I reproduce the main-text result of Figure 4. I omit the log of net-of-tax rate as well as log of hours worked, and I include the log of hourly wages.

Figure A.5: β_k in regression (1) of output price



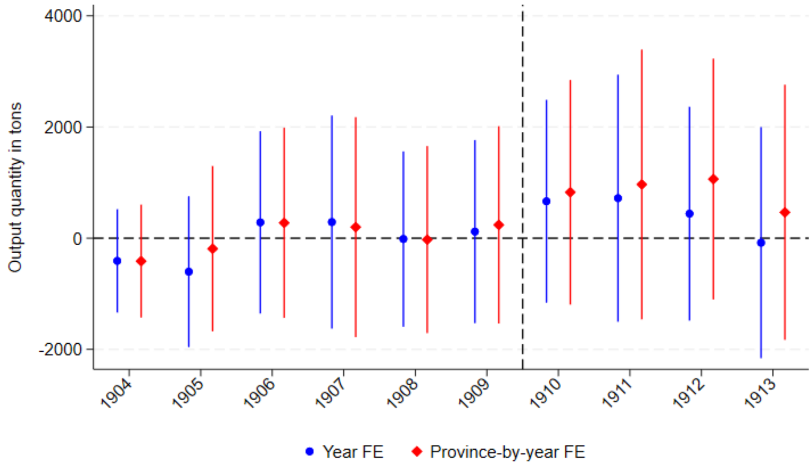
(a) In levels. P-values for H_0 are 0.20 (blue) and 0.23 (red) while within R-squared are 0.014 and 0.01 respectively.



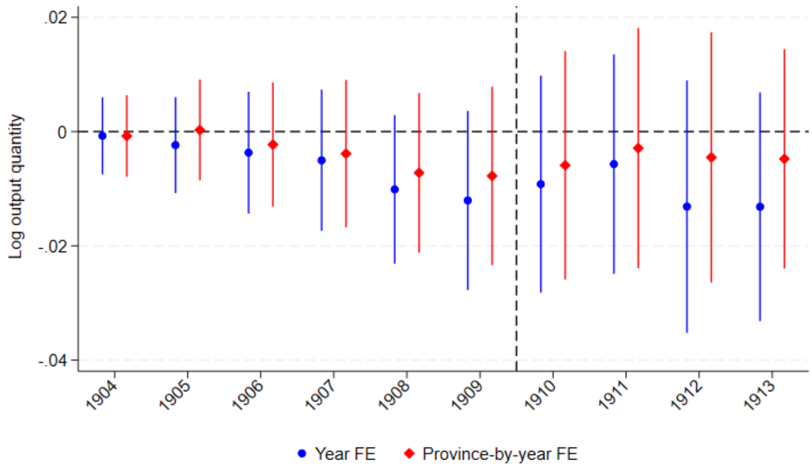
(b) In logs. P-values for H_0 are 0.40 (blue) and 0.41 (red) while within R-squared are 0.009 and 0.008 respectively.

Notes: standard errors are reported at the 95% confidence level. I report the p-value for testing $H_0 : \beta_k = 0$ $\forall k < 1909$ for the blue and red regressions, respectively as well as the within R-squared.

Figure A.6: β_k in regression (1) of output quantity



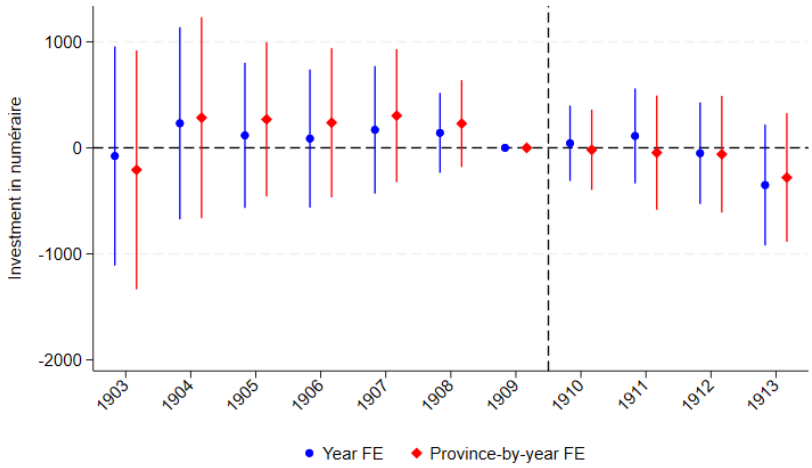
(a) In levels. P-values for H_0 are 0.38 (blue) and 0.60 (red) while within R-squared are 0.01 and 0.01 respectively.



