Working time reductions and monopsony power

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Abstract

This paper studies the consequences of working time reductions when labor markets may be monopsonistic. In a general equilibrium model that unbundles labor inputs into hours and jobs, I show that the marginal utility of a small working time reduction is zero in perfect competition but may be positive in monopsony. However, the policy increases wage rates in perfect competition but decreases monopsonistic wage rates. I test these predictions empirically by evaluating the first-ever working time reduction in Belgium: the maximum 9h workday in 1910's coal mines. I find that the policy had sizable negative effects on profits, employment and earnings. To assess welfare, I generalize the findings to a directed search model with matching frictions where firms have heterogeneous productivity. Utilitarian welfare is expressed in terms of a sufficient statistic whose application to the 1910 reform suggests that the value of leisure was particularly large.

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1 Introduction

Since the Industrial Revolution, labor movements have fought for higher wages and shorter working time per day, per week and per year. Government-mandated working time reductions emerged at the beginning of the 20th century and remain highly heterogeneous across countries to this date. For instance, in France minimal paid time off was set at two weeks in 1936 and amounts to five weeks today, while the United States do not have any nationwide mandate on vacations.

Despite their importance, working time reductions are scarcely justified in public economics because neoclassical labor supply theory assumes that workers choose hours at some wage rate such that any intervention on hours is paternalistic. Moreover, empirical evaluation in labor economics of the pure effect of such policies is challenging because they are typically implemented alongside other measures to compensate firms' losses.

The present paper makes progress on these questions by studying the causes and consequences of working time reductions when labor markets may be monopsonistic. I study a general equilibrium model of the labor market where workers face the canonical leisure-consumption trade-off and firms' labor inputs are unbundled into hours per job and number of jobs. This allows to study the equilibrium codetermination of hours worked, employment and wage rates. I derive two main findings.

First, if firms have monopsony power and the output elasticity of hours is larger than the output elasticity of a job, workers will work long hours. More precisely, the contract offered will feature a wage-hours combination where the marginal utility of working an extra hour is negative at that wage rate for the worker: the negative effect on leisure dominates the positive effect on earnings. This is in sharp contrast to the neoclassical labor supply prediction where the marginal utility of working an extra hour must be zero and workers choose their preferred hours.

Second, this model derives empirical predictions for the effect on wages when there are decreasing returns in production: a working time reduction decreases wage rates in a oligopsonistic labor market but the very same policy increases wage rates in perfect competition. Intuitively, in the pure monopsony case, a working time reduction increases participation to the extent that the monopsonistic firm is able to decrease wage rates. Conversely, in a perfectly competitive labor market, workers' earnings are equal to their marginal product. Decreasing returns per hour implies that a working time reduction by one unit engenders a reduction of marginal product by less than one unit. Hence, earnings decrease proportionally less than hours worked, which implies that competitive wage rates have increased after the reform.

In order to test these empirical predictions, the paper evaluates the first-ever working time reduction implemented in Belgium: the 9 hour maximum workday in coal mines in 1910. It is an ideal setup for at least two reasons. First, as one of the first piece of labor legislation in the country, the law was not coupled with compensatory measures nor wage regulations such that we should be able to observe the pure effect of the policy.[1] Second, there was no downward nominal wage rigidity at the time which should allow to test for wage cuts.

I digitized and assembled administrative datasets from archival sources covering the near-universe of coal mines in the country from 1903 to 1913. The identification strategy follows an event study design and relies on comparing post-reform outcomes of firms with different scheduling practices before the reform. I find sizable, short-run, negative effects of the reform on profits, employment and earnings: a one-hour reduction in miners' working day reduces profits by 88%, employment by 6% and wages by 7% on average over affected firms.

While leisure increased, wages, employment and profits fell. To assess whether this reform was welfare-improving, I embed the model and these results into a directed search model and competitive search equilibrium of the labor market à la Moen (1997) where firms are heterogeneous in productivities. Matching frictions ensure that all participating workers have some non-degenerate job-finding probability. Hence, when a government grants extra holidays, ex-post utilities increase conditional on employment but job-finding probabilities might decrease. In turn, this model aggregates individuals' micro leisure-consumption trade-offs in a macro arbitrage between wages, employment and hours worked.

As in Vergara (2023), this competitive search equilibrium is compatible with any degree of monopsony power. Indeed, when a firm increases wage rates, it will attract new applicants. Yet, because of matching frictions, the probability that these additional applications fill a vacancy is less than one. Workers internalize these frictions such that only a finite number apply. As a result, the labor supply curve observed by the firm is not infinitely elastic and this creates some monopsony power in equilibrium. I derive two main findings.

[1]For example, the French 35h workweek reform studied in Chemin and Wasmer (2009) was accompanied with payroll tax cuts. In the US, Roosevelt's working time reductions were accompanied with wage regulations (see Fishback et al. (2024) for the National Industrial Recovery Act of 1933 and Costa (2000) for the Fair Labor Standards Act of 1938).

First, I study how heterogeneous firm sort in the contract space. It is shown that firms with higher productivity offer contracts with higher wage rates, shorter hours, and a higher job quality but lower job-finding probability. On the workers' side, a local increase in the preference for leisure leads to a higher equilibrium wage rate and lower hours worked.

Second, I derive sufficient statistics and quantity welfare gains. Interestingly, welfare may be assessed without assumptions on production nor 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). I estimate that the average utility gains in leisure must have been sizable for the Belgian reform to produce welfare gains.

Overall, the paper makes two kind of contributions. On the positive side, the paper derives empirical predictions for the wage effects of working time reductions and shows that they differ with the degree of firms' labor market power, i.e. monopsony power. These results can act both as a characterization of monopsony power as well as a detection test. On the normative side, the paper derives sufficient statistics for welfare evaluation of any working time regulation in a general equilibrium environment with rich heterogeneity, matching frictions and imperfect competition in the labor market. In terms of policy, the paper suggests that working time reductions are appealing for workers in monopsonistic markets but their equilibrium effects on wages and employment may offset the welfare gains.

Section 2 discusses the relationship with the literature. Section 3 presents a baseline model of the codetermination of wages, hours and employment and contrasts the effect of working time reductions on marginal utility and wage rates in the pure monopsony equilibrium versus the perfect competition equilibrium. Section 4 presents a reduced-form empirical evaluation of the Belgian coal mines 1910 maximum workday and test for these predictions. Section 5 generalizes the model with a competitive search equilibrium between firms with heterogeneous productivities and workers with heterogeneous leisure preferences and it studies the effects on welfare. Section 6 concludes.

2 Literature

Canonical labor models This paper merges two standard models in labor economics. On the one hand, leisure-consumption trade-offs determines labor market equilibrium like in Rosen (1974, 1986)'s hedonic theory of wages. On the other hand, the model features directed search and competitive search equilibrium[2]. 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. The present paper adds working time and hedonic wages to Vergara (2023) who studied minimum wages in a competitive search equilibrium.

Working time regulations Descriptive facts on vacations can be found in Altonji and Oldham (2003) and Altonji and Usui (2007). Marimon and Zilibotti (2000) and Rocheteau (2002)[3] considered that a working time reduction is desirable if it reduces unemployment. In the present paper, social welfare encompasses the tradeoff between the terms of jobs and the number of jobs. Carry (2023) studied a unique minimum workweek policy in France and builds a model with quasilinear utilities and random search. All of these papers model wage-hour determination as the outcome of bargaining while the present model has contract posting which features two advantages. First, it allows me to escape the assumption that bargaining power is invariant to policy changes, which seems implausible in the present context. Second, posting has been found more relevant than bargaining empirically for low-wage jobs (Caldwell & Harmon, 2019; Hall & Krueger, 2012; Lachowska et al., 2022).

Importantly, Fishback et al. (2024) studied the effect of the introduction of the maximum workweek in the US during the Great Depression which was accompanied with wage and earnings floors. There are several important differences with the current paper. First, the policy in the US was motivated by work-sharing arguments in a acute recession where unemployment was plaguing the economy. This is not the case in the Belgian 1910 context: the business cycle was neither booming nor recessionary. Second, they find massive positive effect on employment while we find the opposite effect. Third, they study a perfectly competitive labor markets with voluntary unemployment, while we allow for the possibility of monopsony power and involuntary unemployment.

Hours and employment Empirical studies found conflicting effects of wage and hours regulations. Some papers documented that increases in minimum wages lead to decreases in hours worked (Di Nola et al., 2023; Gandhi & Ruffini, 2022; Jardim et al., 2022; Kim et al., 2023) but Vergara (2023) finds no effect. Most minimum wage studies finds no effect on employment (Cengiz et al., 2019; Manning, 2021). Gravoueille

[2]Key references include Acemoglu and Shimer (1999), Eeckhout and Kircher (2010a, 2018), Guerrieri et al. (2010), Kircher (2009), Moen (1997), Vergara (2023), and Wright et al. (2021)

[3]Other related papers include Fagnart et al. (2023), Lang and Majumdar (2004), Osuna and Rıos-Rull (2003), and Willington and Navarro (2015). Chemin and Wasmer (2009) studied the French 35-hour workweek and Fishback et al. (2024) studied the Roosevelt working time reduction during the Great Depression.

(2023) showed that an increase in low-earners wage subsidies led to an increase in hours worked but a decrease in wage rates. Carry (2023) finds that low-hours contract restrictions led to a decrease of low-hour jobs at the extensive margin and an increase in the intensive margin of full-time jobs. The present paper provides a unifying theory for such results. Its key elements are the output elasticities of hours versus hires as well as the degree of monopsony power.

Amenities The literature has focused on positive questions[4] such as the relationship of amenities to earnings and productivity (Mas & Pallais, 2017, 2020; Ouimet & Tate, 2023; Sockin, 2022; Sorkin, 2018), monopsony power (Lamadon et al., 2022), job search (Hall & Mueller, 2018), and minimum wages (Clemens, 2021; Clemens et al., 2018). However, the normative aspects of regulating amenities have not been addressed such that the present paper complements this literature. A notable exception is Nekoei (2023) who suggests that mandating amenities can improve efficiency if there is adverse selection à la Akerlof. Yet, in Nekoei (2023) amenities do not have productive value for the firm per se, contrary to hours worked in the present paper.

3 Baseline model

In this section, I contrast the effects of working time reductions between two polar cases: pure monopsony and perfect competition.[5] The model will not impose parametric assumptions neither on preferences nor on production, but it will be assumed that (i) production is concave in jobs and (ii) that the output elasticity of hours exceeds the output elasticity of hires.

Labor supply There is a mass of workers with a utility function $u(c, l)$ which is increasing and concave in consumption c and nonincreasing in hours worked l. Workers receive a wage rate w for each hour worked such that $c = wl$ in equilibrium. Interesting, the marginal utility of an extra hour $\frac{\partial u(\cdot)}{\partial l} = wu'_c + u'_l$ has an ambiguous sign : at low hours, workers would like to work more because the positive consumption effect dominates the negative leisure effect while this is reverted for long hours. Workers are only heterogeneous in an outside option to the labor market which gives utility $d \geq 0$ distributed by a strictly increasing and concave cumulative distribution function $G(d)$. As a result, labor supply N_s is given by $N_s(w, l) = G(u(wl, l))$ and it follows from workers' preferences that $N_s(w, l)$ is increasing in wage rates w and inversely U-shaped (hence concave) in

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

[5]In Appendix A.2, I micro-found these polar cases by building a game-theoretic model compatible with any degree of monopsony power and nesting these two cases.

hours worked l. I additionally require $N_s(w,l)$ to be supermodular such that $\frac{\partial N_s(w,l)}{\partial w \partial l} \geq 0$ which implies that an extra hour worked increases the wage elasticity of labor supply.

