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. A toy model shows that the marginal utility of a small working time reduction is negative when workers control schedules but positive when firms set hours. However, the policy increases wage rates in perfect competition but decreases monopsonistic wage rates. I use newly-digitized datasets to 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 yet short-lived effects on profits, positive effects on employment and negative effect on earnings. Hourly wages decrease in small firms but increase in large firms. I rationalize these findings in a directed search model with matching frictions where firms have heterogeneous productivity, post wages and hours, and use both jobs and hours as inputs. Utilitarian welfare is expressed in terms of a sufficient statistic whose application to the 1910 reform suggests an unambiguous welfare improvement.

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1 Introduction

Today, there is growing evidence that some workers would prefer to work fewer hours at their wage rates. This *hours mismatch* is documented by survey data (Jarosch et al., 2025), revealed preferences (Lachowska et al., 2023), and field experiments (Mas & Pallais, 2017). Historically, governments responded to such workers' requests by imposing caps on daily, weekly and yearly working hours. To date, working hours regulations remain binding, important, and highly heterogeneous across countries. 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 does not have any nationwide mandate on vacations.

This paper studies the consequences of working time reductions for wages and welfare. I demonstrate that these effects differ starkly depending on the model of the labor market. In particular, I use newly-digitized datasets to show that the desirability of working time reduction vary with (i) the structure of competition in the labor market, (ii) the timing (i.e. who chooses what) of the labor market and (iii) the complementarity between jobs and hours in production.

In the first part of the paper, I build a simple general equilibrium toy model of the labor market where production features decreasing returns to hours and workers face the canonical leisure-consumption tradeoff: an extra hour worked increases utility through consumption but decreases utility through leisure. This model brings two key findings.

First, the welfare effects depend on *who sets schedules*. If workers choose hours as in neoclassical labor supply theory, the marginal utility of an extra hour worked must be zero. Conversely, when firms choose hours, the labor contract will feature long hours and workers would welcome a working time reduction for a given wage. This suggests that the *hours mistmatch* can simply be modeled as an alternative timing in the labor market: when firms set schedules, workers would like to work less.

Second, the wage effects depend on *who sets wages*: a working time reduction decreases wage rates in an oligopsonistic labor market but the very same policy increases wage rates in perfect competition. Intuitively, in the pure monopsony case, labor supply increases in wages such that a working time reduction must be associated with a wage cut. 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 evaluate these empirical predictions, the paper studies 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. I obtained detailed firm-level information on yearly production price and quantities, employment and the wage bill. Moreover, I have within-firm occupation-level information on hours worked as well as daily wages. Overall, these data suggest that the reform was binding and implied significant production changes: 86% of firms had to reduced their daily hours volume by 9% on average while 82% of underground workers had to reduced their daily schedule by 10% on average.

At the firm level, I compare post-reform outcomes of firms with different scheduling practices before the reform in a standard event-study design. I find sizable yet short-lived negative effects of the reform on profits: I estimate that the reform reduced treated firms' profits by 70% on average in the first year of the reform, while this effect disappear in subsequent years. I also show that firms substituted hours for jobs: the reform increased treated firms' headcount employment by 45 jobs (3.4%) on average. All of this employment effect originates from underground jobs. These results are economically large and imply sizable elasticities : a 1% mandated reduction in underground hours volume reduces profits by 7.76% in the short run and 3.74% in the medium run while it increases underground employment by 0.52%. This suggests that hours worked are substitutable with jobs, although imperfectly.

At the within-firm occupation level, I compare post-reform daily earnings of occupations with different hours worked before the reform and leverage the fact that only underground workers within firms were affected by the reform while above-ground workers were unaffected. I estimate that the reform reduced treated workers' daily earnings by 2.8% on average with an implied elasticity of daily earnings to a 1% mandated reduction of daily hours amounting to -0.28. However, because daily earnings decrease

[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).

less than hours worked, hourly wage must have increased, contrary to the monopsony prediction of the toy model.

Importantly, I show that this average effect masks an important heterogeneity: hourly wages decreased in small firms but increased in large firms. The elasticity of hourly wages to a mandated reduction in daily hours is -1.1 in the bottom third of the firm size distribution, but $+0.65$ in the top two third of the firm size distribution.

To disentangle the role of firm size and monopsony power, I build a model with large firms where the labor market features directed search model and competitive search equilibrium of the labor market à la Eeckhout and Kircher (2018) and Moen (1997). Production uses as inputs not only hours worked but also jobs and they may be imperfectly substitutes. Firms are heterogeneous in productivity and post wages, hours worked and vacancies.

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.

First, monopsony pushes hourly wages down after a working time reduction. However, this effect is mitigated, and eventually reversed when hours and jobs are complements. Intuitively, because of this complementarity, firms must hire to compensate for the reduction in daily hours. To attract workers, they must bid higher wage rates, and this effect is stronger in large firms.

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

Finally, because workers' utility trades off the quantity of jobs with the quality of jobs, this directed search model is particularly well suited for welfare analysis. Indeed, while leisure and employment increased, workers' earnings fell such that the net impact of the reform on welfare is ambiguous. In turn, this model aggregates individuals' micro leisure-consumption trade-offs in a macro arbitrage between wages, employment and hours worked. 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 conclude that all common assumptions on utility functions would lead to unambiguously infer that the reform was welfare-improving for workers.

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 (i) the degree of firms' labor market power, (ii) the agent controlling schedules, (iii) firm sizes. Our empirical context rejects the standard labor model where there is (i) perfect competition, (ii) workers choose hours and (iii) firms are atomistic. 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 may offset the welfare gains.

Section 2 discusses the relationship with the literature. Section 3 presents the toy model which contrasts the effect of working time reductions on marginal utility and wage rates depending on who sets hours and wages. 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

[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)

in a competitive search equilibrium. As a result, labor supply is not derived from utility-maximization but from profit maximization under a utility constraint.

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 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; Dube & Zipperer, 2024; Manning, 2021). Gravoueille (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 degree of monopsony power as well as the production complementarity between jobs and hours.

[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.

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 Toy model: who chooses what?

In this section, I contrast the theoretical effects of working time reductions on wages and utility depending on who sets hours and wages. I build a simple general equilibrium model of the codetermination of wages and hours.

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

Workers have a utility function $u(c, l)$ that is increasing in consumption c and decreasing in hours worked $l \in [0, 1]$. They have an outside option to the labor contract that gives a reservation utility u_r. When working, their consumption is equal to their earnings $c = wl$. Interestingly, the marginal utility of an extra hour $\frac{du(\cdot)}{dl} = wu'_c + u'_l$ has an ambiguous sign: at low hours, workers would like to work more at the wage rate w because the positive consumption effect dominates the negative leisure effect while this is reverted for long hours. For regularity, I assume that the workers' preferred schedule is neither 0 nor 1[5].

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

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

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

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

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

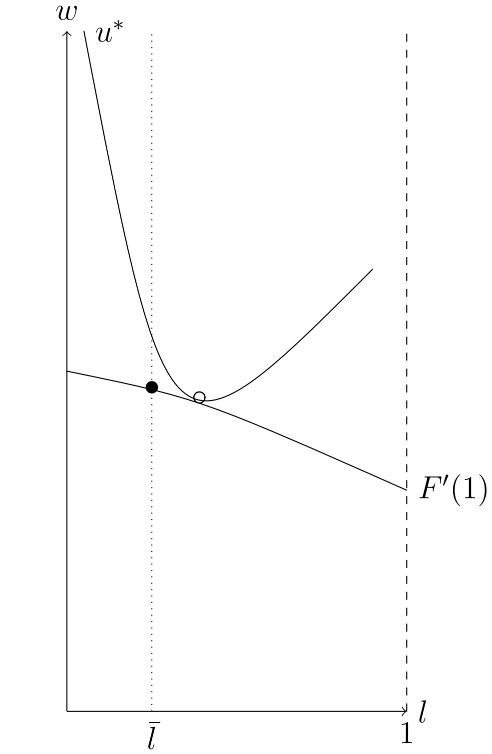
In model 2, workers set again hours such that $\frac{\partial u(\cdot)}{\partial l} \geq 0$. However, firm sets monopsonistic wage rates to maximize profits internalizing the neoclassical labor supply. This gives rises to the standard Robinson (1933) monopsony equation $F'(l) - w = \frac{l}{l'(w)}$ where $l'(w)$ is the derivative of the labor supply function. When $l(w)$ is increasing[6], a working time reduction must necessarily be associated with a decrease in equilibrium wage rates $dw \leq 0$.

