Long Working Hours Make Us Less Productive but Also Less Costly

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Abstract. This paper develops and assesses empirically a simple model of firms' optimal decision regarding working hours, where productivity varies with hours and where the firm faces quasi-fixed labour costs. Using Belgian firm-level data on production, labour costs, workers, and hours, and focusing on the estimation of elasticities along the isoquant and the isocost, we find evidence of not only declining productivity of hours but also of quasi-fixed labour costs in the range of 20 per cent of total labour costs. The tentative conclusion is that firms facing such costs are enticed to raise working hours, even if this results in lower productivity.

A renewed interest in reducing working hours has recently been observed in many countries. In the wake of the 2008 crisis, it has been proposed to combat surging unemployment. It is also seen as a desirable corollary to longer careers (i.e. part-time/gradual retirement schemes) that governments promote in response to population ageing. The canonical model of labour supply states that a worker can flexibly choose his/her own work hours to maximize his or her utility at any given wage.[1] However, findings from several studies, reviewed by Kuroda and Yamamoto (2013), suggest that workers cannot choose work hours freely, or that a change of hours is conditional on a job change.[2] In this context, and following Pencavel's call (Pencavel, 2016) for more research on the demand of labour,[3] this paper focuses on the preferences of firms regarding the working hours of their employees.

In fact, once that intensive dimension of labour is introduced, firms must make a non-trivial decision on the number of workers hired as well as on the hours that are asked from them. A profit-maximizing firm will decide on the number of workers to hire and on working hours by comparing the productivity and cost of both workers and hours. Labour productivity, whether at the intensive or at the extensive margin, has already attracted a lot of interest in the past. A first, rather old, stream or the economic literature develops the idea that longer hours lead to counterproductive hardship. One of the first economists to discuss it was Karl Marx in the Capital Vo. 1, Ch XV, Section 3 (c). Later John Hicks (1932) stated that "probably it has never entered the heads of most employers … that hours could be shortened, and output maintained." A milder version of his story is that, as workers slave away for longer and longer, they lose

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energy, which makes them relatively less productive: in other words, the last hours of work still raise total output but at a declining rate. In contrast, Feldstein (1967) insists on the importance of 'slack' hours. He argues that many hours amount to setting-up time, refreshment breaks, time around lunch, and deliver no output. These paid-but-non-productive hours do not rise proportionately with the number of hours officially worked. An increase in the length of the official working day or week could therefore entail a more than proportionate increase in the number of effective hours of works. Our empirical work follows the conclusions by Leslie and Wise (1980), or more recently by Pencavel (2015) or Collewet and Sauermann (2017) that give credit to the hardship story, but it in its mild form: *average* productivity of hours is decreasing in the number of hours, due to the decreasing *marginal* productivity. This result is, however, only valid at the observed number of hours worked and does not contradict the presence of slack hours due to decreasing number of hours worked.

So, could it be that employers have it all wrong when they oppose reducing working hours even though it could boost productivity? Not necessarily if, as proposed by Oi (1962), Donaldson and Eaton (1984), Dixon and Freebairn (2009) or Kuroda and Yamamoto (2013), the existence of quasi-fixed labour costs is considered. The main contribution of this work is to shed light on the role of quasi-fixed labour costs in understanding firms' demand for hours.

The notion deserves some clarification. Fixed costs of production already benefited from attentive scrutiny in the economic literature. They are usually understood as any financial cost — most often corresponding the cost of capital — not dependent on the level of goods or services produced. Less often explored, quasi-fixed labour costs are the focus of this paper and arise from the explicit modelling of both the intensive and the extensive margin of employment. Here, following Hamermesh's (1993) typology, quasi-fixed labour costs (F) reflect the propensity of a worker's compensation to be not strictly indexed on the hours of work delivered (H) (but rather on the number of workers N). That comprises not only the lump-sum part of pay, non-proportional taxes, or social security contributions, fixed insurance premia, indivisible perks like a company car but also recruitment/training or redundancy/firing costs.

Hamermesh distinguished two types of quasi-fixed labour costs. First, the 'recurring fixed costs' (R). These are the costs associated with non-wage remuneration and fringe benefits: the health insurance, leasing car, paid sickness leave (as well as any other type of leave where the worker remains paid while not delivering any hour). Second 'one-time fixed cost' (T). In Hamermesh's typology these are costs that are paid only once per worker. They typically consist of the cost of (externally or internally provided) training, the cost of operating an HR department, and dismissal costs. At the level of a firm, the one-time fixed costs will enter F *pro rata* the likelihood q of turnover $F = R + qT$. In contrast, variable labour costs are those that vary with the number of hours; and will typically correspond to the product of hours by an hourly wage rate ($w(H)H$). The total labour cost of a typical firm thus writes $C(N,H) = N(w(H)H + F)$. In the presence of significant labour quasi-fixed costs (F), raising the number of hours per worker will decrease the average cost and raise profitability *ceteris paribus.*