Labor demand Firms are owned by capitalists and produce a single output, taken as the *numéraire*, using labor as input. In this paper, the production function unbundles labor inputs into the number of jobs N and hours worked per job l. In this toy model, I assume a Cobb-Douglas specification.[6] The total payroll cost is the product of the workforce size N and earnings per worker wl. As a result, profits read

$$\pi = N^\alpha l^\beta - Nwl$$

The key assumption in this toy model is that $\alpha < \beta < 1$.[7] Concave production in jobs (i.e. $\alpha < 1$) can be seen as a reduced form for fixed cost of hiring while concavity in hours (i.e. $\beta < 1$) could reflect fatigue on the job. Importantly, it is assumed that production is more concave in jobs than in hours by $\alpha < \beta$. In other words, marginally increasing the hours worked by existing employees yields more output than marginally hiring a new employee. This could be micro-founded by on-the-job experience effects: new workers have to be trained to the tasks and get accustomed to the workplace such that their marginal product is lower.

Monopsony equilibrium In pure monopsony, the single firm chooses both the wage rate w and schedule[8] l so as to maximize profit and internalizes that labor demand N must equal labor supply $N_s(w,l)$.

$$\max_{w,l} N^\alpha \, l^\beta - N \, wl \text{ s.t. } N = N_s(w,l)$$

The first-order conditions for an interior solution reads:

$$\begin{aligned} \frac{\partial N_s}{\partial w}(\alpha N^{\alpha-1} l^\beta - wl) - Nl = 0 \\ \frac{\partial N_s}{\partial l}(\alpha N^{\alpha-1} l^\beta - wl) + \beta N^\alpha l^{\beta-1} - wN = 0 \end{aligned} \tag{1}$$

[6] This is sufficient but not necessary for the results. I relegate this discussion to Appendix A.

[7] Contrary to Carry (2023) and Lachowska et al. (2023), my model does not specify structurally an optimal number of hours for firms. Rather, optimal hours are endogenized by the labor production process. The assumption of a larger output elasticity of hours rather than jobs is consistent with the findings of Carry (2023) who showed that *minimum* workweek restrictions in France lead to a decrease of jobs and an increase in hours worked.

[8] Lachowska et al. (2023) showed empirically that firms have some discretion over hours worked today. Clark (1994) documented similar patterns in English factories at the Industrial Revolution. Card (1990), Chetty et al. (2011), Kahn and Lang (1991), Labanca and Pozzoli (2022, 2023), and Moffitt (1982) documented hours constraints within production processes while Bell (1998) and Stewart and Swaffield (1997) surveyed workers preferences for hours.

where the index on equilibrium N is omitted for brevity.
Equation (1) is the familiar Robinson (1933) markdown equation: when firms choose wages, earnings wl are marked down relative to the marginal productivity of jobs $(\alpha N^{\alpha-1}l^{\beta} - wl) > 0$. The second equation shows that the sum of markdowns over both inputs should be zero. Moreover, by multiplying the earnings markdown of equation (1) by $\frac{N}{l}$ and using $\alpha < \beta$, we get that payroll per hour is also marked down relative to the marginal product of hours [9] such that $\beta N^{\alpha} l^{\beta-1} - wN > 0$. In other words, in pure monopsony firms will select wage rates and hours such that there is a double markdown on the input remuneration of hours and jobs. As a result, the second equation implies that the marginal utility of an extra hour is negative for workers $\frac{\partial N_s}{\partial l} \leq 0$. Hence, given the equilibrium wage rate, workers would like to work *less* at the monopsony equilibrium because $\alpha < \beta$.

In order to assess the wage effect of working time reduction, observe that equation (1) can simply be rewritten as follows:

$$\alpha N^{\alpha-1} l^{\beta-1} - w = \frac{N}{\partial N_s / \partial w}$$

First, as workers would like to work less, a working time reduction increases N while decreasing l. This has two effects of opposite signs on the marginal product of a job per hour worked $\alpha N^{\alpha-1} l^{\beta-1}$. On the one hand, because l decreases, one has that $\alpha N^{\alpha-1} l^{\beta-1}$ increases proportionally to $1 - \beta$. On the other hand, because N increases, one has that $\alpha N^{\alpha-1} l^{\beta-1}$ decreases proportionally to $1 - \alpha$. Now because $\alpha < \beta$, we can assert that the negative effect dominates, such that the marginal product of a job per hour worked $\alpha N^{\alpha-1} l^{\beta-1}$ decreases after the reform. Second, on the right handside, the numerator increases while the supermodularity of labor supply ensures that the denominator decreases. This is equivalent to saying that the working time reduction has rendered the labor supply less elastic to wage rates. Overall, the right handside increases and the first term of the left handside decreases, which forces w to decrease. Hence, a working time reduction decreases monopsonistic wage rates.

Competitive equilibrium In perfect competition, firms are price-takers. Workers choose their schedules at some wage rate, firms decide on profit-maximizing employment and wage rates adjust for market-clearing.

$$\begin{aligned} N_d = \arg\max_N N^{\alpha} l^{\beta} - Nwl &\implies & \alpha N_d^{\alpha-1} l^{\beta} - wl = 0 \\ l^* = \arg\max_l u(wl, l) &\implies & w u'_c + u'_l = 0 \\ w \text{ s.t.} & & N_d = N_s(w, l) \end{aligned} \tag{2}$$

[9] Indeed, $\beta N^{\alpha} l^{\beta} - wN > \frac{N}{l}(\alpha N^{\alpha-1} l^{\beta} - wl) > 0$ is a consequence of $\alpha < \beta$.

Three remarks should be raised. First, equation (2.2) implies that profits will be positive in the competitive equilibrium. This comes at no surprise given the decreasing returns in production. As a result, the existence of positive profits is not sufficient to detect imperfect competition in our setting. Second, equation (2.2) also says that the markdown on earnings has vanished in perfect competition, while it was positive in the monopsony case in equation (1). Third, workers' optimization implies that $\frac{\partial N_s}{\partial l} = 0$ in perfect competition, i.e. workers are at their preferred schedules given the wage rate.

In Figure **??**, I prove graphically that a working time reduction will increase competitive wage rates. To see this, observe that the marginal product of job $\alpha N^{\alpha-1} l \beta$ is an increasing concave function in hours worked. Moreover, the fact that $\frac{\partial N_s}{\partial l} = 0$ implies that small working time reduction have no first-order impact on participation. Because earnings must equal the marginal product of a job, the earnings schedule wl is also a concave function of hours worked l. As a result, a working time reduction decrease hours by more than earnings, such that competitive wage rates must increase.

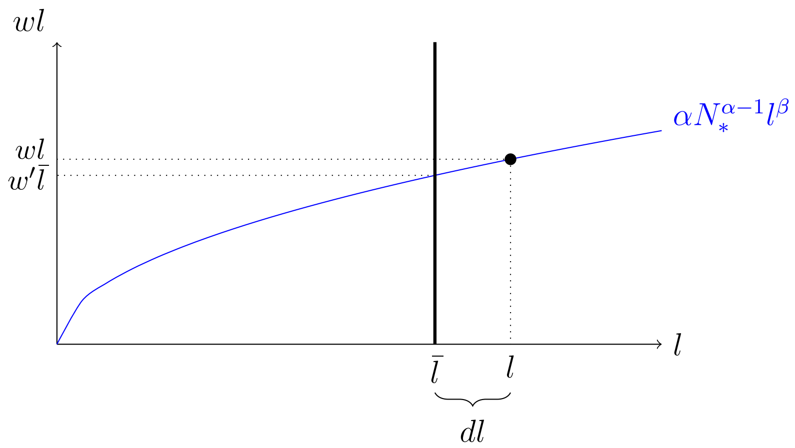


Figure 1: *Graphical proof of the wage effect of a working time reduction in perfect competition. The blue locus reflect the marginal product of job. Before the reform, the competitive equilibrium is (l, wl). After a marginal working time reduction of dl, the blue locus is unchanged as $\frac{\partial N_s}{\partial l} = 0$ and the new equilibrium is $(\bar{l}, w'\bar{l})$. Earnings decrease by less than hours worked, hence competitive wage rates increase after a working time reduction.*

In this section, we have learned two key features of monopsony contracts relative to perfect competition when production is such that the output elasticity of hours exceeds the output elasticity of hires. First, in pure monopsony, workers would like to work less at the wage rate offered while the marginal utility of an extra hour is zero in perfect competition. Second, a working time reduction decreases monopsonistic wage rates but increases competitive wage rates.

These results deserve some comments. The first result suggests that workers are more likely to be favorable to government-mandated working time reductions if they are subject to a monopsonistic contract. The second result suggests that minimum wages and maximum workweek are substitutable policy tools in perfect competition but complementary in monopsony.[10] As a result, the coexistence of wage and hours regulations seems more likely to be justified in monopsonistic labor markets.[11] Finally, the second result may act as an empirical test to reject perfect competition in the labor market. If an empirical evaluation of a working time reduction does not find positive effects on wage rates, this model suggests that the labor market is not competitive. The next section evaluates this empirical prediction.

4 Reduced-form policy evaluation

4.1 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 (Philips & Buyst, 2020).

The policy under study is the first major piece of labor regulation affecting prime-age males in the country.[12] Meanwhile, neighboring countries already had some form of working time regulations in the mining industry: for example, France had a maximum workday of 10 hours in 1900 and 8 hours in 1905.[13] Compared their competitors, Belgian coal mines were relying more on manual labor and less on mechanized extraction (Denoël, 1909). They also exhibited a smaller mortality risk (Leboutte, 1991) despite longer workdays (Cousot, 1908).

The policy was passed on December 31, 1909 and imposed that a workday for underground workers could not exceed 9 hours 30 minutes from January 1, 1911 and 9

[10]Price versus quantity controls in (competitive) general equilibrium have a long history and were studied among others by Drèze (1975), Dworczak et al. (2021), and Guesnerie and Roberts (1984).

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

[12]Earlier regulations were mostly 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 refrom 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).

[13]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).

hours from January 1, 1912.[14]. Before this, there was no regulations on daily schedules. Exceptions were granted for some specific underground occupations such as horseman or cagers, but these exceptions may not exceed one hour per day. Violations were subject to civil fines and criminal charges.

There are two main reasons why studying this reform is interesting with respect to our research question. First, there is no confounding policy at the same time: there was no income tax 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. In Figure **??**, we show that wages display a striking cyclicality both in nominal and real terms. This holds both for the average firm-level wage in panel (a) and for the aggregate variables in panel (b). It also holds in terms of average wage per worker as well as firm-level labor expenditures. In principle, if working time reductions were inducing wage cuts, our setting should allow us to observe them.