(b) In logs. P-values for H_0 are 0.38 (blue) and 0.81 (red) while within R-squared are 0.02 and 0.01 respectively.

Notes: standard errors are reported at the 95% confidence level. I report the p-value for testing $H_0 : \beta_k = 0$ $\forall k < 1909$ for the blue and red regressions, respectively as well as the within R-squared.

Figure A.7: β_k in regression 1 for digging investment in units of numéraire



Notes: standard errors are reported at the 95% confidence level. The p-value for testing $H_0 : \beta_k = 0$ $\forall k < 1909$ is 80.91% in the red regression and 93.63% in the blue regression, while the within R-squared are 0.0051 and 0.0032, respectively.

Table A.7: Static difference-in-differences results for wage measures in log.

Outcome	**Log daily earnings**		**Log hourly wage**	
Regressor	$\text{Treated}_{o,j}$	$\text{h\_reduction}_{o,j}$	$\text{Treated}_{o,j}$	$\text{h\_reduction}_{o,j}$
All sample	-0.057*	-0.005*	0.013	0.003
	(0.033)	(0.003)	(0.032)	(0.003)
Small firms	-0.206**	-0.020**	-0.138	-0.013
	(0.0931)	(0.009)	(0.089)	(0.008)
Big firms	-0.005	0.0001	0.0616**	0.008***
	(0.027)	(0.002)	(0.026)	(0.002)

Notes: This table reports DiD coefficients and standard errors for regressions of log daily earnings and log hourly wages using the static equivalent of regression 2. For each outcome, the first column uses binary treatment and the second column uses the continuous treatment of the main text. Standard errors in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Figure A.8: β_k in regression 2 for wages and earnings

(a) Full sample.

(b) Subsample of units in small firms (bottom third of the size distribution).

(c) Subsample of units in big firms (top 66% of the size distribution).

Notes: standard errors are reported at the 95% confidence level.

B Theory Appendix

B.1 Wage effects in control submarkets

Consistent with qualitative evidence, I assume that control firms do not modify schedules after the reform. Consider firms active in submarkets when $l_m < 9 = \bar{l}$. As explained in the main text, the only effect of the reform on control firms is a perturbation of their applications, which are shifted to treated submarkets all else being equal. Taking the total derivative of the vacancies' first-order condition equation 4, one gets

$$\frac{d\theta}{d(1-\bar{l})}\bigg(\psi F'_N - wl + N^j\psi F''_N\bigg)\frac{\partial q}{\partial \theta} = dv^j\bigg(-\tilde{q}^2\psi F''_N\bigg) + dw\bigg(-\tilde{q}'_w N^j\psi_j F''_N\bigg)$$

where I use the fact that equation 5 holds with equality to simplify the factor multiplying dw. The left-hand side describes workers' reactions to the reform which occurs through equilibrium tightnesses, while the right-hand side governs how firms' decisions variables should react to the reform. Because the within-firm covariance between vacancies and wages is positive, dv^j and dw must have the same sign.

To fix ideas, imagine that the reform implies that workers redirect applications from control submarkets to treated submarkets such that the tightness in control submarkets increases $\frac{d\theta}{d(1-\bar{l})} > 0$. This has a positive effect on equilibrium wages dw if $\psi(F'_N + N^jF''_N) - wl \leq 0$. Using the markdown equation to substitute out for wl, one gets that this condition is equivalent to

$$\frac{N^jF''_N}{F'_N} \leq -\frac{1}{1+\epsilon^w}$$
$$-N^j\psi F''_N \geq \psi F'_N - wl$$

In other words, when this exodus of workers increases the marginal product of a job by a amount larger than the wage markdown, firms will increase hourly wage in control submarkets. This is more likely to happen when ϵ^w is large and the wage markdown is small, or when the production function is sufficiently concave in N. Recall that one can find firms of any sizes N^j_m in these control submarkets which must have the same marginal product of job i.e. $\psi_j > \psi_k$ implies that $N^j > N^k$. The wage effect can differ between these two firms, even if they were in the same submarket initially, because the ratio $\frac{N^jF''_N}{F'_N}$ changes with N.