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

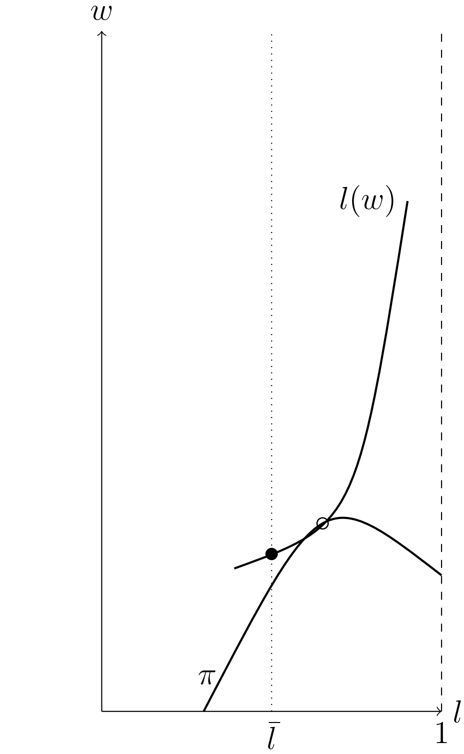
Finally, in model 4, firms choose both wage rates and hours to maximize profits. Equivalently, the firm chooses the profit-maximizing contract on the workers' reservation indifference curve u_r. Necessarily, this is a contract with long hours and low wage

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

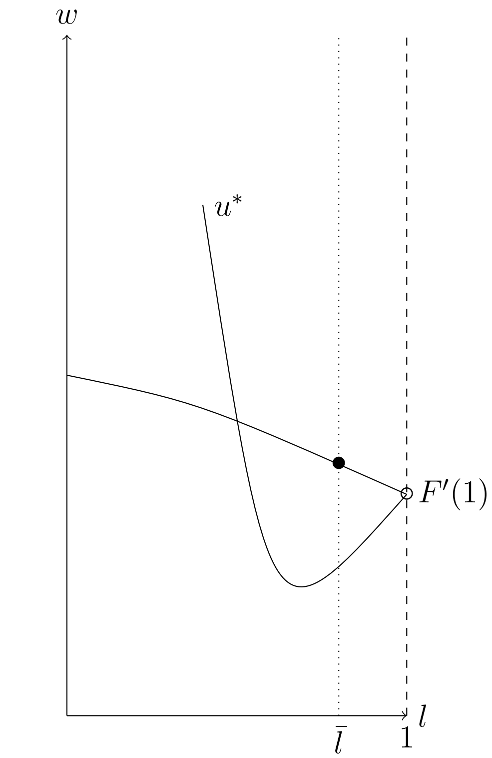
Figure 1: Equilibrium before (∘) and after (•) a small binding working time reduction $\bar{l} < l$.



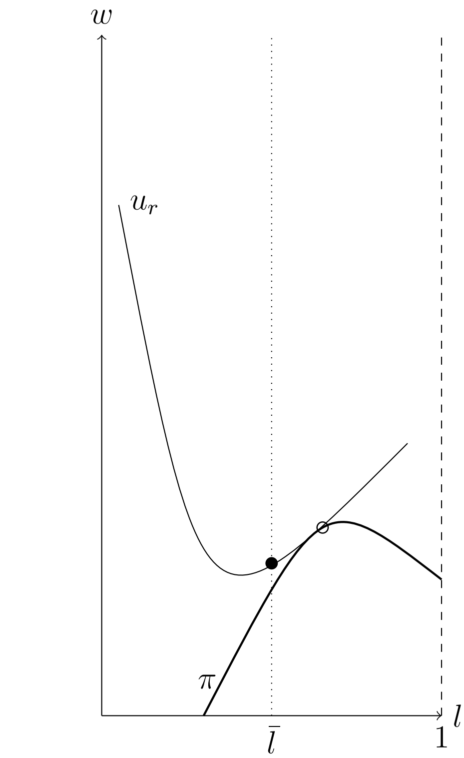
(a) Model 1: workers choose hours, competitive wage rates



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



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



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

Table 1: Summary of theoretical predictions in the four different models.

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

rates such that the marginal utility of an extra hour at that wage rate is negative $\frac{\partial u(\cdot)}{\partial l} \leq 0$ and workers would welcome a working time reduction. However, in equilibrium they must remain on the same indifference curve u_r, such that the utility gains generated by the policy on leisure will be fully compensated by a loss in wage rates, such that $dw < 0$.

In Table 1, I summarize the theoretical predictions on $\frac{\partial u(\cdot)}{\partial l}$ and dw for the four models. The main results of this section can be summarized as follows. First, if wages are rigid, workers are more likely to be favorable to government-mandated working time reductions when firms set hours. Second, the very same working time reduction increases competitive wage rates but decreases monopsonistic wage rates[7].

All these results are derived with only one labor input in the production function, or equivalently assuming a perfect substitutability between jobs N and hours l as well as a fixed inelastic demand for jobs N. It can be shown that the results of this section can be extended to a production function $F(N, l)$ that may have an imperfect sustainability between jobs N and hours worked l provided that the output elasticity of hours exceeds the output elasticity of jobs $lF'_l > NF'_N$. In section 5, I build a search and matching model of the labor market with production function $F(N, l)$ and study the welfare effects of the policy.[8]

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

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

[8]It would be easy to show that models 1 and 2 imply that working time reductions are inefficient while models 3 and 4 give a redistributive role to working time reductions. Welfare when production includes employment is less obvious (and therefore more interesting) because working time reductions affect not only the quality but also the quantity of jobs. I come back to this issue in section 5.

(Philips & Buyst, 2020).

The policy under study is the first major piece of labor regulation affecting prime-age males in the country.[9] 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.[10] Compared their foreign competitors, Belgian coal mines were relying more on manual labor and less on mechanized extraction while wages were lower (Denoël, 1909). They also exhibited a smaller mortality risk (Leboutte, 1991) despite longer workdays (Cousot, 1908).

The policy was signed into law by the King on December 31, 1909 and imposed that a workday for underground workers could not exceed 9 hours 30 minutes from January 1, 1911 and 9 hours from January 1, 1912.[11] Importantly, the law did not regulate the schedules of above-ground workers.[12] Before this, there was no regulations on daily schedules.

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 labor income taxation and barely any other labor regulations. This contrasts with modern-day reforms on working time where these policies are typically coupled with support measures such as payroll tax reductions, rendering identification of the pure impact of working time reductions tedious.

Second, there was no downward wage rigidity at the time. Figure 2 shows 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 equilibrium wage cuts $dw \leq 0$, our setting should allow us to observe them.

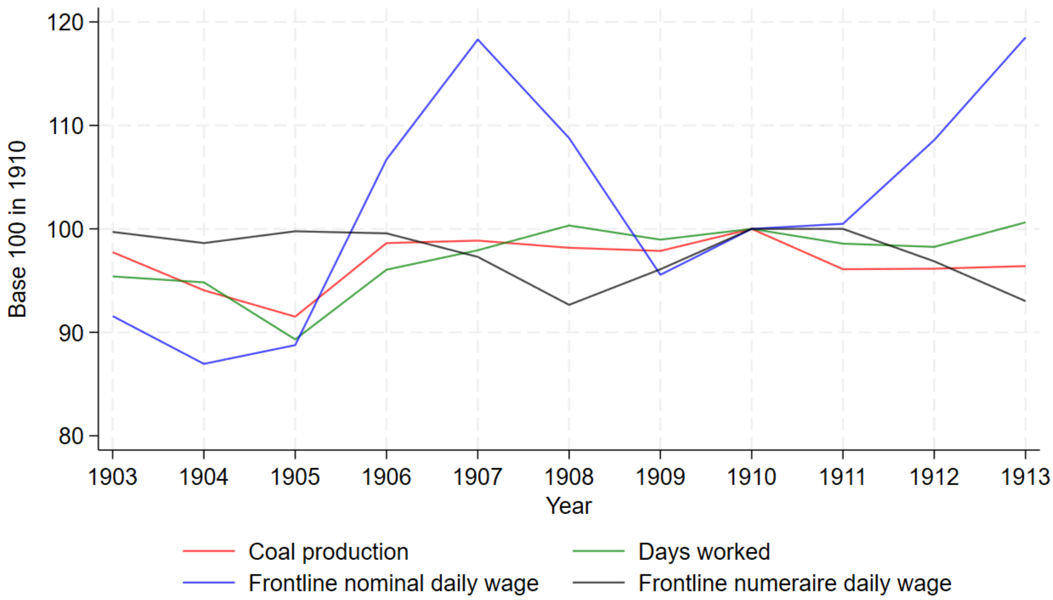
[9]Earlier regulations were only targeted to female and child labor. In the mining industry, underground labor was prohibited for women younger than 21 and male children below 12 from 1892 onward (Annales des Mines, 1907). The 1910 refrom was among the first policies to break the *Laissez-faire* tradition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

[10]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).