4.2 Data

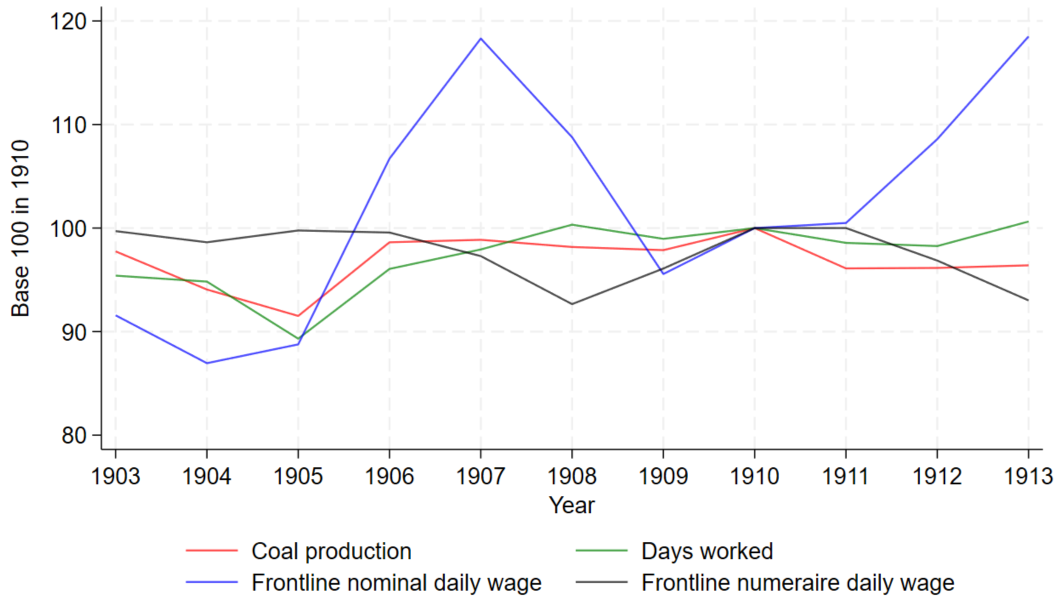
I use administrative data retrieved from archival sources. The coal mining industry was closely scrutinized by the government for several reasons. First, coal mines were subject to a tax (composed of a fee and a linear rate), although it only raised a modest amount: 1.5 million BEF in 1903 i.e. 0.3% of the state's revenue (Chamber of Representatives, 1903). Second, coal mines were important to the state for industrial, political, social, and economic factors. More than 100,000 workers 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 leased for private exploitation[15], 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 in August, state officials[16] were sent to each mine

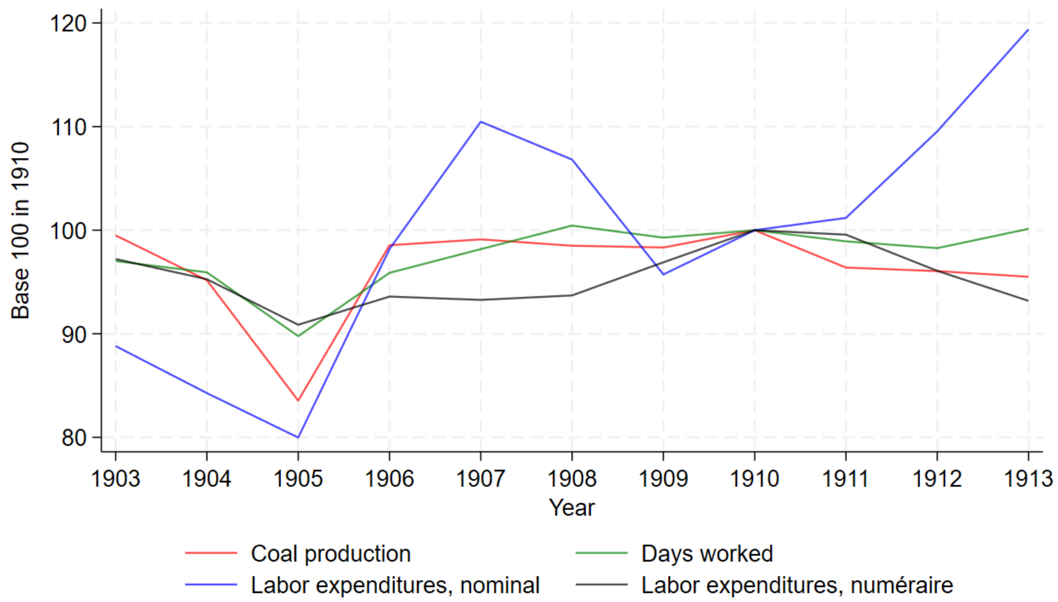
[14]Working time must be understood as *from bank to bank*, i.e. the time from the surface at the beginning of the working day to the time at the surface at the end of the working day. Hence, it includes the time in the lift as well as time needed to walk from the lift to the work station.

[15]This tradition was inherited from the French domination 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 third of national production.

[16]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.



(a) Evolution of the cross-sectional average for selected firm outcomes with respect to base year 1910. Coal production is measured in tons of coal while total days worked include all occupations within the firm. The frontline daily wage is the firm-level average wage paid for a working day to frontline miners. The blue line is the nominal wage in current Belgian francs while the black line is expressed in terms of the numéraire, i.e. divided by the price of output.



(b) Evolution of aggregates over firms for selected outcomes with respect to base year 1910. Coal production is measured in tons of coal while total days worked include all occupations within the firm. The blue line is the nominal labor expenditures in current Belgian francs while the black line is expressed in terms of the numéraire, i.e. divided by the price of output.

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

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 C.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 (forthcoming) digitized the provinces of Liège and Namur. In 1910, the province of Hainaut accounted for 71% of national coal production and 67% of labor expenses. 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 production, costs, employment and wages but not on daily working time. Yet, as one of the first piece of labor legislation, this reform was highly controversial in parliament[17] which initiated a parliamentary commission. This commission produced over 3000 pages of documents and requested information on daily hours worked to the Mining Administration. The latter collected firm-level hours worked in August 1900 and published the data in parliamentary proceedings in 1907 while noting that "*the situation has barely changed since then*" (Annales des Mines, 1907, p.556). Table 1 reports summary statistics for this cross-sectional data on hours worked by geological region.

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

We observe that before the reform, more than half of the mines were above the 9 hour threshold. While geology seems to play a role as workdays are longer in Mons than in

[17]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. These interviews are helpful to understand the labor conflict : all owners opposed the reform and threaten to compensate its effect by cutting wages while all workers were in favor of the reform. Some workers were in favor of the reform even if wages were cut while others opposed wage cuts (Parliamentary Commission, 1909).

Liège geological regions (Vandervelde, 1911), there also exists within-region variation.

Overall, the cross-section of hours worked contains 114 firms which is a fraction of the universe of firms contained in the panel. All estimations below are computed on a dataset matching this panel with the cross-section of hours worked. As reported in appendix Table C.2, this matched dataset covers more than 96% of production and employment. The unbalanced panel of firms contains entities that merged, were acquired or exited the market. In the remainder, I consider that a merged entity is a new firm while an acquired firm espouses the identity of its acquirer. For details on the construction of variables, I refer the reader to Appendix C.

4.3 Policy evaluation

The empirical strategy uses pre-reform hours worked as a measure of exposure to the reform. I construct the continuous variable Exposure_j as the difference between the hours worked by frontline workers at firm j and the maximum workday of 9 hours. It is set to 0 for a firm which was already below the 9h threshold before the reform.

$$\text{Exposure}_j = \max\{\text{Frontline\_Hours}_j - 9; 0\}$$

The main specification follows the following regression equation:

$$y_{j,t} = \beta_0 + \sum_{k \neq 1909} \beta_k \times \text{Exposure}_j \times \mathbf{1}_{t=k} + \mu_j + \nu_{r,t} + \beta X_{j,t} + \epsilon_{j,t}$$

where $y_{j,t}$ denotes the outcome for firm j in year t, μ_j and $\nu_{r,t}$ are firm and region-by-year fixed effects respectively, $X_{j,t}$ are a set of controls and standard errors $\epsilon_{j,t}$ are clustered at the firm level. The coefficients β_k are the object of interest. Because of the construction of Exposure_j, β_k can conveniently be interpreted as the average effect in year k across treated firms of a mandated one-hour reduction. The omitted year is set to 1909 which is the last year before the law is passed.

This strategy is standard in the policy evaluation literature (Carry, 2023; Harasztosi & Lindner, 2019; Saez et al., 2019). The identifying assumption is that firms with different hours worked before the reform would have had parallel evolution in their outcomes if the reform had not happen. This assumption could be rejected if β_k significantly differs from 0 in years prior to the reform.

Profits. I find a large and negative effect of the reform on profits: a reduction of one hour per day reduces profits by 7487 and 5913 tons of coal in 1911 and 1912 respec-

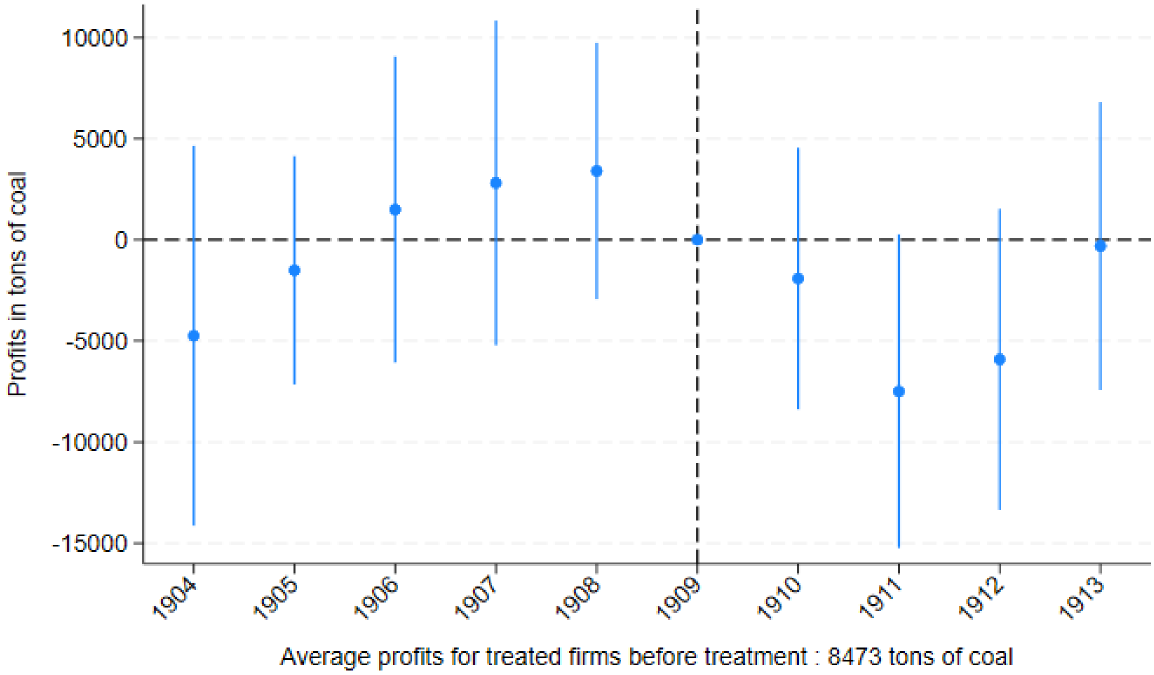


Figure 3: β_k for each year if $y_{j,t}$ are firms' profits in units of the numéraire. Controls $X_{j,t}$ are size of exploitation at the surface in squared meters, TFP, average power of coal veins, share of frontline workers, share of underground workers and tons of coal of auto-consumption. The p-value for $H_0 : \beta_k = 0 \ \forall k < 1909$ is 0.54. The within R-squared is 0.1830.

tively, but only the former is statistically different from 0 as reported in Figure 3. These effects are economically significant as the average profit for firms above the 9h threshold before 1910 was 8473 tons of coal. This confirms anecdotal evidence that the reform was not anticipated and had largely adverse effects on mine owners. I now decompose the results into firms' reactions along the extensive and the intensive margins.