Evidence gathered in this paper, using firm-level data covering the whole Belgian private for-profit economy, suggests both a declining productivity of hours, and a declining average cost per additional hour worked. Using annual firm-level data over a 9-year period (2007–2015), we show that in the Belgian private economy firms operate around a level of hours per year that is synonymous with decreasing average productivity: thus, shorter hours could have a positive effect on labour productivity (value added per hour). But analysing the relationship between total labour cost and hours, we also find strong evidence of substantial quasi-fixed labour costs (around 20–23 per cent of total labour costs) suggesting that maximizing firms have an incentive to push hours beyond the point where labour productivity is maximal. To our knowledge, this paper is the first to quantify quasi-fixed labour costs using only econometric estimates of labour cost functions. So far, economists like Hart (1984), Ehrenberg (2016), or Martins (2004) have always resorted to an intrinsically more descriptive (and time-consuming) approach that consists of an in-depth analysis of accounting data, guided by a knowledge of institutional or contractual arrangements underpinning labour compensation. Finally, it is worth stressing that our paper goes beyond simply quantifying quasi-fixed labour costs. It also assesses their economic significance by looking at their impact on firms' actual labour decisions. Indeed, the paper reports evidence of substitution of hours for workers (i.e. longer hours, less workers) in response to rising quasi-fixed labour costs. This result aligns with those published by Cutler and Madrian (1998); Montgomery and Cosgrove (1993); Buchmueller (1999) or Dolfin (2006); who use descriptive estimation of quasi-fixed labour costs.

One of the tentative conclusions of the paper it that, akin so many other aspects of economic life, the decision of firms on working hours amounts to a trade-off: reducing working hours might improve labour productivity, but it could also raise average labour cost per hour. A better understanding of firms' or industries' incentives to reduce or raise working hours should help policy making. For example, to promote part-time employment for the older workers, policy makers should prioritize industries with low quasi-fixed labour costs or foster tax and compensation policies that ensure that employer costs are as proportional as possible to hours of work.

The rest of the paper is organized as follows. Section 1 exposes a model of the profit-maximizing firm that has all power to not only decide on the number of workers but also on the number of hours each worker must work. The model highlights the likely determinants of the demand for workers and working hours, the role of the productivity of hours, and that of quasi-fixed labour costs. It also suggests a way to identify econometrically the share of fixed labour costs as the workers/hours elasticity along the isocost. Section 2 describes the panel of firm-level data that is used. Section 3 exposes our econometric analysis and results. We first present baseline estimates of the productivity of working hours and of the share of quasi-fixed labour costs in total labour costs. Second, we introduce an industry-by-industry analysis that shows that industries with larger quasi-fixed labour costs tend to have higher average working hours higher and make less use of part-time work. Section 4 exposes a certain number of robustness checks. Section 5 presents and discusses the economic and institutional mechanisms that in the Belgian context generate quasi-fixed labour costs. Section 6 concludes.

1. Working hours as a firm-level decision

Consider a technology where effective labour consists of hours (H) and worker (N), where hours of presence (H) do not equal effective hours of labour $g(H)$. The production function is as follows:

$$Q(K,L) \leq f(K,L) \quad [1]$$

$$L = Ng(H), \;\; g'(H) > 0 \quad [2]$$

Assuming that $g(H) = H$ for every possible value of H is probably unrealistic. Doubling hours per worker will not double the amount of effective hours/labour. As soon as one lifts the assumption of identity, the labour demand can no longer be simply considered as employers just choosing an optimal number of worker-hours (i.e. the product $N.H$ equal to L) (Hamermesh 1993) — with the level of H being essentially a matter of workers' preferences in terms of revenue versus leisure. In this model, we make the opposite assumption that employers are free to choose the number of hours worked per worker as well as the number of workers. It is worth noting that the specific form for $L(N,H)$ will lead to the absence of scale effect on firm's optimal number of hours per worker H^*: the latter is independent of the size of the firm (measured by N).

Following Cahuc *et al.* (2014), we assume firms face the following sequence of choices: first, firm choose between hours and workers by minimizing their labour cost, second they choose between labour (optimally composed of hours and workers) and capital. This sequential choice hypothesis implies that hours versus workers decisions are invariant to firm size and therefore separable from capital.[4] The employers' problem can then be viewed as one of minimizing total labour cost $C(N,H)$ subject to the technological constraint $Y \leq f(K,Ng(H))$. The optimum (H^*,N^*) is described by a series of FOC that lead after some manipulations to equating the ratio of marginal productivities to the ratio of marginal labour costs:

$$\frac{L_H}{L_N} = \frac{C_H}{C_N} \quad [3]$$

or equivalently using [2] and assuming that the true generating process for labour cost is:

$$C(N,H) = FF + \; N[w(H)H + F] \quad [4]$$

where $w(H)$ is the hourly wage ('variable labour costs') and rises with H $(w' > 0)$ to reflect, among other, the legal obligation to pay more for extra hours. Modelling the overtime premium as a continuous increasing hourly wage function allows to compute elasticities that we will be able to estimate in the dataset. The alternative modelling option is to have an overtime premium paid per hour above a legal threshold, however, our data would not allow us to estimate the increase in remuneration at the threshold.