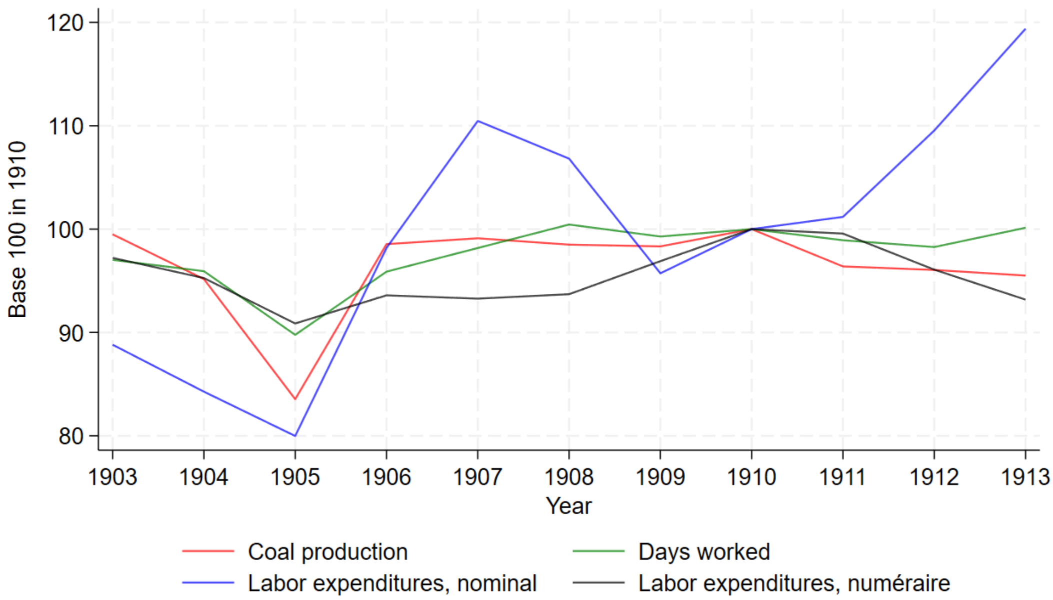
[11]Working time must be understood as *from bank to bank*, i.e. the time from the surface at the beginning of the working day to the time at the surface at the end of the working day. Hence, it includes the time in the lift as well as time needed to walk from the lift to the work station.

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

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



(a) Evolution of the cross-sectional firm average for selected outcomes.



(b) Evolution of industry aggregates over firms for selected outcomes.

Notes: Base year is set to 100 in 1910. Coal production is measured in tons of coal while total days worked include all occupations within the firm. The blue lines are expressed in nominal currency. The black lines are expressed in units of numéraire by dividing by the price of output.

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 fixed fee and a linear rate), although it only raised a modest amount: 1.5 million BEF in 1903 i.e. 0.3% of the state's revenue (Chamber of Representatives, 1903). Second, coal mines were important to the state for industrial, political, social, and economic factors. More than 120,000 workers[13] 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[14], the government was keen on monitoring production.

As a result, the Mining Administration kept a consistent record of data of remarkable quality for the time. Each year, state officials[15] were sent to each mine to collect statistics on production, prices, employment and wages. These reports were then collected by the administration to establish a firm-level panel dataset. In Figure A.1, I provide examples of a report in (a) and of the panel dataset in (b).

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

This dataset contains firm-level information on annual coal production[16], output prices, input costs, headcount employment, total days worked, and the wage bill. Moreover, it also contains occupation-level information on yearly employment and daily wages both for underground workers (affected by the reform) as well as above-ground workers (not affected by the reform). However, the dataset does not contain information on daily working time.

[13]This corresponds to more than 10% of the labor force of the provinces of Hainaut, Liège and Namur combined.

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

[15]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.

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

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 occupation-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).

This cross-sectional dataset covers hours worked for 9 occupations working underground, while the panel dataset only contains 2 types of underground occupations (frontline and non-frontline underground workers). I match the two datasets such that the resulting aggregate distribution of hours worked resembles an aggregate distribution collected by the Mining Administration on November 29, 1907. I describe the matching procedure in appendix A.2.1. In Figure 3, I report the distribution of hours worked in the matched dataset in green in panel (a) together with the (exact) distribution of the Mining Administration in blue in panel (b) (Parliamentary Commission, 1908).

Importantly, the fraction of workers working more than 9 hours is identical in both distribution : 82% of underground workers.[18] The average working day lasts 9h46 in the green distribution and 9h49 in the blue distribution. Although the green distribution is less dispersed than the blue, the former represents an annual average.

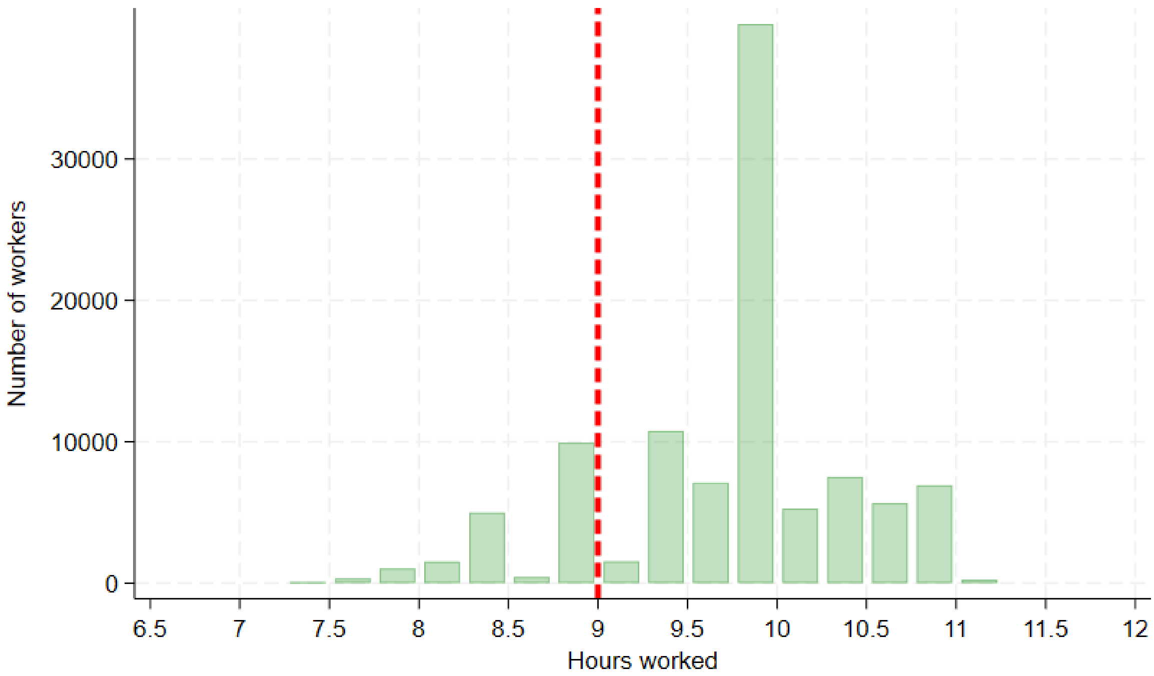
The rest of the paper uses a balanced matched dataset, i.e. firms belong to the dataset if (i) I have information on their daily hours worked and (ii) they did not exit, did not participate in merger, and were not acquired during the sample period. Appendix Table A.3 shows that requirement (i) is met by firms covering 96% of national production while Appendix Table A.4 shows that the balanced panel satisfying both (i) and (ii) covers around 86% of the industry's production and employment and contains 99 firms. In Appendix Table A.5, I show that the occurrence of mergers, acquisitions, or firm exits are relatively balanced between treated and control groups both before and after the reform.

Finally, the law allowed for deviation to the 9-hour rule for exceptional circumstances (such as urgent safety work) provided that this deviation was recorded and reported to

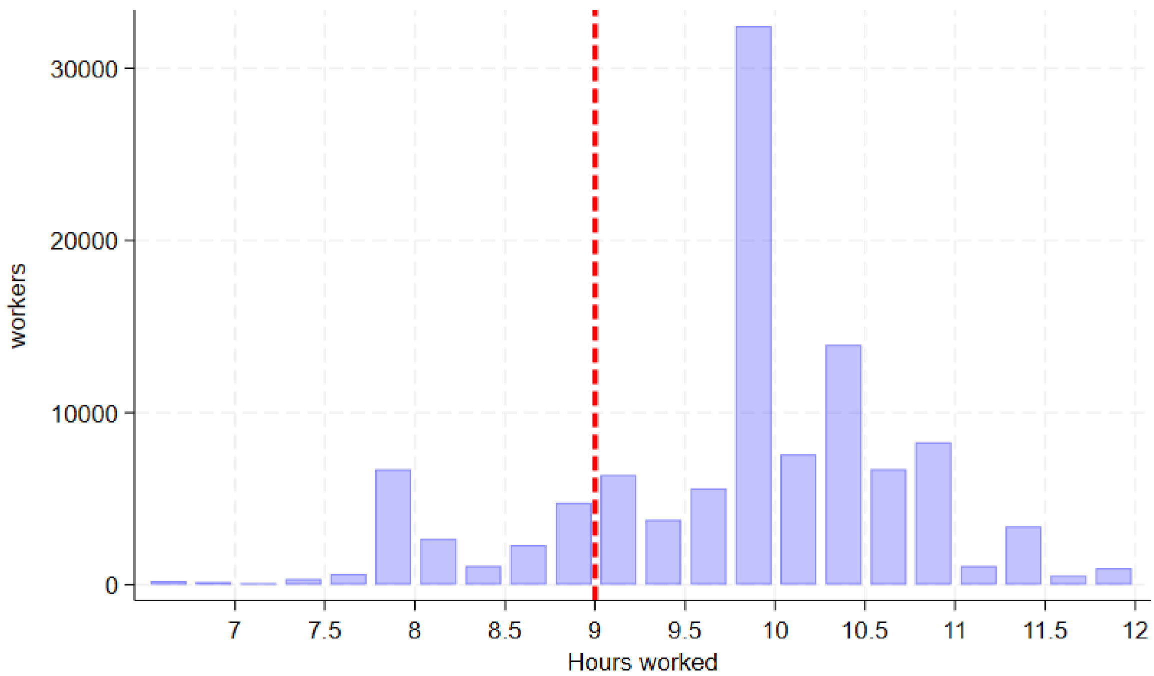
[17] The bill was introduced by socialist M.P. Destrée in 1903. From 1884 and until World War I and despite electoral reforms toward universal suffrage, the Catholic party had an absolute majority and initially opposed the maximum workday in the coal mines, as did King Leopold II. In 1907, some Catholic 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.