Extensive margin Given adverse effects on profits, firms may react to the policy along the extensive margin by exiting the market. In appendix Figure **??**, I report the count of firms' exit per year. While only one firm exited the market in the period 1903-1909, 6 firms shut down operations after 1909. The remainder of the results will be computed on the subsample of firms that will never shut down operations over the entire period sample.[18]

Intensive margins In Figure **??**, I report the values of β_k for regressions with the log of employment in panel (a) and wages in panel (b) for frontline workers as outcomes.[19] I find that a mandated one-hour reduction of working time reduces employment by 6.13%

[18]This is motivated by the fact that intensive margins responses are comparable when one uses log transformations for which 0 values create indeterminacy. See Chen and Roth (2024) for a characterization of the problem and motivations for splitting results along the intensive and extensive margins.

[19]The patterns for other workers category follow similar patterns.

and wages by 7% in 1913, although these estimates are somewhat noisily estimated in the sense that the parallel trend hypothesis may be rejected. However, in panel (c) I show the effect on the average product per frontline worker: a mandated one-hour reduction increases average product per worker by 6.5 % and this effect is significant.

Overall, these results suggests that the policy had a negative effect on wages and employment as well as a positive effect on the average product of workers. Importantly, wage here is measured as earnings wl per unit of output produced, i.e. the total compensation received by frontline miners in a year divided by the monetary value of their annual production of coal. In order to retrieve wage rates w, we must divide this by hours worked l.

So far, the results for wage rates are inconclusive and not reported here. This could be due to several factors. First, the statistical test for parallel trends on the earnings outcome suggest that there is a violation. I will add a control to attenuate this: a firm's exposure to strikes in its town. Second, it could be due to heterogeneity with some workers in competitive markets while others in monopsonistic markets such that the average effect is zero. Third, it could be that the mines' production function violates the assumptions of section 1.

5 General model

In this section, I embed the model of section 1 into a larger model where firms have heterogeneous productivities. The labor market features directed search and contract posting[20] as in the seminal paper by Moen (1997) but it is kept static as in Vergara (2023).[21]

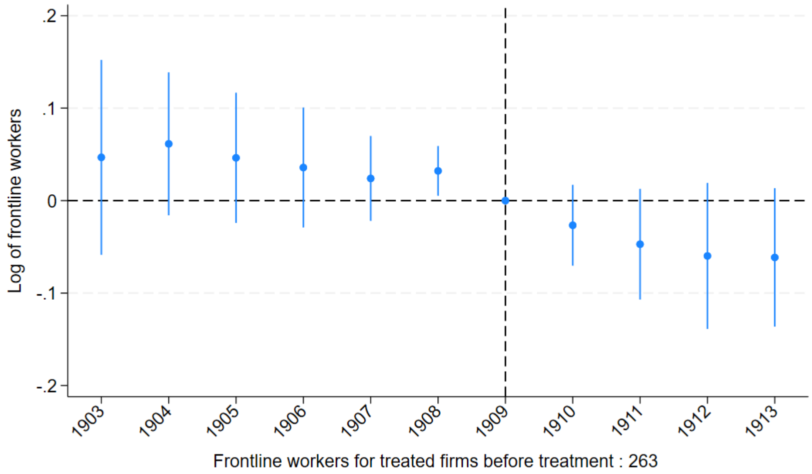
5.1 Directed search model

Labor market Consider a set of measure L of workers who are each endowed with a unit of time.[22] 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 for each type. Workers are applying to one vacancy among

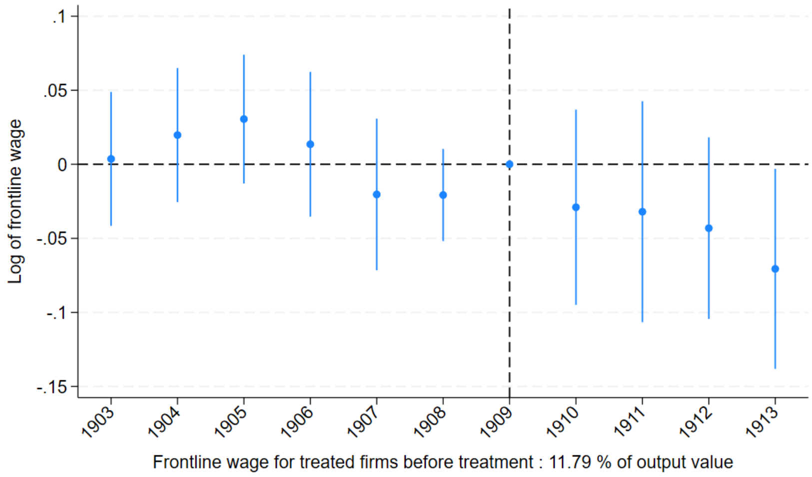
[20] There is a long literature exploring the relevance of posting in labour market. For example, Eeckhout and Kircher (2010b) showed that price posting (sorting workers types ex-ante) emerges as an equilibrium trading mechanism rather than auctions (screening workers types ex-post) when the meeting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

[21] The key difference with Vergara (2023) is the presence of leisure.

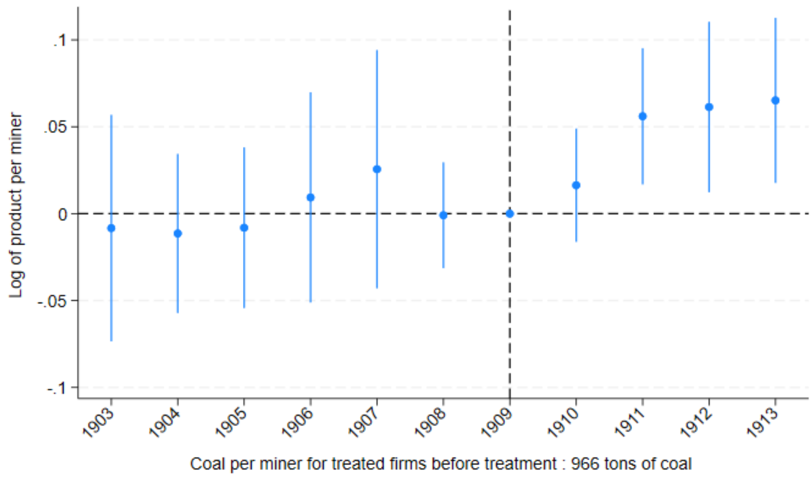
[22] All the analysis in this section could be carried out in a model where workers have heterogeneous types as long as firms observe it and the labor market is segmented.



(a) Log of the number of frontline workers. The p-value for H_0 is 0.31. Within R-squared is 0.45.



(b) Log of wage for frontline workers.The p-value for H_0 is 0.05. Within R-squared is 0.61.



(c) Log of average yearly product per frontline worker. P-value for H_0 is 0.66. Within R-squared is 0.68.

Figure 4: β_k for each year. Standard errors are reported at 95% confidence level. I report the p-value of the joint statistical test with $H_0 : \beta_k = 0$ for all $k < 1909$. Controls $X_{j,t}$ are size of exploitation at the surface in squared meters, TFP, average power of coal veins, share of frontline workers, share of underground workers.

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.[23] 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

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

and $q_m = p(\theta_m) \times \frac{1}{\theta_m}$. It is further assumed that the matching technology is twice continuously differentiable, increasing and concave. Hence,

$$\frac{\partial p(\theta_m)}{\partial \theta_m} > 0 \qquad \frac{\partial q(\theta_m)}{\partial \theta_m} < 0$$

In other words, the tighter submarket, the higher will be the job-finding probability and the lower will be the job-filling rate.

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 $G(\cdot)$. 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.[24]. 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

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

[24] This formulation supposes that inactives are entitled to the same benefit coverage B than unemployed. This is made solely for analytical tractability, as it is typically not the case in actual economies. Germain (2023) studies this mismatch in depth. For the value of nonemployment versus unemployment, see Jäger et al. (2020).

same expected utility[25] (net of their d) that I will denote by $\bar{U}$.[26] 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 is an implicit function of three variables $\theta(\underset{-}{w_m}, \underset{+-}{l_m}, \underset{+}{\bar{U}})$.

A worker of type d participates if and only if $\bar{U} \geq d + u(B, 0)$ such that the total number of participants is given by $G(\bar{U} - u(B, 0)) \times L$.[27]

Firms All firms face perfect competition in the single output market whose homogeneous good is set as the numéraire. Firms are only heterogeneous in their total factor of productivity ψ_j.[28] They share the same production technology $F(N, l)$ whose inputs are jobs $N = qv$ and hours worked l. Firms internalize workers' decisions such that their job-filling probabilities $\tilde{q}_m$ are implicitly defined by equation (3) with $\tilde{q}_m = q(\theta(\underset{-}{w_m}, \underset{+-}{l_m}, \underset{+}{\bar{U}})$. Conditional on entering the labor market, they maximize expected profit by choosing the number of vacancies v_m to post in each submarket m along with the associated wage-hours (w_m, l_m):

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

where $k(\cdot)$ is the increasing and convex 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 half-time and full-time contracts.[29]

[25]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 $U(m) = U(m')$.

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

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

[28]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. See Eeckhout and Kircher (2010a, 2018) for a rigorous treatment.

[29]See Carry (2023) for empirical evidence of such imperfect substitutability the French case.

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 ser 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 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 *in each submarket* $m = (w_m, l_m)$ *as well as a mapping* $P(\cdot)$ *from productivity to submarkets*

1. ***Firms are expected profit-maximizers****:*
   The tuples (v_m, w_m, l_m) *solve the FOC of firms of type* $\psi_j = P^{-1}(m)$ *for* $m \in [P(\psi^*), P(\bar{\psi})]$ *taking* ψ^* *and* $\bar{U}$ *as given*

$$v_m : \quad \tilde{q}^i_m(\psi_j F'_N - w_m l_m) \leq k'(v_m) \qquad \textit{with equality if } v_m > 0 \quad (3)$$

$$w_m : \quad v_m \tilde{q}'_{m,w}(\psi_j F'_N - w_m l_m) \leq q_m v_m l_m \qquad \textit{with equality if } w_m > \underline{w} \quad (4)$$

$$l_m : \quad v_m \tilde{q}'_{m,l}(\psi_j F'_N - w_m l_m) + \psi F'_l \geq \tilde{q}_m v_m w_m \qquad \textit{with equality if } l_m < \bar{l} \quad (5)$$

   where $\underline{w} \geq 0$ *denotes the legal minimum wage and* $\bar{l} \leq 1$ *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* $\tilde{q}'_{m,l} = \frac{\partial \tilde{q}_m}{\partial l}$*.*

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

$$\psi^* \textit{ solves } \pi(\psi^*) = x \qquad \textit{taking } \bar{U} \textit{ given} \qquad (6)$$

3. ***Across-submarket equilibrium condition*** *:*
   Applications in a submarket ensures that all submarkets yields market utility

$$a_m \textit{ solves } \bar{U} = p_m u(w_m l_m, l_m) + (1 - p_m) u(B, 0) \qquad (7)$$

   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 constraints :***

$$\bar{U} \text{ solves } \int_{P(\psi^*)}^{P(\bar{\psi})} a_m dm = G(\bar{U} - u(B,0)) \times L \tag{8}$$

taking ψ^*, u and a_m as given.