Proposition 4. *If the reform shifts workers' applications from control to treated submarkets, the wage effects of a working time reduction in a given* ***control*** *submarket m for firm* *j for which* $\frac{d\theta}{d(1-\bar{l})} > 0$ *are*

$$\text{If } \frac{1}{1+\epsilon^w} \leq \frac{-N^j F_N''}{F_N'} \implies dw \geq 0$$
$$\text{If } \frac{1}{1+\epsilon^w} \geq \frac{-N^j F_N''}{F_N'} \implies dw \leq 0$$

Now, our reduced form estimates are $ATT_w = \mathbb{E}_{j\text{treated}}[dw|\text{ is treated}] - \mathbb{E}_{j\text{control}}[dw|\text{is control}]$. Remarkably, the sufficient conditions of this proposition are analogous to those of Proposition 2 in the main text. Hence, if $\frac{1}{1+\epsilon^w} \geq \frac{-N^j F_N''}{F_N'}$, wages fall in control submarkets but increase in treated submarkets, such that the ATT and event-study estimates must be positive. Hence, when wages increase in treated submarkets, they decrease in control submarkets under the proviso that monopsony and technology are identical.

Workers' reactions When the government reduces working time of long hours contracts $d(1-\bar{l}) > 0$, workers will react along two channels. First, ex-ante utility is affected in each submarket.

$$\frac{d\bar{U}}{d(1-\bar{l})} = \frac{\partial p_m}{\partial \theta_m} \frac{d\theta_m}{d(1-\bar{l})} u(w_m l_m, l_m) + p_m \frac{du(w_m l_m, l_m)}{d(1-\bar{l})}$$

In 'treated' submarkets where hours were long and the reform is binding, the second term is positive: the reform increases leisure which is unambiguously good for a fixed wage rate. Because ex-post utility increases in these submarkets, more workers apply to them. This effect is captured by the first term, which is negative: job quality has increased at the cost of job-finding probability.

In 'control' submarkets where hours were below the threshold, the second term of this equation cannot be signed, yet the first term is positive: the exodus of workers towards treated submarkets increases the probability of finding a job in control submarkets.

Second, the extensive margin reaction in equation 9 in equation implies that some workers will join the labor market when $d\bar{U}/d(1-\bar{l}) > 0$. However, this effect is scaled by $g(\bar{U} - u(B, 0))$, i.e. the mass of agents being indifferent between working in the mines and the outside option. Our empirical setting is unable to identify that quantity, but we may assume it is small given that an industry-specific regulation should have moderate aggregate effects.

B.2 Numerical simulation

The numerical simulation reported in Figure 7 assumes that all firms have the same CES production technology. First, let us take the total derivative of equation 4 in the case of treated submarkets.

$$\frac{dw}{w} + \gamma_v dv = \frac{1}{l}\frac{dl}{d(1-\bar{l})}\left[\frac{\beta l^{\rho}}{\alpha N^{\rho}}\frac{\epsilon^w}{1+\epsilon^w} - 1 + \frac{1}{\epsilon^w}\frac{\rho}{1-\rho}\right]$$

where γ_v is some positive coefficient. This tells us that the term between brackets is necessary and sufficient for determining the sign of the wage effect. In the main-text Figure 7, I plot the regions where $dw > 0$ in red and the regions $dw < 0$ in blue in the space (ρ, N). This is achieved by determining the sign of the bracketed term when one assumes some values for α, β and ϵ^w.

Rather than plotting all the points in the (ρ, N) space, I restrict my attention to those that are compatible with workers calling for a working time reduction $\tilde{q}_l' < 0$. This is achieved by using Proposition 1.