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

Figure 3: Validation of hours worked variable



(a) Implied distribution of hours worked by underground workers in 1907 by my dataset matching.



(b) Distribution of hours worked by underground workers on November 29, 1907 (Parliamentary Commission, 1908).

the mining administration. This allows to observe enforcement of the reform. Aggregate statistics reveals that the volume of overtime hours amounted to 143,868 hours and 157,274 hours in 1912 and 1913 respectively, which represents 0.058% and 0.064% resp. of the aggregate volume of hours of 1909. This corresponds to 1h45 and 1h53 per underground worker per year, i.e. 21 and 23 seconds per day, respectively. Moreover, the number of complaints filed by workers for employers' non-compliance is positive but small. In the remainder of the paper, I assume perfect compliance to the legal thresholds for post-reform hours worked.

Besides datasets, these archival sources also provide qualitative information on the context of the reform. In particular, the parliamentary commission interviewed mine owners and workers in various locations and asked their opinion on the reform. These interviews are helpful to understand the labor conflict: all owners opposed the reform and threatened to compensate its effect by cutting wages. On the workers' side, all were in favor of a reform cutting hours holding wages constant. Some were in favor of the reform even if wages were cut while others opposed wage cuts (Parliamentary Commission, 1909). This qualitative evidence is consistent with model 4 in section 3 where firms set both hours and wages and the marginal utility of an extra hour is negative $\frac{\partial u(\cdot)}{\partial l} \leq 0$.

4.3 Reduced-form estimates

4.3.1 Firm-level

The first empirical strategy leverage variation in pre-reform scheduling practices across firms. The object of interest will be the share of a firm's underground daily hours volume in 1909 that is composed of schedules above the 9 hour cutoff. More formally, I define $\mathrm{vol\_reduction}_j$ as

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

where $h_{o,j,1909}$ and $N_{o,j,t}$ are the daily hours worked and headcount employment of occupation o in firm j in 1909. If no underground occupation works more than 9 hours per day, a firm's $\mathrm{vol\_reduction}_j$ is equal to 0 and it will be part of the control group, while all firms with positive values belong to the treated group. The average $\mathrm{vol\_reduction}_j$ among treated firms is 9.07 with a standard deviation of 3.4. In Table 2, I report summary statistics for pre-treatment values of treated and control firms.

Unsurprisingly, treated firms produce differently than control firms : the former are

Table 2: Summary statistics for control and treated firms in 1903-1909.

	Control firms	**Treated firms**
Profits, units of numéraire	9,813.91	9,024.95
	(21,312.46)	(25,661.59)
TFP	1.129	1.092
	(0.303)	(0.129)
Labor share	0.558	0.521
	(0.124)	(0.064)
Total days worked	**198,967**	**391,174**
	(342,923)	**(276,198)**
Headcount employment	**660**	**1,309**
	(1,143)	**(921)**
Share underground employment	**0.780**	**0.733**
	(0.063)	**(0.056)**
Share frontline among workers	**0.334**	**0.244**
	(0.158)	**(0.047)**
Share of self-consumed production	**0.043**	**0.098**
	(0.039)	**(0.046)**
Yearly days worked per worker	294.51	298.75
	(15.16)	(7.09)
Daily product per worker, tons	0.589	0.583
	(0.227)	(0.108)
Output, tons per m^2	0.851	0.901
	(0.214)	(0.176)
Average power of coal veins, meter	0.628	0.680
	(0.151)	(0.136)
Yearly product per frontline miner, tons	809.83	1,027.96
	(418.40)	(310.28)
Average wage per worker, units of numéraire	0.303	0.299
	(0.055)	(0.041)
Output price, current BEF	**13.56**	**14.97**
	(2.18)	(1.59)
Investment-to-sales ratio	0.092	0.109
	(0.047)	(0.052)
vol_reduction_j	0.00	9.07
	(0.00)	(3.44)
Observations	13	86

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

on average twice bigger in terms of headcount employment and rely relatively more on non-frontline underground employment. However, per-worker variables are remarkably similar in both groups. Moreover, profits and wages display similar mean and dispersion in both treated and control groups.

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

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

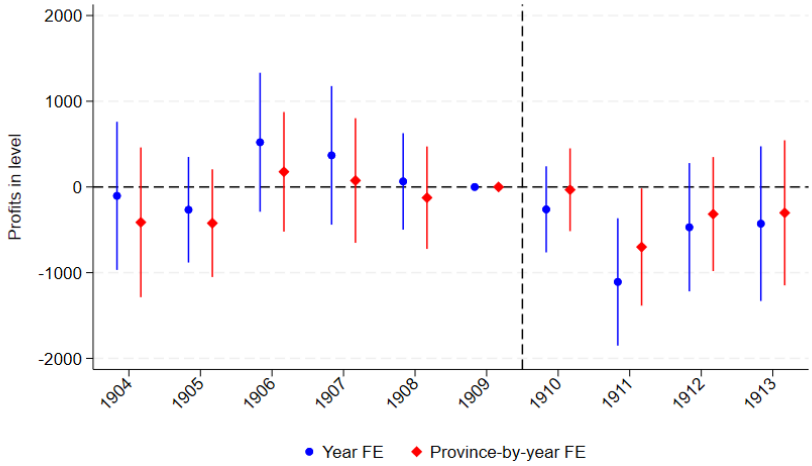
where $X_{j,t}$ are a set of controls and $\epsilon_{j,t}$ are standard errors clustered at the firm level. The omitted year is set to 1909 which is the last full year before the law is passed. All the results are presented for two sets of time fixed effects: year fixed effects control for industry-wide shocks in a given year while province-by-year fixed effects control for region-specific shocks in a given year. The coefficients β_k are the objects of interest. Because of the definition of vol_reduction_j, β_k can conveniently be interpreted as the average effect in year k across treated firms of a 1% mandated reduction in the volume of hours.[19]

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 scheduling practices 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 Results for regression 1 for profits are reported in Figure 4. I find a large, negative yet short-lived effect on profits : in the red specification, a 1% mandated reduction in the volume of hours reduced firms' profits by 701 units of numéraire in 1911 (p-value 4.5%) while the effect cannot be distinguished from zero after that. To understand the magnitude of the effect, recall that the average mandated reduction of 9.06% implies an ATT of $9.06 \times (-701) = -6351$ units of numéraire, i.e. a reduction of 70% relative to the pre-treatment average profits among treated. Although this magnitude seems unreasonable for modern-day economies, one ought to remember that the year-to-year change in profits was particularly large at that time. This confirms anecdotal evidence that the reform was not anticipated and had largely adverse effects on mine owners.

[19] The average treatment effect on the treated (ATT) can be obtained by averaging the estimated coefficient $\hat{\beta_k}$ for $k > 1909$ multiplied by the average vol_reduction_j, i.e. 9.06%.

Figure 4: β_k in regression (1) of profits in units of numéraire.



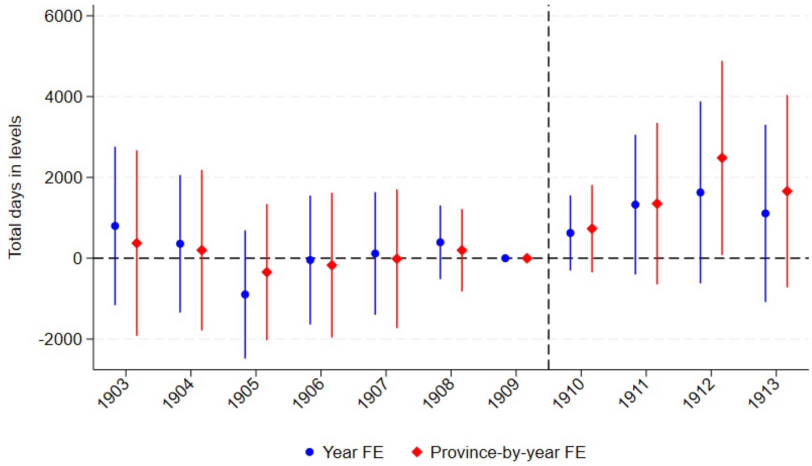
Notes : standard errors are reported at the 95% confidence level. Controls $X_{j,t}$ are the size of the exploitation at the surface in squared meters, the fraction of self-consumed output, the price of output in current BEF, and the average power of coal veins in meters. The p-value for testing $H_0 : \beta_k = 0 \, \forall k < 1909$ are 0.17 and 0.28 for the blue and red regressions, respectively. The within R-squared are 0.37 in both cases.