F denotes labour quasi-fixed costs (i.e. costs that are invariant to the number of hours per worker, but vary with the number of workers).

FF are firm-level fixed costs [i.e. costs that are invariant to the number of workers (human resources personnel, administrative procedures vis-à-vis insurers, public authorities)].

we get

$$\frac{L_H}{L_N} = \frac{Ng'(H)}{g(H)} = \frac{C_H}{C_N} = \frac{Nw'(H)H \; + \; w(H)N}{w(H)H \; + \; F} \quad [5]$$

One can also restate the equilibrium using the implicit function theorem,[5] where the ratio of marginal productivities L_H/L_N is equal to the slope of the isoquant:

$$-\frac{L_H}{L_N} = \frac{\mathrm{d}N}{\mathrm{d}H_{|\mathrm{dL}=0}} \qquad [6]$$

And multiplying by H/N leads to the elasticity along the isoquant $\sigma(H, N)$:

$$-\frac{H}{N}\frac{L_H}{L_N} = \frac{H}{N}\frac{\mathrm{d}N}{\mathrm{d}H_{|\mathrm{d}L=0}} = -\sigma(H, N) \qquad [7]$$

Similarly, the ratio of hours and men marginal labour cost C_H/C_N can be related to the elasticity of substitution along the isocost $\gamma(H, N)$:

$$-\frac{H}{N}\frac{C_H}{C_N} = \frac{H}{N}\frac{\mathrm{d}N}{\mathrm{d}H_{|\mathrm{dC}=0}} = -\gamma(H, N) \qquad [8]$$

Thus, as alternative to [3], the optimum N^*,H^* can be described as the equality of the slopes of the isoquant/isocost in the *(N,H)* space; or the equality of the elasticities of hours per worker along both the isoquant and isocost (Dixon *et al.*, 2005):

$$\sigma(H, N) = \gamma(H, N) \qquad [9]$$

or equivalently, given [2] and [4]:

$$\sigma(H, N) = \frac{g'(H)}{\frac{g(H)}{H}} = \gamma(H, N) = \frac{1 + \varepsilon}{1 + rF} \qquad [10]$$

where: $\varepsilon \equiv \frac{w'(H)}{\frac{w(H)}{H}}$ is the elasticity of hourly wage to working hours;[6]

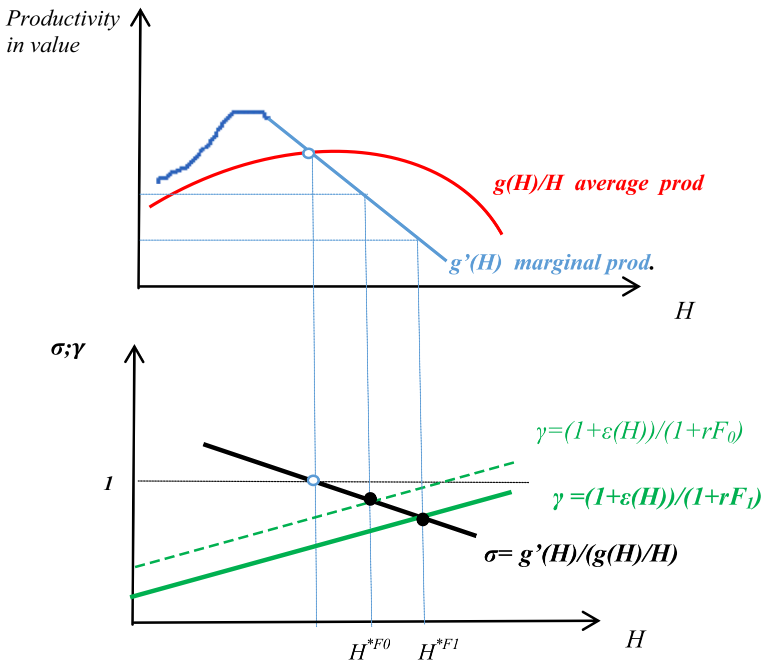
$rF \equiv \frac{F}{w(H)H}$ the ratio of fixed to variable worker-level labour costs.

Note that [10] can be rewritten as $\gamma(H, N) = (1 + \varepsilon)w(H)H/[W(H)H + F]$ showing that $\gamma(H,N)$ it is the upper bound ($\varepsilon \geq 0$) of the share of variable costs in total labour costs. As a consequence, hereafter, 1 − $\gamma(H,N)$ will interpreted as a lower bound estimate of the share of quasi-fixed labour costs in total labour costs.