5.2 Properties

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

Firm and submarket sizes In a single submarket may be found vacancies from several firms. Say that we find two firms $\psi_j > \psi_k$ in some given submarket (w, l). By equation (2.3) and (2.5) respectively, it must be that

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

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.

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. However, in general firms may post vacancies in several submarkets, i.e. (3) may be saturated for many m. This is so because the presence of risk and non-degenerate job-filling probabilities induces a portfolio choice for the firm, whose optimal strategy may consists in diversification to hedge against risk. To see why firms are not risk-neutral, observe that (i) the vacancy posting cost $k(v)$ is paid almost surely and (ii) concave production may imply risk aversion. Hence, consistent with the empirical setup studied in section 4, this model produces large firms in the sense of Eeckhout and Kircher (2018).

Monopsony power As in the baseline model of section 3, the general model produces an earnings markdown. If the firm-specific wage elasticity of labor supply is $\epsilon_m^w = \frac{\partial \tilde{q}_m v_m}{\partial w_m} \frac{w_m}{\tilde{q}_m v_m}$, then equation 3 reads

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

which is again the original Robinson (1933) markdown equation: the earnings markdown is inversely proportional to the firm-specific elasticity of labor supply. It is noteworthy that the present model has two sources of monopsony power.[30] As in section 3, there is monopsony power because agents' utility function implies that the wage elasticity of labor supply is finite. Yet, contrary to section 3, there is monopsony power because of matching frictions. Indeed, observe that when matching frictions increase, ϵ_m^w decrease and the earnings markdown increase.

Moreover, observe that equations 4 and 5 are *mutatis mutandis* identical to the monopsony toy model's first-order conditions. As a result, it can easily be shown that whenever we assume production to follow $F(N,l) = N^\alpha l^\beta$, with $\alpha < \beta$, one gets $\tilde{q}'_{m,l} < 0$. In that case, workers have a negative marginal utility of hours worked: workers would like to work less conditional on wage rates. As a result, the analysis of the wage effect of working time regulations follow the same line as in section 3.

Contract dispersion and sorting The model produces wage dispersion among (observably) identical workers[31] 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 3 in a particular submarket away from corner solutions one gets

$$dv\,\underbrace{(\tilde{q}^2\psi F''_N - k''(v))}_{<0 \text{ if } F''_N \leq 0} + dw\,\underbrace{(\tilde{q}'_w(\psi F'_N - wl) - \tilde{q}l + \tilde{q}v\tilde{q}'_w\psi F''_N)}_{<0 \text{ by equation (2.4)}} + dl\left(\gamma_l\right) + d\psi\,\underbrace{(\tilde{q}F'_N)}_{>0} = 0$$

where indices are omitted for brevity. Hence, a firm with higher productivity will post more vacancies and higher wages. With respect to hours worked, the coefficient γ_l multiplying dl is difficult to sign in the general case. However, if one assumes that labor production follows the toy model's $F(N,l) = N^\alpha l^\beta$ with $\alpha < \beta < 1$, one gets that $\gamma_l > 0$, such that higher productivity firms post contracts with shorter hours. The proof is relegated to appendix B.

Under these assumptions, firms with higher productivities offer higher wage rates, and lower hours worked, hence a higher ex-post utility to their workers. However, ex-ante utilities are equal for all workers. This implies that job-finding probabilities are smaller in firms with higher productivities. In other words, the larger number of vacan-

[30] Berger et al. (2024) quantifies the empirical importance of several determinants of monopsony power including preferences and search frictions.

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

cies in these firms is dominated by the larger number of applications such that equilibrium tightness $\theta_m = \frac{v_m}{a_m}$ decreases with firms' productivity.

We can also study comparative statics when the preferences for leisure of agents locally increase: the slope of its indifference curve gets steeper. This does not affect labor supply in level, but it affects labor supply elasticities. As a result, the firm reacts by modifying w_m and l_m according to equations (2.4) and (2.5) . In particular, observe that a simple rearrangement of these equations for interior solutions yields

$$-\frac{\tilde{q}_l' l}{\tilde{q}_w' w} = \frac{\psi F_l'}{\tilde{q} v w}$$

where the left handside coincides with the marginal rate of substitution derived from $u(\cdot)$ at the particular contract. Hence, when the indifference curve gets steeper, the left handside decreases. The equilibrium conditions imposes that on the right handside firms must marginally increase w or decrease l. Hence, a marginal increase in the preference for leisure locally increases wage rates and decreases hours worked.

5.3 Welfare analysis

The competitive search equilibrium features monopsony power, large firms, and sorting patterns that are consistent with the empirical context of section 4. Moreover, the welfare effects of the policy is ambiguous here because the negative effects on wages and employment may be offset by positive effects on leisure. In this section, I quantify welfare gains and losses 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. Interestingly, it features a trade-off between jobs quantity and job quality. I now express it in terms of sufficient statistics as in Vergara (2023). Recall that for each submarket m we have

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

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 8. 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. It is straightforward to show the following result.

Proposition 1. *A small working time reduction*[32] $d\bar{l}$ *has a positive impact on on ex-ante welfare* $\frac{d\bar{U}}{d\bar{l}} > 0$ *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 $\bar{l}$ we can write the percentage change in utility η^u as a function of the percentage change in consumption and leisure:

$$
\begin{aligned}
\frac{du}{d\bar{l}} &= u_c' \frac{dc}{d\bar{l}} + u_l' \frac{dl}{d\bar{l}} \\
\eta^u = \frac{\bar{l}}{u} \frac{du}{d\bar{l}} &= \frac{cu_c'}{u} \frac{\bar{l}}{c} \frac{dc}{d\bar{l}} + \frac{lu_l'}{u} \frac{\bar{l}}{l} \frac{dl}{dl} = \zeta_c^u \eta^c + \zeta_l^u \eta^l
\end{aligned}
$$

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. In particular, it does not require to take 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

[32] 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 by assuming that the government does not observe the identity of firms in a particular submarket, hence the second fundamental theorem of welfare economics may not be used.

(Azar et al., 2022; Card et al., 2018). 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. The estimates derived in section 4 may be used to compute the welfare effects using these sufficient statistics.[33] However, two caveats must be raised.

First, I must assume a cardinal utility function to derive ζ_c^u and ζ_l^u. Obviously, welfare assessment will be sensitive to this choice.[34] Second, the estimates of section 4 are average treatment effects on the treated. As a result, I apply the welfare analysis only on workers from treated firms i.e. workers whose hours worked were above the maximum workweek prior to the reform. I also assume that the number of workers sending job applications to these firms is unaffected by the reform, which is a conservative assumption for my results.[35]

The estimates from section 4 give us $\hat{\eta}^N = -6.13$ and $\hat{\eta}^c = -7$ while $\hat{\eta}^l = -1.03/10.03 * 100 = -10.27$. If preferences can be represented by a Cobb-Douglas utility, $\zeta_c^u = \delta = 1 - \zeta_l^u$, the reform is increasing treated workers' ex-welfare if

$$\begin{aligned} -6.13 + \delta(-7) - (1-\delta)(-10.27) &> 0 \\ 1 - \delta &> 0.76 \end{aligned}$$

In others words, workers must spend at least 76% of their income buying leisure for this reform to be welfare-improving in the Cobb-Douglas case. In future iteration of the paper, I intend to use the equilibrium conditions in equations 4 and 5 to pin down values of ζ_c^u and ζ_l^u and then estimating these moments with my data to provide a nonparametric welfare estimation.

6 Conclusion

The paper has studied theoretically and empirically the effects of working time reductions on wages, employment and profits. The key theoretical assumption was that the

[33]The estimates of section 2.4 are expressed as the effect of a working time reduction by one hour, while these statistics are the effect of the overall reform. This does not change the analysis because multiplying $\eta^N + \eta^u$ by a scalar does not modify the sign. Moreover, the mean working time reduction was 1.03 hour such that our estimates are quantitatively close to the average impact of the reform.

[34]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 take 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.

[35]To see this, 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.

output elasticity of new hires is lower than the output elasticity of hours worked. On the normative side, we have shown that the empirical effect of working time reductions on employment, wages and profits are sufficient for welfare evaluation. The empirical application uncovered large and negative effects on wages and employment in the first-ever working time reduction in Belgium such that the overall welfare effects may only be positive if workers had a large value attached to leisure.

There are several ways in which this line of research can be extended. First, the interaction with progressive taxes is of obvious interest for public economists. Second, the chacterization of optimal policy and efficiency has been left aside, while heterogeneous preferences for leisure would allow us to discuss the desirability of gendered holidays or retirement policies. Third, the (counter)cyclicality of working time regulations could be interesting to relate to the literature on short-time work (Giupponi & Landais, 2023).

References

Abbeloos, J.-F. (2008). Belgium's expansionist history between 1870 and 1930: Imperialism and the globalisation of Belgian business. In *Europe and its empires* (pp. 105–127). Pisa Plus.

Acemoglu, D., & Shimer, R. (1999). Efficient unemployment insurance. *Journal of political Economy*, *107*(5), 893–928.

Altonji, J. G., & Oldham, J. (2003). Vacation laws and annual work hours. *Economic Perspectives-Federal Reserve Bank of Chicago*, *27*(3), 19–29.

Altonji, J. G., & Usui, E. (2007). Work hours, wages, and vacation leave. *ILR Review*, *60*(3), 408–428.

Annales des Mines, . (1907). Proposition de loi fixant la durée de la journée du travail dans les mines - réponses du gouvernement aux questions posées par la section centrale. *Annales des Mines*, *12*(2), 553–604.

Azar, J., Marinescu, I., & Steinbaum, M. (2022). Labor market concentration. *Journal of Human Resources*, *57*(S), S167–S199.

Bell, L. A. (1998). Differences in work hours and hours preferences by race in the us. *Review of Social Economy*, *56*(4), 481–500.

Berger, D., Herkenhoff, K., Kostol, A., & Mongey, S. (2024). An anatomy of monopsony: Search frictions, amenities and bargaining in concentrated markets. *NBER Macroeconomics Annual Volume*, *38*.

Boppart, T., & Krusell, P. (2020). Labor supply in the past, present, and future: A balanced-growth perspective. *Journal of Political Economy*, *128*(1), 118–157.

Buyst, E., Smits, J., & Van Zanden, J.-L. (1995). National accounts for the Low Countries, 1800–1990. *Scandinavian Economic History Review*, *43*(1), 53–76.

Caldwell, S., & Danieli, O. (2024). Outside options in the labor market. *Review of Economic Studies*, *91*(6), 3286–3315.

Caldwell, S., & Harmon, N. (2019). Outside options, bargaining, and wages: Evidence from coworker networks. *Mimeo*, 203–207.

Caldwell, S., & Oehlsen, E. (2018). Monopsony and the gender wage gap: Experimental evidence from the gig economy. *Massachusetts Institute of Technology Working Paper*.

Card, D. (1990). Labor supply with a minimum hours threshold. *Carnegie-Rochester Conference Series on Public Policy*, *33*, 137–168.

Card, D. (2022). Who set your wage? *American Economic Review*, *112*(4), 1075–1090.