Employment Results for regression 1 for several employment outcomes are reported in Figure 5. In panel (a), we report mildly positive effects : a 1% mandated reduction in a firm's volume of hours increases total days worked by 2484 units in 1912 (p-value 4.3%) in the red specification, while the other estimates cannot be distinguished from zero. To understand the magnitude of this effect, given the 9.06% average reduction in hours volume among treated firms, this effect corresponds to a $\frac{9.06\times(2484)}{391{,}174} = 5.75\%$ increase in employment relative to treated firms' pre-treatment average. Panel (b) and (c) suggest that this effect comes almost entirely from an increase in headcount underground employment. Indeed, panel (b) suggests that a 1% mandated reduction in a firm's hours volume increases employment by 5 jobs in 1911-1913 while panel (c) shows that all of these jobs are underground jobs. This suggests that firms' reacted to the reform by hiring underground workers (affected by the reform) without changing the number of above-ground workers (not affected by the reform). The estimated ATT is $\frac{5\times 9.06}{1309} = 3.4\%$ for overall employment and $\frac{5\times 9.06}{954} = 4.75\%$ for underground employment.

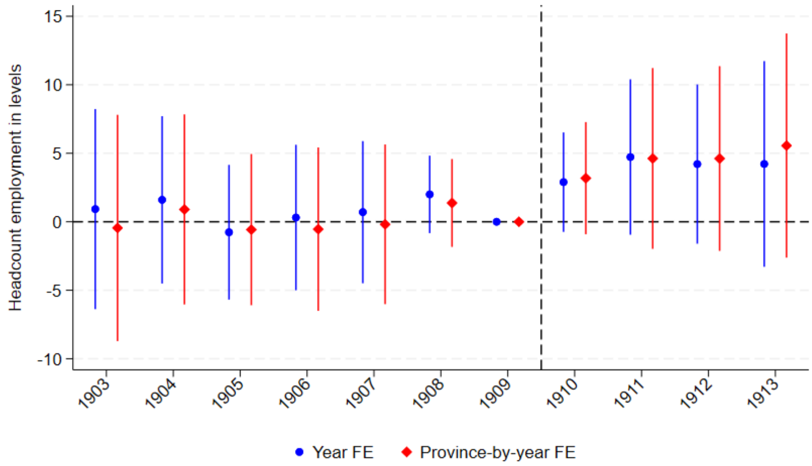
4.3.2 Occupation-level analysis

In this section, I exploit the variation in hours worked within-firm across occupations in addition to variation across firms. Again, we exploit the continuous nature of the treatment and define the regressor of interest as the fraction of daily hours that occupation o in firm j in excess of the legal limit. Importantly, recall that aboveground workers were

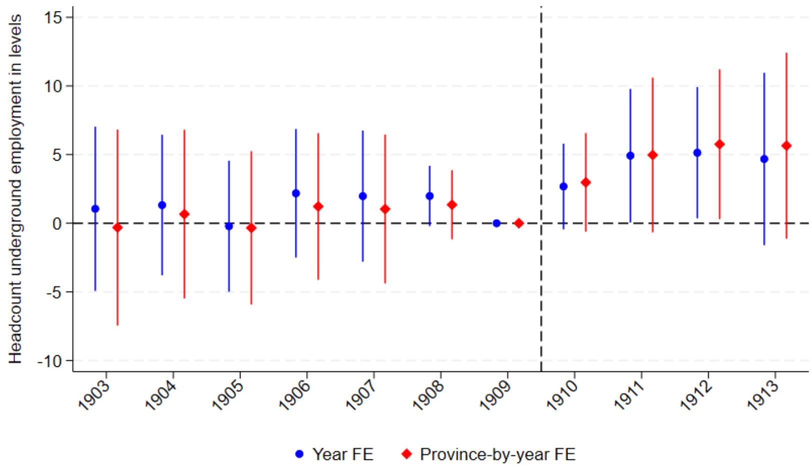
Figure 5: β_k in regression (1) of various employment outcomes in levels.



(a) Total days worked over the year. P-values are 0.43 (blue) and 0.97 (red) while within R-squared are 0.008 and 0.012 respectively.



(b) Headcount employment. P-values are 0.51 (blue) and 0.82 (red) while within R-squared are 0.005 and 0.008 respectively.



(c) Headcount underground employment. P-values are 0.42 (blue) and 0.83 (red) while within R-squared are 0.008 and 0.012 respectively.

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

not affected by the workday restriction. More formally, I defined $\text{h\_reduction}_{o,j}$

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

An underground occupation o in firm j is treated whenever it was working more than 9 hours before the reform, or equivalently when $\text{h\_reduction}_{o,j}$ is positive. The average $\text{h\_reduction}_{o,j}$ among treated units is 10 with a standard deviation of 3.87 . The distribution of treated and control units across firms is reported in Table 3.

Table 3: Distribution of Treated (T) and Control (C) units across occupation types and firms

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

Out of the 86 treated firms studied in the previous section, we see that 63 of them had schedules beyond the 9 hours threshold for all their underground occupations. However, 7 firms (resp. 16) had only frontline (resp. non-frontline) workers with schedules above the threshold. We have 3 occupations in each firm for a total of 297 units, of which 149 units (70 frontline and 79 non-frontline) will be treated and 148 units will be part of the control group. In Table 4, we show that treated units are larger in terms of employment size and receive larger wage. I report the firm-level statistics analog to Table 2 for this new treated and control (o, j) units in Appendix Table A.6.

Our main object of interest is the effect of the reform $d(1-\bar{l}) > 0$ on hourly wage. Observe that the ATT on the log hourly wage is a linear combination of the following :

$$\frac{dln((1-\tau)wl)}{d(1-\bar{l})} = \frac{dln(w)}{d(1-\bar{l})} + \frac{dln(l)}{d(1-\bar{l})} + + \frac{dln(1-\tau)}{d(1-\bar{l})}$$
$$\frac{dln(w)}{d(1-\bar{l})} = \frac{dln((1-\tau)wl)}{d(1-\bar{l})} - \frac{dln(l)}{d(1-\bar{l})} - \frac{dln(1-\tau)}{d(1-\bar{l})} \quad (2)$$

where τ is the (observed) firm-specific withholding rate[20] and l are actual hours worked. In the remainder, I assume that hours worked l for (untreated) above-ground are 10

[20] As said before, there was no payroll taxes nor labor income taxation. However, some firms withhold a fraction of workers' wage. There are two types of withholding: fines to punish workers' behavior as well as employer-provided insurance covering workplace injury and death. Old-age pensions did not arrive before World War I.

Table 4: Summary statistics for control and treated units (o, j) in 1903-1909.

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

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

hours. All results are numerically insensitive to this assumption.

I use the identification strategy and specification follow the same line as above *mutatis mutandis* except that the dependent variable is now in $\log$:

$$\ln y_{o,j,t} = \beta_0 + \sum_{k \neq 1909} \beta_k * \text{h\_reduction}_{o,j} + \mu_{o,j} + \nu_{o,t} + \epsilon_{j,t} \tag{3}$$

where $\mu_{o,j}$ control for time-invariant unit-specific characteristics, $\nu_{o,t}$ control for occupation-specific aggregate shocks and $\epsilon_{j,t}$ are standard errors clustered at the firm level.

In Figure 6, I report results for three dependent variables in logs: the net daily earnings $\ln(1-\tau)wl$, hours worked $\ln(l)$ and net-of-tax withholding rate $\ln(1-\tau)$. Panel (a) shows these effects for the full sample. One finds a negative effect on earnings : the average treatment effect on the treated is -2.8% and the associated elasticity of daily earnings to a 1% mandated reduction in daily hours amount to -0.28. Because this elasticity is is larger than -1 and the net-of-withholding rate $(1-\tau)$ is unaffected by the reform, by equation 2, this implies that the average treatment effect on hourly wage is positive, contrary to the prediction of Model 4 in section 3.

However, panels (b) and (c) show that the effect is completely different depending on the size of firms. In panel (b), we see that a 1% mandated reduction of hours worked reduces earnings by 2.1% for treated workers in small firms. Given that the net-of-tax rate is stable, this implies that the elasticity of hourly wages to a mandated reduction of daily hours is -1.1. By contrast, the ATT for daily earnings in big firms is estimated to be -0.05% which implies that the elasticity of of hourly wages to a mandated reduction of daily hours is +0.65.