Equation [10] means that H^* is such that the ratio of its marginal to average productivity $[g'(H)/g(H)/H]$ equals [1 + ε(*H*)/1 + *rF*]. The higher quasi-fixed costs relative to the sensitivity of wage rate to hours, the more likely $\gamma(H,N)$ will be less than 1 (in absolute value) (Figure 1, lower part). Simultaneously, if that is the case employers will push for longer hours; certainly, beyond the point where marginal productivity starts declining (presumably due to hardship, lassitude), and beyond the point where average productivity of hours reaches its maximum (Figure 1, upper part) i.e. $\sigma(H, N) < 1$.[7] Said differently, the only reason for firms to push working hours to the point where average productivity is declining, is that they are better able to spread fixed costs.

This finally leads to positing that the (conditional) labour demand for working hours looks like

Figure 1. Optimal hours, ratio of marginal to average productivity of hours and quasi-fixed labour costs ($F_1 > F_0$)



$$H^* \equiv q(\overbrace{\sigma}^{-}) = m(\overbrace{\gamma}^{-}) =\equiv m(\overbrace{F}^{+}, \overbrace{\varepsilon}^{-}) \qquad [11]$$

with the last right-hand term reflecting the positive relationship between hours and quasi-fixed labour cost.

2. The economic and institutional factors underpinning quasi-fixed labour costs in the Belgian context

As stressed in the introduction, one of the novelties of this paper is to quantify quasi-fixed costs using econometric estimates of the elasticities along firm's labour isocost and isoquant. What has been done on quasi-fixed costs in the existing empirical literature (Ehrenberg, 2016; Hart, 1984; Martins, 2004) consists of analysing accounting data, and identify the components that qualify as being (quasi)-fixed, based on relatively detailed and country-specific knowledge of institutional or contractual arrangements underpinning labour compensation. The advantage of our econometric approach — and of the algebra from which it derives, see Section 1 —, is that there is no need to invest time in scanning firms' financial reports or to develop an in-depth understanding of institutions. Our results simply derive from the estimation of the parameters of either a production function or a labour cost function comprising the duration of work and the number of workers. The challenge is more to estimate these functions correctly, and avoid statistical biases. This said, it is quite natural for the reader who discovers our results — quasi-fixed costs in the range of 20 per cent — to ask, in the context of Belgium, which might be the actual drivers and determinants of these fixed costs. The lines that follow try to answer that interrogation.

2.1 One-time fixed costs

A starting point is to discuss the presence 'one-time fixed costs': recruitment, firing/severance, and training costs (Hamermesh, 1993). These exist in Belgium. The singularity of Belgium probably is that its severance costs — particularly for white collars — are very high (i.e. in excess of one year of pay white-collar workers with seniority) — and may be a significant contributor to Belgium's overall level of quasi-fixed costs.[8]

2.2 Recurrent quasi-fixed labour costs

Things are trickier when it comes to 'recurrent' quasi-fixed labour costs; that labour economists traditionally associate to nonwage compensation (pension/unemployment/health insurance, paid sick or holiday leave, perks). In Belgium, not all of these amount to 'purely' quasi-fixed costs, as some are directly or indirectly indexed on hours. Only a cautious, case-by-case examination may lead to a definite judgement as to their degree of 'fixity'.

Strictly speaking in Belgium, all social security contributions (financing the health insurance, the unemployment insurance and legal pensions; i.e. the 1st pillar) are computed as a percentage of the gross remuneration, that is itself proportional to the number of hours worked. Therefore, these contributions do not *a priori* qualify as 'fixed'. Also, in principle, important mandatory benefits (end-of-year bonus, single and double holiday bonuses) are directly indexed on annual hours of work. For instance, if the worker has been absent during the year, the amount of her end-of-the-year bonus is reduced *pro rata* the number of days of absence. The same logic holds for occupational pensions (the so-called 2nd pillar of the pension system, paid by the employers to top-up legal pensions). Instalments are indexed on salaries, and thus on hours.