Card, D., Cardoso, A. R., Heining, J., & Kline, P. (2018). Firms and labor market inequality: Evidence and some theory. *Journal of Labor Economics*, *36*(S1), S13–S70.

Carry, P. (2023). The effects of the legal minimum working time on workers, firms and the labor market. *Mimeo*.

Cengiz, D., Dube, A., Lindner, A., & Zipperer, B. (2019). The effect of minimum wages on low-wage jobs. *The Quarterly Journal of Economics*, *134*(3), 1405–1454.

Chamber of Representatives, B. (1903). Budget des voies et moyens.

Chemin, M., & Wasmer, E. (2009). Using alsace-moselle local laws to build a difference-in-differences estimation strategy of the employment effects of the 35-hour workweek regulation in france. *Journal of Labor economics*, *27*(4), 487–524.

Chen, J., & Roth, J. (2024). Logs with zeros? some problems and solutions. *The Quarterly Journal of Economics*, *139*(2), 891–936.

Chetty, R., Friedman, J. N., Olsen, T., & Pistaferri, L. (2011). Adjustment costs, firm responses, and micro vs. macro labor supply elasticities: Evidence from danish tax records. *The Quarterly Journal of Economics*, *126*(2), 749–804.

Clark, G. (1994). Factory discipline. *The Journal of Economic History*, *54*(1), 128–163.

Clemens, J. (2021). How do firms respond to minimum wage increases? understanding the relevance of non-employment margins. *Journal of Economic Perspectives*, *35*(1), 51–72.

Clemens, J., Kahn, L. B., & Meer, J. (2018). The minimum wage, fringe benefits, and worker welfare. *National Bureau of Economic Research Working Paper*, (w24635).

Costa, D. L. (2000). Hours of work and the fair labor standards act: A study of retail and wholesale trade, 1938–1950. *ILR Review*, *53*(4), 648–664.

Cousot, G. (1908). Rapport de la section centrale. *Proposition de Loi fixant la durée de la journée du travail dans les mines*.

d'Aspremont, C., & Dos Santos Ferreira, R. (2021). *The economics of competition, collusion and in-between*. Springer.

Delabastita, V., & Rubens, M. (forthcoming). Colluding against workers. *Journal of Political Economy*.

Denoël, L. (1909). Les moyens de production et l'effet utile de l'ouvrier dans les houillères belges. *Commision d'enquête sur la durée du travail dans les mines de houille*, 1–136.

Di Nola, A., Wang, H., & Haywood, L. (2023). Gendered effects of the minimum wage. *UB Economics–Working Papers, 2023 E23/450*.

Diamond, P. A. (1971). A model of price adjustment. *Journal of Economic Theory*, *3*(2), 156–168.

Dixit, A. K., & Stiglitz, J. E. (1977). Monopolistic competition and optimum product diversity. *The American economic review*, *67*(3), 297–308.

Drèze, J. H. (1975). Existence of an exchange equilibrium under price rigidities. *International Economic Review*, 301–320.

Dworczak, P., Kominers, S. D., & Akbarpour, M. (2021). Redistribution through markets. *Econometrica*, *89*(4), 1665–1698.

Eeckhout, J., & Kircher, P. (2010a). Sorting and decentralized price competition. *Econometrica*, *78*(2), 539–574.

Eeckhout, J., & Kircher, P. (2010b). Sorting versus screening: Search frictions and competing mechanisms. *Journal of Economic Theory*, *145*(4), 1354–1385.

Eeckhout, J., & Kircher, P. (2018). Assortative matching with large firms. *Econometrica*, *86*(1), 85–132.

Fagnart, J.-f., Germain, M., & Van der Linden, B. (2023). Working time reduction and employment in a finite world. *The Scandinavian Journal of Economics*, *125*(1), 170–207.

Fishback, P., Vickers, C., & Ziebarth, N. L. (2024). Labor market effects of workweek restrictions: Evidence from the great depression. *American Economic Journal: Macroeconomics*, *16*(4), 77–113.

Gandhi, A., & Ruffini, K. (2022). Minimum wages and employment composition. *Mimeo*.

Germain, A. (2023). Basic income versus fairness: Redistribution with inactive agents. *CORE Discussion Paper*.

Giupponi, G., & Landais, C. (2023). Subsidizing labour hoarding in recessions: The employment and welfare effects of short-time work. *The Review of Economic Studies*, *90*(4), 1963–2005.

Gravoueille, M. (2023). Wage and employment effects of wage subsidies. *mimeo*.

Guerrieri, V., Shimer, R., & Wright, R. (2010). Adverse selection in competitive search equilibrium. *Econometrica*, *78*(6), 1823–1862.

Guesnerie, R., & Roberts, K. (1984). Effective policy tools and quantity controls. *Econometrica*, 59–86.

Hall, R. E., & Krueger, A. B. (2012). Evidence on the incidence of wage posting, wage bargaining, and on-the-job search. *American Economic Journal: Macroeconomics*, *4*(4), 56–67.

Hall, R. E., & Mueller, A. I. (2018). Wage dispersion and search behavior: The importance of nonwage job values. *Journal of Political Economy*, *126*(4), 1594–1637.

Hall, R. E., & Schulhofer-Wohl, S. (2018). Measuring job-finding rates and matching efficiency with heterogeneous job-seekers. *American Economic Journal: Macroeconomics*, *10*(1), 1–32.

Harasztosi, P., & Lindner, A. (2019). Who pays for the minimum wage? *American Economic Review*, *109*(8), 2693–2727.

Hwang, H.-s., Mortensen, D. T., & Reed, W. R. (1998). Hedonic wages and labor market search. *Journal of Labor Economics*, *16*(4), 815–847.

Jäger, S., Roth, C., Roussille, N., & Schoefer, B. (2022). Worker beliefs about outside options.

Jäger, S., Schoefer, B., Young, S., & Zweimüller, J. (2020). Wages and the value of nonemployment. *The Quarterly Journal of Economics*, *135*(4), 1905–1963.

Jäger, S., Schoefer, B., & Zweimüller, J. (2023). Marginal jobs and job surplus: A test of the efficiency of separations. *The Review of Economic Studies*, *90*(3), 1265–1303.

Jardim, E., Long, M. C., Plotnick, R., Van Inwegen, E., Vigdor, J., & Wething, H. (2022). Minimum-wage increases and low-wage employment: Evidence from seattle. *American Economic Journal: Economic Policy*, *14*(2), 263–314.

Kahn, S., & Lang, K. (1991). The effect of hours constraints on labor supply estimates. *The Review of Economics and Statistics*, 605–611.

Kim, J. H., Lee, J., & Lee, K. (2023). Minimum wage, social insurance mandate, and working hours. *Journal of Public Economics*, *225*, 104951.

Kircher, P. (2009). Efficiency of simultaneous search. *Journal of Political Economy*, *117*(5), 861–913.

Labanca, C., & Pozzoli, D. (2022). Constraints on hours within the firm. *Journal of Labor Economics*, *40*(2), 473–503.

Labanca, C., & Pozzoli, D. (2023). Hours constraints and wage differentials across firms. *Journal of Human Resources*.

Lachowska, M., Mas, A., Saggio, R., & Woodbury, S. A. (2022). Wage posting or wage bargaining? a test using dual jobholders. *Journal of Labor Economics*, *40*(S1), S469–S493.

Lachowska, M., Mas, A., Saggio, R., & Woodbury, S. A. (2023). Work hours mismatch. *National Bureau of Economic Research Working Papers*.

Lamadon, T., Mogstad, M., & Setzler, B. (2022). Imperfect competition, compensating differentials, and rent sharing in the US labor market. *American Economic Review*, *112*(1), 169–212.

Landais, C., Michaillat, P., & Saez, E. (2018). A macroeconomic approach to optimal unemployment insurance: Theory. *American Economic Journal: Economic Policy*, *10*(2), 152–181.

Lang, K., & Majumdar, S. (2004). The pricing of job characteristics when markets do not clear: Theory and policy implications. *International Economic Review*, *45*(4), 1111–1128.

Lavetti, K. (2023). Compensating wage differentials in labor markets: Empirical challenges and applications. *Journal of Economic Perspectives*, *37*(3), 189–212.

Leboutte, R. (1991). Mortalité par accident dans les mines de charbon en belgique aux xixe-xxe siècles. *Revue du Nord*, *73*(293), 703–736.

Manning, A. (2021). The elusive employment effect of the minimum wage. *Journal of Economic Perspectives*, *35*(1), 3–26.

Marimon, R., & Zilibotti, F. (2000). Employment and distributional effects of restricting working time. *European Economic Review*, *44*(7), 1291–1326.

Mas, A., & Pallais, A. (2017). Valuing alternative work arrangements. *American Economic Review*, *107*(12), 3722–3759.

Mas, A., & Pallais, A. (2020). Alternative work arrangements. *Annual Review of Economics*, *12*, 631–658.

Mirrlees, J. A. (1971). An exploration in the theory of optimum income taxation. *The Review of Economic Studies*, *38*(2), 175–208.
Moen, E. R. (1997). Competitive search equilibrium. *Journal of Political Economy*, *105*(2), 385–411.
Moffitt, R. (1982). The tobit model, hours of work and institutional constraints. *The Review of Economics and Statistics*, 510–515.
Nekoei, A. (2023). Will markets provide humane jobs? *Available at SSRN 4523278*.
Neuville, J. (1981). *L'évolution des relations industrielles.Tome 2. La lutte ouvrière pour la maitrise du temps. Le temps des 12 heures et le glissement vers les 10 heures.* (Vol. 1). Editions Vie Ouvrière, Bruxelles.
Osuna, V., & Rıos-Rull, J.-V. (2003). Implementing the 35 hour workweek by means of overtime taxation. *Review of Economic Dynamics*, *6*(1), 179–206.
Ouimet, P., & Tate, G. A. (2023). Firms with benefits? nonwage compensation and implications for firms and labor markets. *National Bureau of Economic Research*.
Parliamentary Commission, X. (1909). Rapport final. *Commission d'enquête sur la durée du travail dans les mines de houille*, 1–33.
Petrongolo, B., & Pissarides, C. A. (2001). Looking into the black box: A survey of the matching function. *Journal of Economic literature*, *39*(2), 390–431.
Philips, R. C., & Buyst, E. (2020). Regional industrialization in belgium and the netherlands 1. In *An economic history of regional industrialization* (pp. 49–78). Routledge.
Robinson, J. (1933). *The economics of imperfect competition*. Springer.
Rocheteau, G. (2002). Working time regulation in a search economy with worker moral hazard. *Journal of Public Economics*, *84*(3), 387–425.
Rosen, S. (1974). Hedonic prices and implicit markets: Product differentiation in pure competition. *Journal of political economy*, *82*(1), 34–55.
Rosen, S. (1986). The theory of equalizing differences. *Handbook of labor economics*, *1*, 641–692.
Rosés, J. R., & Wolf, N. (2021). Regional growth and inequality in the long-run: Europe, 1900–2015. *Oxford Review of Economic Policy*, *37*(1), 17–48.
Saez, E., Schoefer, B., & Seim, D. (2019). Payroll taxes, firm behavior, and rent sharing: Evidence from a young workers' tax cut in sweden. *American Economic Review*, *109*(5), 1717–1763.
Sockin, J. (2022). Show me the amenity: Are higher-paying firms better all around? [Publisher: CESifo Working Paper].
Sorkin, I. (2018). Ranking firms using revealed preference. *The Quarterly Journal of Economics*, *133*(3), 1331–1393.
Stewart, M. B., & Swaffield, J. K. (1997). Constraints on the desired hours of work of british men. *The Economic Journal*, *107*(441), 520–535.
Vandervelde, E. (1911). La journée de neuf heures dans les mines et l'enquète belge sur la durée du travail dans les mines de houille. *Revue d'économie politique*, *25*(2), 185–209.
Vergara, D. (2023). Minimum wages and optimal redistribution. *arXiv preprint arXiv:2202.00839*.
Willington, M., & Navarro, L. (2015). Work hours regulation in a search economy with adverse selection. *Economics Letters*, *136*, 46–48.