To conclude this section, recall that all firms, whether big or small, were controlling schedules. Hourly wage decreased in small firms while the positive hourly wage effect in big firm is consistent with perfect competition. However, there is no reason to believe that large firms face a different, more competitive labor market than small firms since Delabastita and Rubens (2025) documented widespread monopsony power in that industry. Rather, one should remember that the toy model did not allow employment effects. I address this in the next section.

5 General model

The empirical findings suggest that (i) all workers were asking for a working time reduction, (ii) the reform increased hourly wage in big firms and (iii) the reform decreased hourly wage in small firms. This suggests that big firms acted as predicted by Model 3 while small firms acted as predicted by model 4 of section 3. However, these models do not allow for extensive labor supply responses, both on the supply and demand side. However, we documented positive employment effect. In this section, I build a model where firms produce using both jobs N and hours worked l through a production function $F(N, l)$. I allow for heterogeneous firm productivity while the labor market features directed search and contract posting[21] as in the seminal paper by Moen (1997) but it is kept static as in Vergara (2023).[22]

5.1 Directed search model

Labor market Consider a set of measure L of workers who are each endowed with a unit of time.[23] Firms are posting vacancies with a pair $m = (w_m, l_m)$ of wage rate and hours worked. All vacancies v_m at a given pair m form a submarket and there may be potentially many submarkets. Workers are applying to one vacancy among the various submarkets m and the number of applicants for a given submarket is denoted by a_m.

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

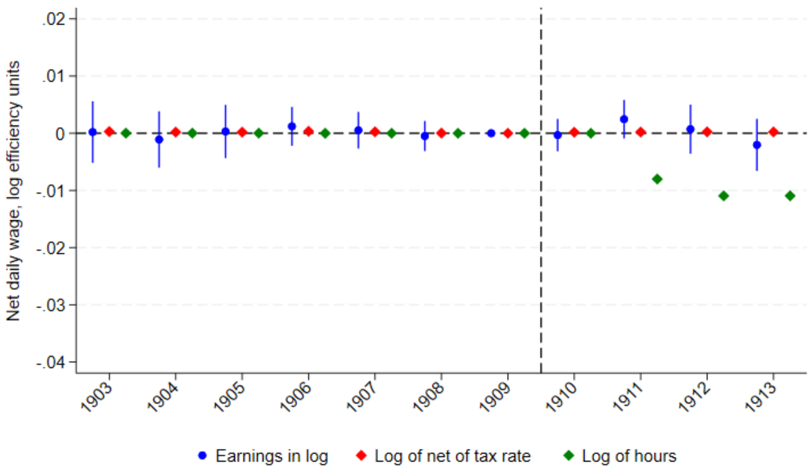
[22] The key difference with Vergara (2023) is the presence of leisure.

[23] 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.

Figure 6: β_k in regression 3 for components of net daily wage in efficiency units

(a) Full sample. P-value : 0.39. Within R-squared : 0.007.

(b) Subsample of units in small firms (bottom third of the size distribution). P-value : 0.15. Within R-squared : 0.054.



(c) Subsample of units in big firms (top 66% of the size distribution). P-value : 0.76. Within R-squared : 0.002.

Notes : standard errors are reported at the 95% confidence level. Controls $X_{j,t}$ are empty. I report the p-value for testing $H_0 : \beta_k = 0 \ \forall k < 1909$ as well as the within R-squared for the blue regression only.

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.[24] 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,

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

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.[25]. I assume that each worker may only apply to one submarket, such that the expected utility of participating to the labor market for a worker of disutility of participation d reads

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

An individual worker applies by taking p_m as given but the aggregate behavior of all workers will pin down p_m. Hence, in equilibrium, it must be that all agents have the same expected utility[26] (net of their d) that I will denote by $\bar{U}$.[27] However, the fact that all workers of the same type enjoy the same expected utility ex-ante does not imply that

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

[25] 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).

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

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

they all enjoy the same ex-post utility.

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

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 $G(\bar{U} - u(B, 0)) \times L$.[28]

Firms All firms face perfect competition in the single output market whose homogeneous good is set as the numéraire. Indeed, Delabastita and Rubens (2025) documented that Belgian coal mines had no price-setting power in their output market. Firms are only heterogeneous in their total factor of productivity ψ_j.[29] 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 short-hours and long-hours contracts.[30]

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 func-

[28] 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).

[29] 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.

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

tion is monotonically increasing in ψ_j, there exists a decisive ψ^* such that $\pi(\psi^*) - x = 0$. All capitalists with $\psi_j < \psi^*$ abstain from entering the labor market and remain inactive while all with $\psi_j \geq \psi^*$ participate.

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

$$v_m : \quad \tilde{q}_m(\psi_j F'_N - w_m l_m) \leq k'(v_m) \qquad \textit{with equality if } v_m > 0 \quad (4)$$

$$w_m : \quad v_m \tilde{q}'_{m,w}(\psi_j F'_N - w_m l_m) \leq q_m v_m l_m \qquad \textit{with equality if } w_m > 0 \quad (5)$$

$$l_m : \quad v_m \tilde{q}'_{m,l}(\psi_j F'_N - w_m l_m) + \psi F'_l \geq \tilde{q}_m v_m w_m \qquad \textit{with equality if } l_m < \bar{l} \quad (6)$$

   where $\bar{l} \leq 1$ *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*** *:*

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

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

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

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

4. ***Workers' participation constraints :***

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

   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, one may find vacancies from several firms. Say that we find two firms $\psi_j > \psi_k$ in some given submarket (w, l). By equations 4 and 6 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 will post vacancies in several submarkets, i.e. equation 4 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 Although search is competitive, the labor market remuneration might not be. Indeed, this model produces an earnings markdown and workers are paid below their marginal product. If the 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 5 reads

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

which is 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.[31] As models 2 and 4 in section 3, there is monopsony power because agents' utility function implies that the wage

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

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^w_m decrease and the earnings markdown increase.

Wage effects of working time reduction To assess the wage effects of small working time reduction, take the total derivative of equation 4 in interior solutions:

$$\frac{l}{w}\frac{dw}{dl} = \underbrace{-\frac{l}{w}\frac{\tilde{q}'_{m,l}}{\tilde{q}'_{m,w}}}_{(A)} + \underbrace{\frac{1}{\epsilon^w_m}\frac{l}{N}\frac{1}{F''_N}\frac{F'_l}{N}}_{(B)} - \underbrace{\frac{1}{\epsilon^w_m}\frac{l}{N}\frac{F''_{N,l}}{F''_N}}_{(C)}$$

where $N_m = \tilde{q}_m v_m$. The first term (A) is the ratio of the derivative of job-filling probabilities, which is directly proportional to workers' utility : it is the marginal rate of substitution between l and w. This is exactly the same mechanism as in Model 4 of Section 3: when workers would like to work less at the wage rate w, $\tilde{q}'_{m,l} < 0$ and the first term is positive such that the monopsonistic decreases wage rate after a working time reduction.

However, now that employment may react to the reform, there are two additional terms in the equation. Because the monopsonist may cut wages after a working time reduction, some workers will leave the firm (proportionally to $\frac{1}{\epsilon^w_m F''_N}$). This has two effect of opposite signs. In (B), because some agents leave, the firm looses the marginal product of their hours. This effect moderates the wage cut. In (C), these quitters may increase the marginal product of workers who remain in the firm when $F''_{N,l}$ is large enough. The net effect of workers' outflows depend on the relative magnitude of $\frac{F'_l}{N}$ and $F''_{N,l}$. When these quantities are equal, (B) and (C) cancels out and we are back to the pure monopsony case of Model 4. This happens when a new hire has a marginal product of an hour worked equal to the firm average. For example, this happens if $F(N,l) = Nl + N^\alpha$.

Now for a standard CES case $F(N,l) = A[\alpha N^\rho + (1-\alpha)l^\rho]^{1/\rho}$, the expression reduces to

$$\frac{dw}{dl} = -\frac{\tilde{q}'_{m,l}}{\tilde{q}'_{m,w}} + \frac{1}{\epsilon^w_m}\left(\frac{\alpha\rho + (1-\alpha)(\frac{l}{N})^\rho}{\alpha(\rho-1)}\right)$$

Our empirical results are consistent with $\frac{dw}{dl}$ being positive for small firms and negative for large firms while all workers are calling for a working time reduction which we can assimilate to $\frac{\tilde{q}'_{m,l}}{\tilde{q}'_{m,w}} < 0$ for all m. This means that rationalizing our findings requires to find values of ρ such that the bracketed factor decreases with N. This is true for $\rho < 0$, that is when labor inputs are complements. Importantly, I note that the change of sign does not come from a different production function between large and small firms, nor from a difference in monopsony power. Simply put, when jobs and hours a complements, firms compensate the working time reduction with hiring and this mitigates the negative wage effects of monopsony power. When the firm is large enough, it needs to attract many workers to compensate for a working time reduction, and this increases equilibrium wage rates.