Belgium has many regimes of 'assimilation' i.e. days not worked but 'assimilated' to days of work and thus remunerated and/or qualifying for social security payments. The most important one is the regime of employer-paid sick leave.[9] The list also comprises maternity/parental leave, educational/training leave, union leave. There is also a regime of 'economic unemployment'; i.e. situations of temporary economic recess where workers are sent home but are still paid by the employers. All these 'assimilated' days give rise to sizeable additional labour costs. But a priori, these are indexed on hours worked. Mathematically, if H_1 is the number of hours actually worked and H_2 is the number of 'assimilated' hours, the total labour cost writes $C = F + w(H_1 + H_2)$. If $H_2/H_1 = \alpha$ is constant (ex: a probability of illness…), then the assimilated days are similar to variable costs i.e. $C = F + w(1 + \alpha)H_1$. Simply, the effective wage rate writes $w(1 + \alpha)$ and is inflated *pro rata* the share α of 'assimilated' hours. However, in practice, there are reasons to believe that $\alpha = H_2/H_1$ is decreasing with H_1. Why? The most obvious case is that of temporary/economic unemployment. It typically intervenes during periods of overall reduction of the number hours worked (i.e. low H_1). Also, some 'assimilation' regimes (e.g. maternity leave) tend to work predominantly to the benefit of workers who work less hours (women). Similarly, one relatively unknown feature of Belgium's occupational pensions is the presence of 'social' contributions: extra payments by employers aimed at improving the pension capital of the lowest earners; that also often correspond to those working less hours.[10]

Then there is the case of perks and in-kind benefits. Mainly for fiscal reasons,[11] Belgian employers are prone to remunerate their employees in kind. The point is that many in-kinds are 'fixed'. The most significant one is the company car. It represents up to 20 per cent of a worker's gross remuneration and is very common in Belgium.[12] Other in-kinds comprise home/work travel allowances,[13] mobile phones, laptops and tablets. Also, employers must insure each employee against the risk of workplace and home-to-work commuting accident. Whatever the number of hours worked, employees benefit from mandatory, employer-paid, health checks performed in the workplace. All in all, in-kind benefits were estimated to be around 14 per cent of the labour cost for Belgian workers (Labour Cost Survey, SPF Economie, 2012).

Other sources of 'fixity' are worth mentioning. In Belgium, there are rules imposing that employers do not pay less than a certain amount, even if the number of hours actually worked is small. For part-timers, the Belgian legislation imposes that contracts (and the remuneration they generate) should be a least equivalent to a weekly minimum of one-third of the reference full time; with a daily minimum of 3 hours. Remuneration minima for night-shift workers (i.e. those who worker after 10 PM) are even stricter.[14] If, with some positive likelihood, the actual duration of work is inferior to these thresholds, then the hourly wage rises considerably. In that sense, these rules can lead to a caricature of the idea of quasi-fixed labour costs.

Finally — but this is not specific to Belgium, — compensation schemes for middle or top managers tend to amount to quasi lump-sum commitments. They receive an annual salary (+ in-kinds) for an indicative number of hours of service; that *de facto* fluctuates considerably, with no or little impact on the amount received. Ceteris paribus, the more prevalent these schemes, the more labour costs should appear a quasi fixed.

3. Data

The data we use in this paper essentially come from Bel-First (Tables 1–4, Figure 2),[15] that all for-profit firms located in Belgium must feed to comply with the legal prescriptions on income declaration. It consists of a large unbalanced panel of 115,337 firm-year

Table 1. Bel-first. Number of firms

Year	Number of firms
2007	11,944
2008	12,213
2009	12,369
2010	12,698
2011	12,949
2012	13,272
2013	13,365
2014	13,370
2015	13,157
N obs	115,337
Total no. firms	14,544

Source: Bel-First (2016).

observations corresponding to the situation of 14,544 firms with at least 20 employees, from all industries forming the for-profit Belgian private economy,[16] in the period 2007–2015.[17] Our dataset comprises a large variety of firms. First along the firm size dimension, we include all data for firms from 20 workers (FTE) to very large firms (above 1,000 workers), corresponding to well-known international companies.[18] These firms are largely documented in terms of industry (NACE[19] or NAICS[20]), size (number of workers), capital used (total equity), total labour cost (more on this below) and productivity (value added).

Descriptive statistics on this large sample are reported in Tables 1–4. One of the originalities of this paper is to consider both the productivity and the labour cost of hours and workers. Table 2 contains descriptive statistics on productivity (Q/N where Q is value added) and average labour costs (C/N). The latter is logically inferior to productivity.

In this paper, labour costs are measured as a firm-level aggregate independently from production. They include the value of all wage and non-wage compensations paid to or on behalf of the total labour force (both full- and part-time plus interim/temporary workers) on an annual basis. Labour costs comprise: annual gross wage (including end-of-the year bonuses, paid holiday/sickness/maternity leave), employees' social contributions