Wright, R., Kircher, P., Julien, B., & Guerrieri, V. (2021). Directed search and competitive search equilibrium: A guided tour. *Journal of Economic Literature*, *59*(1), 90–148.

A Baseline model: additional results

A.1 Sufficient conditions

In this section, we derive a set of sufficient conditions for the results of the toy model with a general production function $F(N,l)$ increasing in its arguments. We assume $F(\cdot,0) = F(0,\cdot) = 0$.

A.1.1 Perfect competition

The equilibrium is characterized by $F'_N - wl = 0$. Taking the total derivative, one gets

$$dw\left(\frac{\partial N_s}{\partial w}F''_N - l\right) + dl\left(\frac{\partial N_s}{\partial l}F''_N + F''_{N,l} - w\right) = 0$$

The coefficient multiplying dw is negative if $F''_N \leq 0$.
With respect to the coefficient multiplying dl, observe that workers' hours optimization implies $\frac{\partial N_s}{\partial l} = 0$. Moreover,

$$F''_{N,l} - w = F''_{N,l} - \frac{F'_N}{l}$$

As a consequence, sufficient conditions for a negative equilibrium covariance between hours worked and wage rates in perfect competition are

$$F''_N \leq 0$$
$$F''_{N,l} - \frac{F'_N}{l} \leq 0$$

The first condition is a standard concavity of production in jobs. The second condition states that the marginal product of a job should grow with hours at a decreasing pace.

A.1.2 Monopsony

The equilibrium is characterized by $\frac{\partial N_s}{\partial w}(F'_N - wl) = Nl$. The total derivative reads

$$dw\left(\frac{\partial^2 N}{\partial^2 w}(F'_N - wl) + (\frac{\partial N}{\partial w})^2 F''_N - 2\frac{\partial N}{\partial w}l\right) + dl\left(\frac{\partial^2 N}{\partial w \partial l}(F'_N - wl) + \frac{\partial N}{\partial w}(\frac{\partial N}{\partial l}F''_N + F''_{N,l} - \frac{F'_N}{l}) - \frac{\partial N}{\partial l}l\right)$$

and must be equal to 0. Observe that the coefficient multiplying dw is negative whenever $\frac{\partial^2 N}{\partial^2 w} \leq 0$ and $F''_N \leq 0$. Note that the latter was already required by the perfect competition equilibrium. As to the former, observe that $N_s(w,l) = G(u(wl,l))$ implies that

$$\frac{\partial^2 N}{\partial^2 w} = (lu'_c)^2 \frac{\partial g(u(wl,l))}{\partial d} + g(u(wl,l))l^2 u''_c$$

Hence, the concavity of the labor supply N_s with respect to w is an immediate consequence of the concavity of the cdf $G(d)$ and the concavity of utility in consumption.
With respect to the coefficient multiplying dl, it is positive if

$$\begin{aligned} \frac{\partial^2 N}{\partial w \partial l} &\geq 0 \\ \frac{\partial N}{\partial l} &\leq 0 \\ \frac{\partial N}{\partial l} F''_N + F''_{N,l} - \frac{F'_N}{l} &\geq 0 \end{aligned}$$

The first line was assumed in the main text. As for the second line, observe that the first-order condition with respect to l yields in interior solutions

$$\begin{aligned} \frac{\partial N_s}{\partial l}(F'_N - wl) + F'_l - wN = 0 \\ \frac{\partial N_s}{\partial l}(F'_N - wl) + \frac{N}{l}(\frac{l}{N}F'_l - wl) = 0 \end{aligned}$$

We have that $\frac{\partial N_s}{\partial l} \leq 0$ if

$$\begin{aligned} \frac{l}{N}F'_l - wl \geq F'_N - wl > 0 \\ lF'_l \geq NF'_N \end{aligned}$$

In other words, the marginal product of an hour must be larger than the marginal product of a job. This is exactly the same intuition as in the main text.
To sum up, the set of sufficient conditions for obtaining a positive equilibrium covariance between wage rates and hours worked in monopsony are

$$\begin{aligned} lF'_l &\geq NF'_N \\ \frac{\partial N}{\partial l} F''_N + F''_{N,l} - \frac{F'_N}{l} &\geq 0 \end{aligned}$$

A.2 A game-theoretic microfoundation

The toy model in the main text considers two polar cases. In the monopsony equilibrium, firms choose hours while they are derived from utility-maximization in perfect competition. In this section, we sketch a micro-foundation for such a modelling choice. We build a game-theoretic model which is compatabile with any degree of monopsony power and nest the limiting case of perfect competition.

Consider J identical firms whose profits are defined by the difference between their production $F(N_j, l_j)$ and their total wage bill $N_j w_j l_j$. Firms choose which contract

(w_j, l_j) to offer, understanding that all workers accept the utility-maximizing contracts. As a result, the problem for the firm j reads:

$$\max_{w_j, l_j, N_j} F(N_j, l_j) - N_j w_j l_j$$

$$\mathrm{N}_j \leq \begin{cases} 0 & \text{if } u(w_j l_j, l_j) < \max\limits_{-j \in J \backslash \{j\}} u(w_{-j} l_{-j}, l_{-j}) \\ \dfrac{N_s(w, l)}{J} & \text{if } u(w_j l_j, l_j) = u(w_{-j} l_{-j}, l_{-j}) \quad \forall -j \in J \backslash \{j\} \\ N_s(w_j, l_j) & \text{if } u(w_j l_j, l_j) > \max\limits_{-j \in J \backslash \{j\}} u(w_{-j} l_{-j}, l_{-j}) \end{cases}$$

Given that this maximization program holds for all (w_{-j}, l_{-j}), it also completely describes the best-response function of firm j.

Observe that when $J = 1$, we are trivially reproducing the pure monopsony case of section 2.

Proposition 2. *If production is concave in N, any Nash equilibrium of this game with positive production and participation is symmetric.*

Proof. I prove the statement for the duopsony case where $J = 2$.
By contradiction, consider $(w_1^*, l_1^*) \neq (w_2^*, l_2^*)$ but $\{(w_1^*, l_1^*), (w_2^*, l_2^*)\}$ is a Nash equilibrium of this game.
First, imagine that $u(w_1^*, l_1^*) < u(w_2^*, l_2^*)$ such that $\pi_1^* = 0$ and $\pi_2^* = F(N_s(w_2^*, l_2^*), l_2^*) - N_s(w_2^*, l_2^*) w_2^* l_2^*$.
If $\pi_2^* < 0$ then it violates the participation constraint of firm 2.
If $\pi_2^* = 0$ then earnings are equal to average product. Yet, first order conditions indicate that $F'_N > w_2^* l_2^*$ and concavity implies that average product is larger than marginal product. As a result, it must be that $\pi_2^* > 0$.
If firm 2 has positive profits, observe that agent 1 can simply deviate by replicating agent 2's strategy. Agent 1's profits by deviating would be

$$\begin{aligned} \pi_1^d &= F(\frac{N_s(w_2^*, l_2^*)}{2}, l_2^*) - \frac{N_s(w_2^*, l_2^*)}{2} w_2^* l_2^* \\ &= F(\frac{N_s(w_2^*, l_2^*)}{2}, l_2^*) - \frac{N_s(w_2^*, l_2^*)}{2} \left(\frac{F(N_s(w_2^*, l_2^*), l_2^*)}{N_s(w_2^*, l_2^*)} - \frac{\pi_2^*}{N_s(w_2^*, l_2^*)} \right) \\ &= F(\frac{N_s(w_2^*, l_2^*)}{2}, l_2^*) - \frac{F(N_s(w_2^*, l_2^*), l_2^*)}{2} + \frac{\pi_2^*}{2} \end{aligned}$$

where the last line is positive because of Jensen's inequality.
The arguments prove that it cannot be the case that $u(w_1^*, l_1^*) < u(w_2^*, l_2^*)$ in equilibrium. A symmetric argument can be made to prove the converse strict inequality. Hence, in must be that $u(w_1^*, l_1^*) = u(w_2^*, l_2^*)$.

This implies that in equilibrium all firms hire the same number of employees $\frac{N_s}{2}$. As a consequence, we can prove that firms' profits must be equal. If it were not the case, say $\pi_1^* < \pi_2^*$, we would have a profitable deviation for firm 1 : mimicking 2's strategy does not affect the number of workers employed in firm 1 and yet increases profits.
So far, we have shown that the equilibrium contracts (w_1^*, l_1^*) and (w_2^*, l_2^*) must lie on the same indifference curve and iso-profit curve. To prove that firms will offer the same equilibrium contract, say that by contradiction $l_1^* > l_2^*$.
Equal utility imposes that $w_1^* l_1^* > w_2^* l_2^*$ as utility function is strictly decreasing in l. Hence we have

$$\begin{aligned}\pi_1^* = F(\frac{N_s}{2}, l_1^*) - \frac{N_s}{2} w_1^* l_1^* &< F(\frac{N_s}{2}, l_1^*) - \frac{N_s}{2} w_2^* l_2^* \\ &\leq F(\frac{N_s}{2}, l_2^*) - \frac{N_s}{2} w_2^* l_2^* = \pi_2^*\end{aligned}$$

which contradicts $\pi_1^* = \pi_2^*$. A symmetric argument can be made for the case $l_1^* < l_2^*$. Hence, it must be that $l_1^* = l_2^*$. Given that utility is strictly increasing in consumption, we must have $w_1^* = w_2^*$. This contradicts the premise and complete the proof.

■

A consequence of this proposition is that each firm faces that same program that can be written

$$\max_{w,l,N} F(N, l) - Nwl$$
$$\text{s.t. } N \leq \frac{N_s(w, l)}{J}$$

The associated Lagrangian for this problem reads

$$\mathcal{L} = F(N, l) - Nwl + \lambda[\frac{N_s(w, l)}{J} - N]$$

where $\lambda \geq 0$ is the Lagrangian multiplier. The remaining KKT conditions are

$$\begin{aligned}F'_N - wl &= \lambda \\ F'_l - wN + \lambda \frac{1}{J} \frac{\partial N_s}{\partial l} &= 0 \\ lN &= \lambda \frac{1}{J} \frac{\partial N_s}{\partial w} \\ \lambda[\frac{N_s(w, l)}{J} - N] &= 0\end{aligned}$$

Observe that when $J = 1$, these KKT conditions are completely equivalent to the pure monopsony problem presented in section 1.

With respect to the perfect competition equilibrium, it is compatible with these KKT conditions when $\lambda = 0$ and $\frac{\partial N_s}{\partial l} = 0$. This holds for J and functional forms such that $F'_l - wN = 0$ and $J \leq \frac{N_s(w,l)F'_N}{lF'_l}$.