Contract dispersion and sorting The model produces wage dispersion among (observably) identical workers[32] which is a long-standing finding of empirical labor studies (see Card et al. (2018)) because there is a continuum of submarkets in equilibrium. It is naturally interesting to study how heterogeneous firms are sorting in the contract space. Taking the total derivative of equation 4 in a particular submarket away from corner solutions one gets

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

where indices are omitted for brevity. Hence, a firm with higher productivity ψ_j will post more vacancies and higher wages. With respect to hours worked, the coefficient γ_l multiplying dl is difficult to sign in the general case as it depends on the firms' size and inputs complementarity.

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 5 and 6 . In particular, observe that a simple rearrangement of these equations for interior solutions yields

$$\frac{\tilde{q}'_l l}{\tilde{q}'_w w} = 1 - \frac{\psi F'_l}{\tilde{q}vw} = \frac{\partial u(wl,l)/\partial l}{\partial u(wl,l)/\partial w}\frac{l}{w}$$

This shows that at equilibrium, the marginal rate of substitution must be equal to 1 minus the markdown on hours worked. Whenever hours input are marked down, the marginal rate of substitution is negative and workers would like to work less at the given wage rate. Hence, when the indifference curve gets steeper and the preference for leisure increases locally, this equilibrium condition implies that the markdown on hours will increase.

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

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, welfare effects of the policy are ambiguous here because the negative effects on wages may be offset by positive effects on leisure and employment. 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

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

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

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

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

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

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*[33] $d(1-\bar{l})>0$ *has a positive impact on on ex-ante welfare* $\frac{d\bar{U}}{d(1-\bar{l})}>0$ *if and only if*

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

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

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

$$\frac{du}{d(1-\bar{l})}=u_c'\frac{dc}{d(1-\bar{l})}+u_l'\frac{dl}{d(1-\bar{l})}$$

$$\eta^u=\frac{(1-\bar{l})}{u}\frac{du}{d(1-\bar{l})}=\frac{cu_c'}{u}\frac{(1-\bar{l})}{c}\frac{dc}{d(1-\bar{l})}+\frac{lu_l'}{u}\frac{(1-\bar{l})}{l}\frac{dl}{d(1-\bar{l})}=\zeta_c^u\eta^c+\zeta_l^u\eta^l$$

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 (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. However, three 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 ATT, not ATE. As a result, I apply the welfare analysis only on workers from treated

[33]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.

[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.

occupations-firms. Third, despite the heterogeneity in the model and in the empirical results, only ATT, i.e. average effects are needed to compute utilitarian welfare.

Recall that the ATT are -2.8% for daily earnings and -6.7% for daily hours worked. Assuming away application reaction to the reform[35], we estimate η^N to 4.75%, i.e the ATT on underground employment. One obtains that the reform improved welfare if

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

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

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

That the elasticity of utility to consumption is smaller than 1.7 seems realistic and is typically delivered by standard functional forms. I conclude that the reform increased workers' welfare beyond doubt, and redistributed from firms' profits to workers welfare. Our analysis suggested that this is less likely to be the case in settings where workers control schedules and where jobs and hours are less complementary to one another.

6 Conclusion

The paper has studied theoretically and empirically the effects of working time reductions on wages, employment, profits and welfare. The empirical application uncovered large and negative effects on profits and wages. Importantly, we showed that the effect of working time reductions depend on (i) who sets schedules, (ii) the extent of imperfect competition and (iii) the extent of complementarity between jobs and hours.

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 characterization 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).

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

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.

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. (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.

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*.

Delabastita, V., & Rubens, M. (2025). Colluding against workers. *Journal of Political Economy*, *133*(6).

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.

Dube, A., & Zipperer, B. (2024). Own-wage elasticity: Quantifying the impact of minimum wages on employment. *National Bureau of Economic Research Working Paper w32925*.

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.

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.

Jarosch, G., Pilossoph, L., & Swaminathan, A. (2025). *Should friday be the new saturday? hours worked and hours wanted* (tech. rep.). National Bureau of Economic Research.

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.

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.

Levinsohn, J., & Petrin, A. (2003). Estimating production functions using inputs to control for unobservables. *The review of economic studies*, *70*(2), 317–341.

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.

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.

Olley, G. S., & Pakes, A. (1996). The dynamics of productivity in the telecommunications equipment industry. *Econometrica*, *64*(6), 1263.

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. (1908). Données statistiques recueillies par l'adminstration des mines. *Commission d'enquête sur la durée du travail dans les mines de houille*, 1–33.

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.

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 Empirical appendix

A.1 Data collection

A.2 Construction of variables

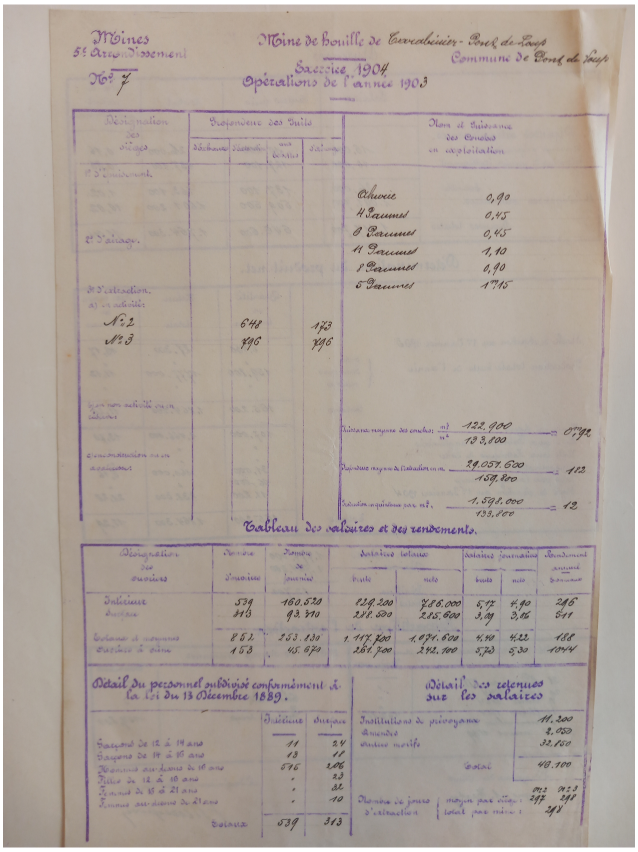
A.2.1 Hours worked

The panel dataset contains information on three occupations : frontline underground workers, non-frontline underground workers as well as above-ground workers. However, the 1902 cross-sectional dataset on hours worked contains information on 9 underground occupations : frontline workers, first transport workers, dirt diggers, stone diggers, second transport workers, path-makers, horseman, backfillers, and lift keepers.

I assign frontline workers' hours to the panel frontline workers. For non-frontline underground workers, I assign them a weighted average of the cross-sectional occupations. The weights are chosen such that the resulting probability distribution of hours worked in the matched dataset is reasonably close to an exact aggregate distribution of hours worked retrieved from Parliamentary Commission (1908). The Mining Administration computed that aggregate distribution for hours worked on November 29, 1907, which I report in panel (b) of Figure 3 along with the implied distribution of my dataset in panel (a).

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

Although both distribution are close, they differ notably at extreme values (which is the consequence of taking a weighted average of occupations). With respect to observations below 9 hours, this has no consequences for our estimations because the intensity of hours do not matter in the control group. With respect to hours worked above 10 hours, this could be affecting the results for continuous treatment specifications. However, the green distribution is on a yearly basis while the blue distribution is specific to a given date. The Mining Administration notes while providing the blue distribution that *[t]he chosen day is the Friday of the week preceding the feast of Saint Barbara; it is one of the days of the year when the number of workers is highest and daily production reaches its peak.* (page v., Parliamentary Commission (1908)). Both remarks suggest that the hours worked in the matched dataset can be trusted.