Table 2. Descriptive statistics, main variables

Year	Avg. value added per empl. Q/N [EUR]	Avg. labour cost per empl. C/N [EUR]	Avg. capital per empl. [EUR]	Hours and workers (mean)			
				Hours per empl. [annual] H	Workers full time $N\ ft$	Workers part time $N\ pt$	Workers interim/temp $N\ int$
2007	77,133.03	43,237.04	325,163.3	1,472.4	80.38	24.78	14.57
2008	78,996.69	44,680.06	413,030.7	1,472.4	80.77	24.83	12.98
2009	73,856.15	45,153.60	426,619.2	1,428.4	76.80	24.97	11.51
2010	76,494.41	45,898.61	322,024.1	1,433.2	74.66	25.57	12.59
2011	79,430.76	47,709.65	610,067.9	1,437.2	76.33	27.14	12.28
2012	76,136.48	49,003.94	639,064.7	1,427.9	75.78	28.02	12.57
2013	76,403.06	49,705.03	485,220.0	1,422.4	75.44	29.02	12.81
2014	77,347.08	50,599.59	462,562.8	1,427.7	90.82	36.38	12.37
2015	79,568.47	50,779.37	329,668.3	1,430.1	75.33	37.95	13.67
All years	77,269.98	47,517.51	447,715.7	1,438.5	78.49	28.87	12.81
N obs	115,337						

Source: Bel-first (2016).

Table 3. Descriptive statistics, workers, and hours: details (percentiles)

Moment	Number of workers (N)	Av. hours [full-time w.] ($H\ ft$)	Av. hours [part-time w.] ($H\ pt$)	Av. hours [interim w.] ($H\ int$)	Share of full-time w.[a]	Share of part-time w.[a]	Share of interim w.[a]
P25	27.00	1,464.92	857.25	1,634.33	0.68	0.06	0.00
p50	40.00	1,581.86	1,044.60	1,883.59	0.83	0.12	0.00
p75	74.00	1,666.90	1,201.75	2,004.15	0.92	0.27	0.03
p99	1,169.00	2,438.83	1,859.00	2,742.00	1.00	0.97	0.33
Mean	112.06	1,563.63	1,022.38	1,791.26	0.75	0.22	0.03
N obs	115,337						

Source: Bel-first (2016).
[a]Total number of workers.

Table 4. Importance of within [over time] versus between [across] firm variation of employment and hours

	Number of workers (N)	Working hours (H)	Working hours FT (H^{FT})
Std_error (between) [a]	454.15	281.62	207.00
Std_error (within) [b]	686.73	185.31	188.67
Within share of total var. $[b]^2/([a]^2+[b]^2)$	0.696	0.302	0.454

Source: Bel-first.

(representing 13.07 per cent of gross wage), employers' contributions to social security (38 per cent of the gross wage), employers' contributions to extra-legal insurances and pensions, stocks, and other (taxable) perks like 'meal vouchers', company car, mobile phone. Most of the costs of externally provided training are included in the firms' total labour cost used here.[21] And so are Belgium's notoriously high severance payments including the special regimes applicable to older workers.[22,23]

All in all, the firm-level aggregate that we use is thus likely to capture most of the 'recurrent' and 'one-time' quasi-fixed costs mentioned in the introduction. Still there is a need of an in-depth analysis of which of these items can be considered as genuinely 'fixed'. By contrast, our aggregate does not comprise the costs for externally-provided search/recruitment and training. These appear in the books as intermediates. Also, internal training costs, as well as those of HR departments involved in search and recruitment are unlikely to appear in our data as fixed labour costs. This is because they essentially take the form of wages paid to specialized workers (who also deliver a certain number of hours just like any other employee of the firms). In our data, there is no way to isolate their labour cost.

Of crucial importance in this paper is the distinction between the number of workers (N) and the number of hours (H) (Table 2 right-hand columns, Table 3). The former is simply the headcount, or more precisely the average over the year of the headcount at the end of each month. The latter corresponds to the number of worked and paid hours over the year.[24] It does not consider unpaid overtime, holidays, sick leaves, short-term absences, and hours lost due to strikes or for any other reasons.

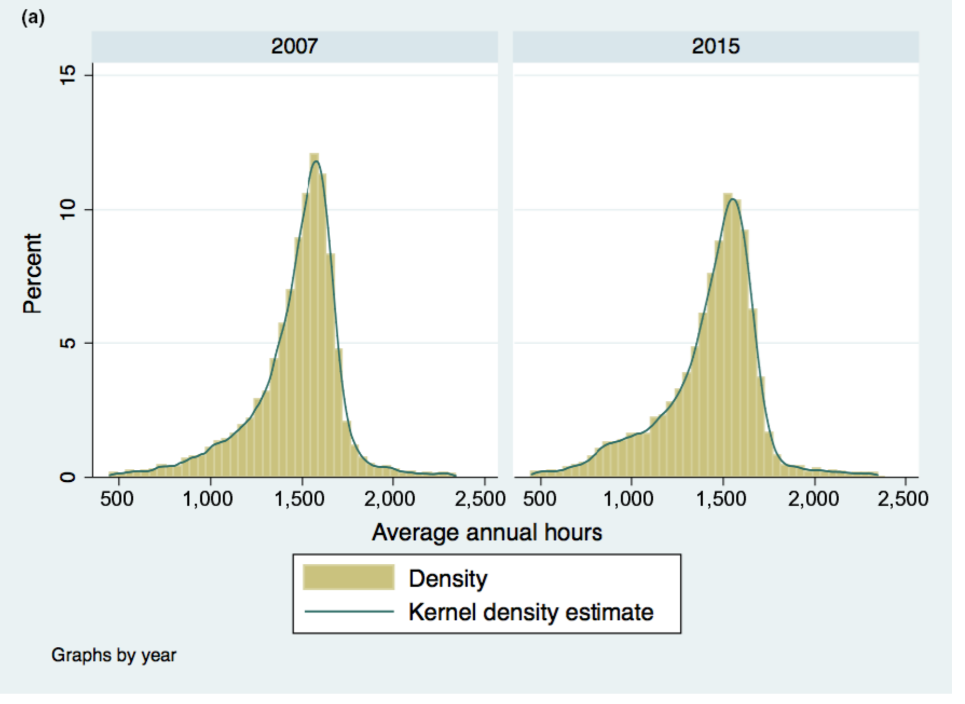
The average hours worked varies strongly in our sample; even among full-time workers (Figure 2). The standard deviation of hours worked (overall or for full-time workers only) within firm is only slightly smaller than between firms (Table 4). Generally, we observe non-negligible variation of both hours and workers within firm, over time representing more than 30 per cent of total variation.[25] This observation of large within-firm variations is important to allow for meaningful firm-level fixed effect regressions in the subsequent econometric analysis.