We conclude this section by underlining an interesting link between this labor market model and the industrial organization literature. This game-theoretic model can be seen as the labor market equivalent of the Cournot-Bertrand games of d'Aspremont and Dos Santos Ferreira (2021) who study imperfect competition on output markets (à la Dixit and Stiglitz (1977)) when firms choose both prices and quantities, thereby competing both for the market size and the market share. Here, the product market is competitive but the labor market is oligopsonistic.

B General model: sorting

We prove here that $\gamma_l > 0$ in interior solutions whenever production is $F(N, l) = N^\alpha l^\beta$ with $\alpha < \beta < 1$.

$$\gamma_l = \tilde{q}'_l(\psi F'_N - wl + \tilde{q}vF''_N) + \psi\tilde{q}F''_{N,l} - \tilde{q}w$$

Substituting equation (2.5) for the last term yields

$$\gamma_l = \tilde{q}'_l(\tilde{q}vF''_N) + \psi\tilde{q}F''_{N,l} - \psi F'_l\frac{1}{v}$$

Multiplying by v preserves the sign

$$v\gamma_l = v\tilde{q}'_l(\tilde{q}vF''_N) + \psi\tilde{q}vF''_{N,l} - \psi F'_l$$

Developing using the functional form and using the identity $N = \tilde{q}l$, one gets

$$\begin{aligned} v\gamma_l &= v\tilde{q}'_l(\psi\alpha(\alpha-1)N^{\alpha-1}l^\beta) + \psi\alpha\beta N^\alpha l^{\beta-1} - \psi\beta N^\alpha l^{\beta-1} \\ &= (\alpha-1)\psi N^\alpha l^{\beta-1}\left(\beta + \alpha l\frac{\tilde{q}'_l}{\tilde{q}}\right) \end{aligned}$$

We are left with signing the last bracketed factor. Observe that equation (2.5) can be written as

$$v\tilde{q}'_l = -\frac{\psi F'_l - \tilde{q}vw}{\psi F'_N - wl}$$

Hence we get

$$
\begin{aligned}
l\frac{\tilde{q}_l'}{\tilde{q}} &= -\frac{\psi\beta N^{\alpha-1}l^{\beta} - wl}{\psi\alpha N^{\alpha-1}l^{\beta} - wl} \\
\beta + \alpha l\frac{\tilde{q}_l'}{\tilde{q}} &= (\alpha-\beta)\frac{wl}{\psi\beta N^{\alpha-1}l^{\beta} - wl}
\end{aligned}
$$

This prove that the bracketed factor is negative whenever $\alpha < \beta$. Hence, it must be that $\gamma_l > 0$, proving that firms with higher productivity ψ_j offer contracts with shorter hours worked.

C Empirical appendix

C.1 Data collection

C.2 Construction of variables

C.2.1 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.

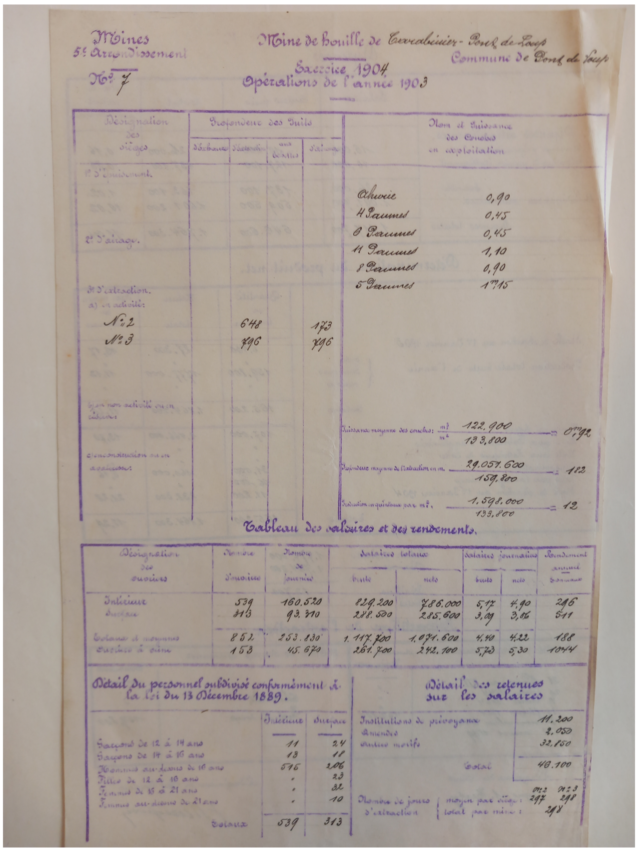
C.2.2 TFP

I use a measure of TFP as control variable in various regressions. I assume a Cobb-Douglas production function and take the log to obtain a regression equation of the form

$$
\ln q_{j,t} = \beta_1 \ln l_{j,t} + \beta_2 \ln m_{j,t} + \mu_j + \epsilon_{j,t}
$$

where $q_{j,t}$ is the output in tons of coal and $l_{j,t}$ and $m_{j,t}$ are labor and non-labor expenditures, respectively. I set $\ln TFP_{j,t} = \mu_j + \epsilon_{j,t}$ and retrieve $TFP_{j,t}$ by exponentiation. For firms with zero production in year t, I assign as TFP the value of the TFP of that firm for the year with positive production closest to t.

C.3 Additional empirical results



Mines
5e Arrondissement
No 7

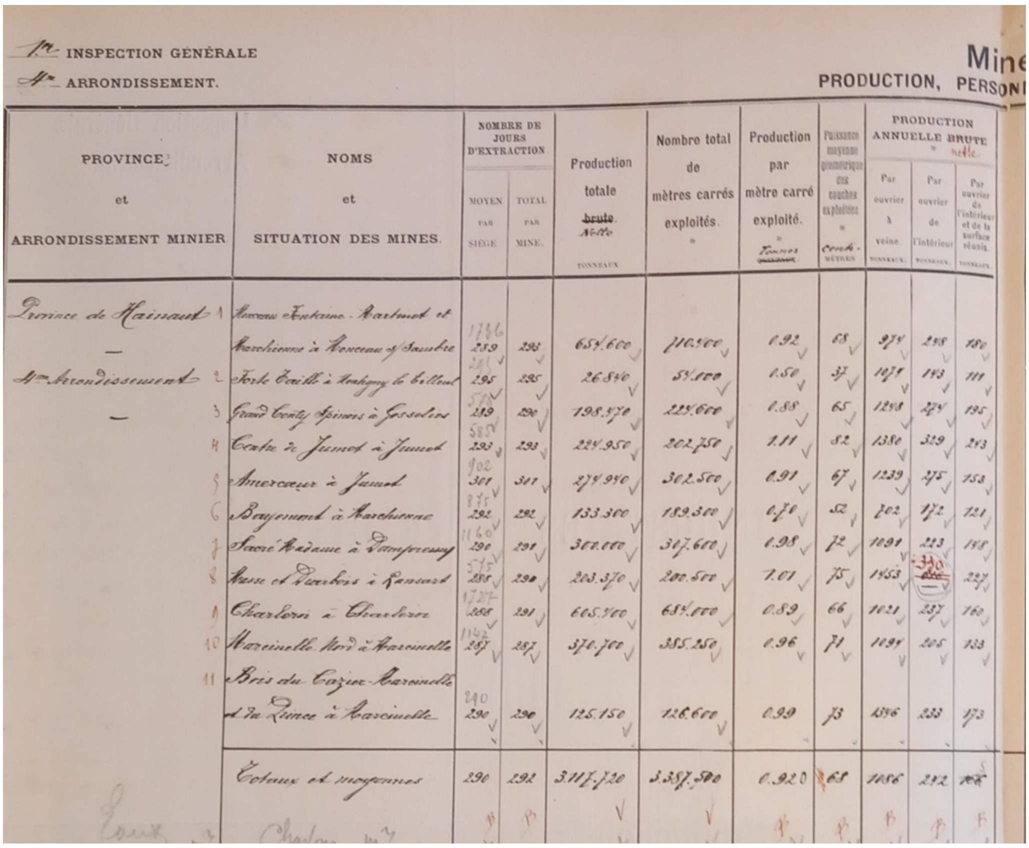
Mine de houille de Carabinier-Pont de Loup
Commune de Pont de Loup
Exercice 1904
Opérations de l'année 1903

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[illegible]
PRODUCTION, PERSON[illegible]

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)	Par ouvrier de l'intérieur (TONNEAUX)	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	248	180
4me Arrondissement	2	Forte Taille à Montigny le Tilleul	295	295	26.840	54.000	0.50	37	1079	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	301	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 ~~[illegible]~~	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 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	168

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

Figure C.1: Pictures of the data collection

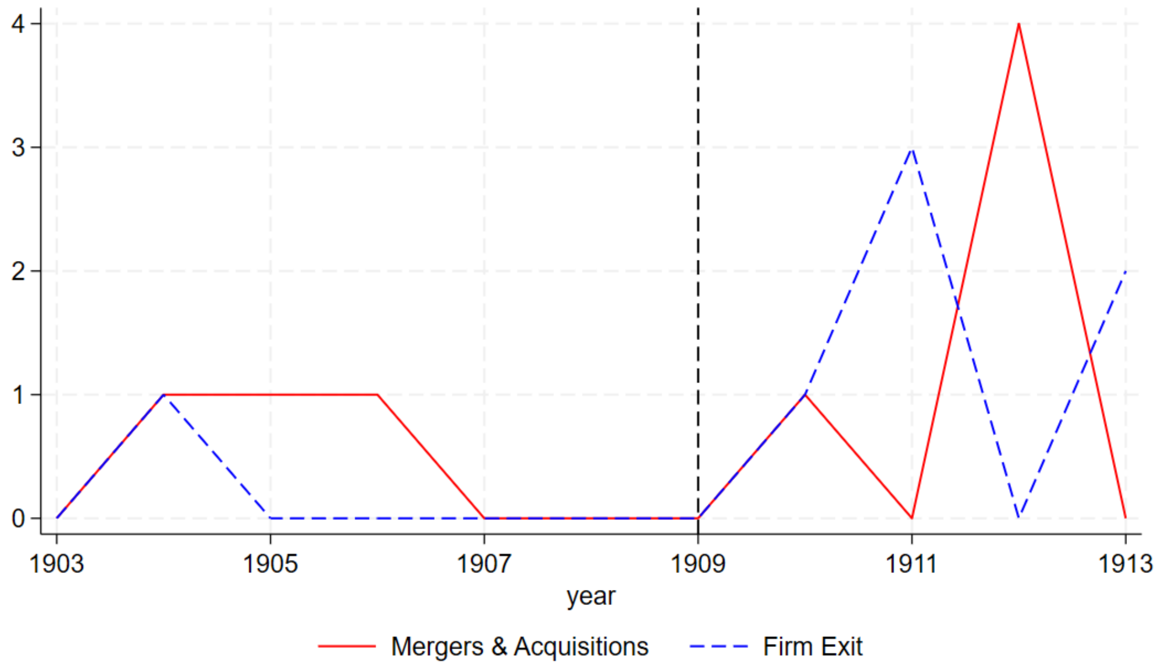


Figure C.2: Count of mergers and acquisitions and firm exit per year.

Year	Matched	Population	Share of Covered (%) Output	Share of Covered (%) 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

Table C.2: Number of firms for which there is information on hours worked (*Matched*) versus the total number of firms in the country (*Population*) by year.