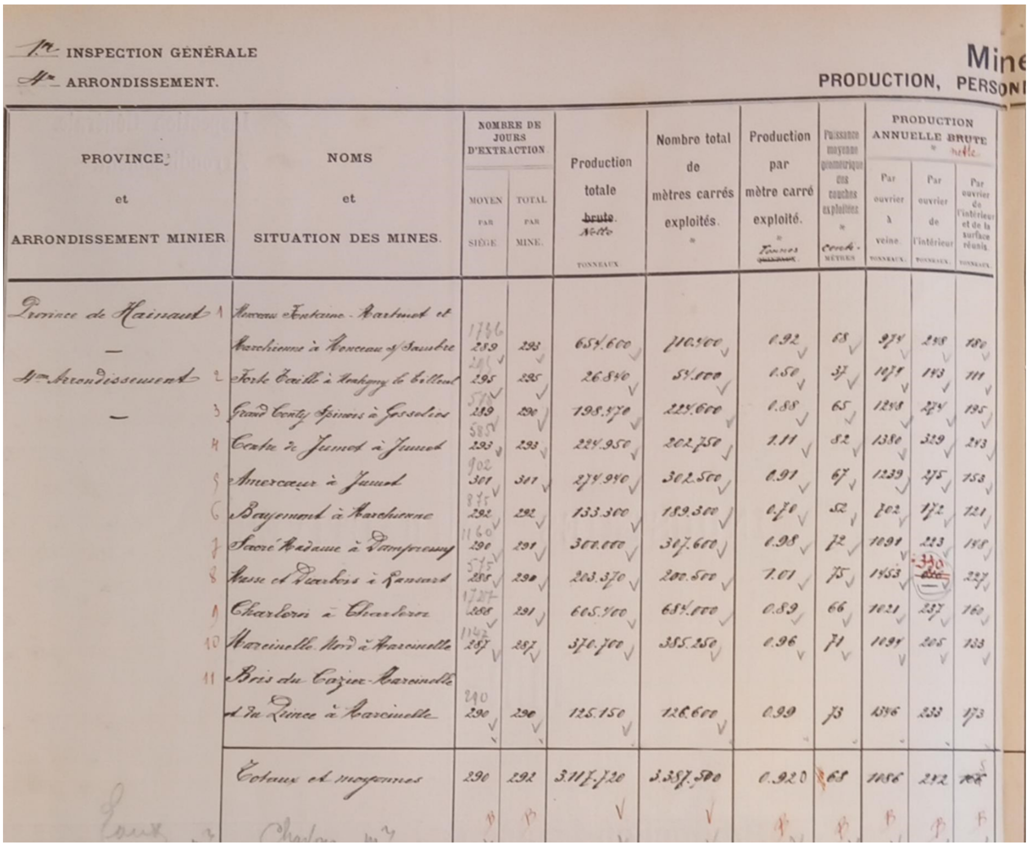


Mines
5e Arrondissement
No 7

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.

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



1re INSPECTION GÉNÉRALE
4me ARRONDISSEMENT.

Mines
PRODUCTION, PERSONNEL

PROVINCE et ARRONDISSEMENT MINIER		NOMS et SITUATION DES MINES	NOMBRE DE JOURS D'EXTRACTION: MOYEN PAR SIÈGE	TOTAL PAR MINE	Production totale ~~brute~~ Nette (tonneaux)	Nombre total de mètres carrés exploités	Production par mètre carré exploité (Tonnes)	Puissance moyenne des couches exploitées (Centi-mètres)	PRODUCTION ANNUELLE ~~BRUTE~~ nette: Par ouvrier à veine	Par ouvrier de l'intérieur	Par ouvrier de l'intérieur et de la surface réunis
Province de Hainaut — 4me Arrondissement —	1	Monceau-Fontaine-Martinet et Marchienne à Monceau s/ Sambre	289	293	654.600	710.500	0.92	68	974	248	180
	2	Forte Taille à Montigny le Tilleul	295	295	26.840	54.000	0.50	37	1078	193	111
	3	Grand Conty Spinois à Gosselies	289	290	198.970	225.600	0.88	65	1258	274	195
	4	Centre de Jumet à Jumet	293	293	224.950	202.750	1.11	82	1380	329	243
	5	Amercoeur à Jumet	301	311	274.980	302.500	0.91	67	1239	275	253
	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	158
	8	Masse et Diarbois à Ransart	288	290	203.370	200.500	1.01	75	1453	[illegible]	227
	9	Charleroi à Charleroi	288	291	665.400	684.000	0.89	66	1021	237	160
	10	Marcinelle Nord à Marcinelle	287	287	370.700	385.250	0.96	71	1094	205	133
	11	Bois du Cazier Marcinelle et du Prince à Marcinelle	290	290	125.150	126.600	0.99	73	1396	233	173
		Totaux et moyennes	290	292	3.117.720	3.387.500	0.920	68	1086	242	[illegible]

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

Figure A.1: Pictures of the data collection

A.2.2 Profits

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

A.2.3 Earnings

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

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

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

A.2.4 TFP

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

$$\ln q_{j,t} = \beta_1 \ln l_{j,t} + \beta_2 \ln m_{j,t} + \ln \psi_{j,t} \tag{A.1}$$

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 and $\psi_{j,t}$ is unobserved TFP. Estimating this equation with OLS leads to bias estimates because unobserved productivity shocks are positively correlated with observed input choices, the well known simultaneity bias.

The typical way to overcome this identification challenge is to rely on the control function approach since Levinsohn and Petrin (2003) and Olley and Pakes (1996). Delabastita and Rubens (2025) estimate production functions of Belgian coal mines in that spirit. I pinpoint two differences with their estimation. First, the present paper has a much smaller set of years but a larger number of firms. Second and related, the present paper does not have information on capital. As a result, these methods may not be used.

I assume that $\ln \psi_{j,t}$ is a Markov process of order 1 with productivity shocks $\epsilon_{j,t}$. I consider the following moment restriction:

$$E[\epsilon_{j,t} | \ln l_{j,t-1}, \ln m_{j,t-1}] = 0$$

This moment restriction allows to retrieve β_1 and β_2 by GMM estimation. The results are reported below.

Outcome	$\ln$ **production**$_{j,t}$	$\ln$ **production**$_{j,t}$	$\ln$ **production**$_{j,t}$
$\ln$ `labor expenses` β_1	0.745 (0.026)	**0.654 (0.052)**	0.661 (0.041)
$\ln$ `nonlabor expenses` β_2	-0.070 (0.021)	**0.315 (0.050)**	0.237 (0.080)
$\ln$ `capital`	n/a	n/a	0.102 (0.088)
Serial corr $\ln \psi_{j,t}$ if AR(1)	0.967 (0.008)	0.879 (0.018)	0.853 (0.157)
Years covered	1903-1913	1903-1913	1845-1913
Firms covered	Near universe	Near universe	Liège, Namur
Method	OLS (biased)	GMM (own)	Delabastita and Rubens (2025)

Table A.1: Production function estimation

Despite differences in samples and in methodology, the estimates obtained by the GMM approach in the present paper are remarkably similar to those of Delabastita and Rubens (2025) both in their magnitudes and in their precision. The present paper computes $\psi_{j,t}$ for each firm-year cell by predicting equation A.1 using the GMM estimated $\hat{\beta}_1, \hat{\beta}_2$. The use of lags implies that TFP cannot be estimated for 1903 such that the main results only show 1904-1913. For firms with positive production in year $t > 1903$ but zero production in $t-1$, I set the value of $\psi_{j,t}$ equal to the one of $\psi_{j,t+1}$.

A.3 Additional empirical context

Table A.2 reports summary statistics for this cross-sectional data on hours worked by geological region.

Observe that there are 7 events of mergers and acquisitions in Table A.5 while there are only 6 firms less in 1913 than in 1903 in Table A.3. This comes from the fact that one firm, *Charbonnages de Haine Saint Pierre, La Hestre et Houssu*, was divided in 2 parts merged with two different firms in 1912: the *Houssu* merged with *Ressaix* while the *Haine-Saint-Piere et La Hestre* merged with *Mariemont*.

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

Table A.2: Firm-level average daily hours worked for frontline workers before the reform, by geological region.

Table A.3: Unbalanced sample selection

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

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

Table A.4: Balanced sample selection

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

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

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

Table A.5: Count of mergers & acquisitions and firm exits per year. A firm exit is defined as a zero coal production in the calendar year. Control or treatment status is counted on the consolidated entity after merger or acquisition.

Table A.6: Summary statistics for control and treated units (o, j) in 1903-1909.

	Control units	**Treated units**
Profits, units of numéraire	8,999.66	9,256.57
	(24,673.12)	(25,309.15)
TFP	1.111	1.093
	(0.190)	(0.130)
Labor share	**0.602**	**0.598**
	(0.050)	**(0.043)**
Total days worked	**327,758**	**403,856**
	(302,805)	**(272,987)**
Headcount employment	**1,094**	**1,353**
	(1,011)	**(908)**
Share underground employment	**0.751**	**0.727**
	(0.059)	**(0.055)**
Share frontline among underground	**0.267**	**0.244**
	(0.098)	**(0.044)**
Share of self-consumed production	**0.083**	**0.099**
	(0.052)	**(0.044)**
Yearly days worked per worker	298.31	298.08
	(9.98)	(6.90)
Daily product per worker, tons	0.586	0.582
	(0.147)	(0.106)
Output, tons per m^2	0.885	0.904
	(0.193)	(0.167)
Average power of coal veins, meter	0.662	0.684
	(0.143)	(0.132)
Yearly product per frontline miner, tons	809.83	1,027.96
	(418.40)	(310.28)
Output price, current BEF	**14.56**	**15.00**
	(1.87)	**(1.56)**
Investment-to-sales ratio	**0.102**	**0.110**
	(0.051)	**(0.051)**
h_reduction_j	**0.00**	**1.02**
	(0.00)	**(0.44)**
Observations	148	149

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