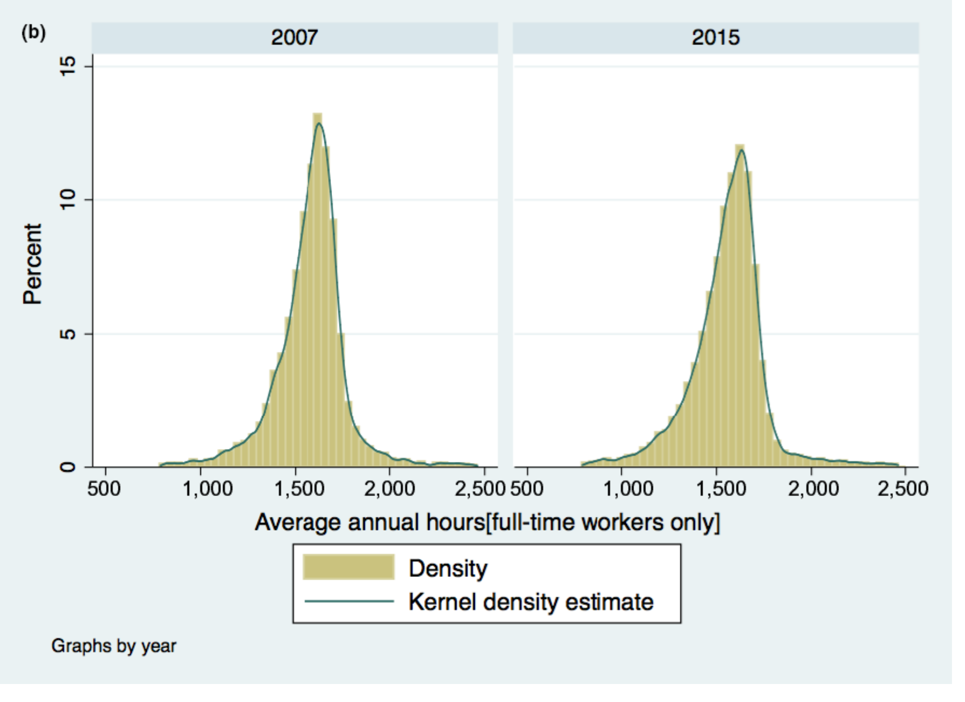
In the extension of the main econometric analysis (Section 5) we also use individual-level international data from PIAAC.[26]

4. Econometric analysis of firm-level data

In this section, using firm-level panel data, we estimate both production and labour cost functions[27] with the aim of assessing the productivity of working hours and the (relative)

Figure 2. Annual average working hours per worker: (a) full-time and part-time and (b) full-time only. Distribution across firms. Belgium private economy 2007–2015





Source: Bel-first (2016)

importance of quasi-fixed labour costs. The advantage of firm-level data is that workers and hours can be analysed simultaneously. And as the data consist of panels, they can be used to control for firm-level unobserved heterogeneity as well as for the risk of simultaneity bias (both being synonymous with endogeneity). What is more, the dataset is sufficiently large to allow for: (i) the identification of cross-industry differences (in terms of $\sigma(H,N)$, $\gamma(H,N)$) and (ii) an econometric analysis of these differences' impact in terms of duration of hours or the incidence of part-time work (Section 4.2).

4.1 Identification strategy

The simple model, spelled out in Section 1, suggests that hours worked per worker are determined at the firm level by the equality of the elasticity along the workers–hours isoquant curve $\sigma(H,N)$ to the elasticity along the isocost curve $\gamma(H,N)$, assuming firms operate at their cost-minimization optimum.

We use Belgian annual firm-level data on total labour cost (wages, contributions to social security and paid holidays, annual bonuses) alongside information about annual hours and number of workers in each of the firms present in the dataset. As we do not observe fixed costs F and the elasticity of unit wage to hours worked ε, there is no way we can directly compute $\gamma(H,N)$ as specified in [10]. The same applies for $\sigma(H,N)$. But these elasticities can be retrieved by estimating n^{th} order polynomial approximations of (the log of) $C(H,N)$) and $Q(K,H,N)$, respectively. In the case of second-order approximations (i.e. translog specification) we have

$$c_{it} \approx A + \theta n_{it} + \lambda h_{it} + \frac{1}{2}\chi_1 h_{it}^2 + \frac{1}{2}\chi_2 n_{it}^2 + \chi_3 h_{it} n_{it} + T_t + v_{it} \qquad [12]$$

$$q_{it} \approx B + \alpha k_{it} + \beta n_{it} + \pi h_{it} + \frac{1}{2}\psi_1 h_{it}^2 + \frac{1}{2}\psi_2 n_{it}^2 + \psi_3 h_{it} n_{it} + T_t + \mu_{it}, \qquad [13]$$

where lower case *c, q, h, n* correspond to the log of *C, Q, H, N,* respectively, T_t are time dummies, and v_{it}, μ_{it} the residuals.

The derivatives of these translogs vis-à-vis *n* and *h* are equal [ignoring firm and time indices] to:

$$\frac{\partial c}{\partial n} = \frac{\partial lnC}{\partial lnN} = \frac{C_N}{C/N} \approx \theta + \chi_2\, n + \chi_3 h \qquad [14]$$

$$\frac{\partial c}{\partial h} = \frac{\partial lnC}{\partial lnH} = \frac{C_H}{C/H} \approx \lambda + \chi_1\, h + \chi_3 n \qquad [15]$$

$$\frac{\partial q}{\partial n} = \frac{\partial lnQ}{\partial lnN} = \frac{Q_N}{Q/N} \approx \beta + \psi_2\, n + \psi_3 h \qquad [16]$$

$$\frac{\partial q}{\partial h} = \frac{\partial lnQ}{\partial lnH} = \frac{Q_H}{Q/H} \approx \pi + \psi_1\, h + \psi_3 n \qquad [17]$$

and thus following [7], [8] the elasticities along the isocost/isoquant can be approximated using the estimated parameters of [12], [13]:

Table 5. Econometric estimation of the productivity of hours and of the (relative) importance of quasi-fixed labour costs — Fixed effect as (a) mean centring and (b) first differences

	First-order approximation		Second-order approximation		Third-order approximation	
	Productivity	**Labour cost**	**Productivity**	**Labour cost**	**Productivity**	**Labour cost**
(a) Mean centring						
$k_{it} \equiv ln(K_{it})$	0.0878***		0.0864***		0.0853***	
	(0.001)		(0.001)		(0.001)	
$n_{it} \equiv ln(N_{it})$	0.779***	0.926***	0.788***	0.930***	0.800***	0.933***
	(0.002)	(0.001)	(0.002)	(0.001)	(0.003)	(0.002)
$h_{it} \equiv ln(H_{it})$	0.627***	0.711***	0.672***	0.746***	0.687***	0.759***
	(0.004)	(0.003)	(0.005)	(0.003)	(0.005)	(0.003)
n_{it}^2			−0.00159	−0.00973***	−0.00421*	−0.00150
			(0.001)	(0.001)	(0.002)	(0.001)
h_{it}^2			0.0830***	0.0699***	−0.0388***	−0.0678***
			(0.003)	(0.002)	(0.005)	(0.003)
$n_{it}\, h_{it}$			0.0908***	0.0805***	−0.0344***	−0.0367***
			(0.003)	(0.002)	(0.006)	(0.004)
n_{it}^3					−0.00444***	0.00159***
					(0.001)	(0.000)
h_{it}^3					−0.0270***	−0.0307***
					(0.001)	(0.001)
$n_{it}^2 h_{it}$					−0.0189***	−0.00997***
					(0.002)	(0.001)
$n_{it}\, h_{it}^2$					−0.0422***	−0.0412***
					(0.002)	(0.001)
Controls:	**year, province, join commission, and industry (NAICS 4-digit)**					
R^2	0.83	0.92	0.83	0.92	0.83	0.92
Implied elasticities along the effective labour isocost/isoquant+ test of alignment						
$\sigma;\gamma$	0.80	0.77	0.67	0.75	0.68	0.76
Prob = 1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Prob $\sigma = \gamma$	0.0105		0.0000		0.0000	
(b) First differences						
$k_{it} \equiv ln(K_{it})$	0.0913***		0.0903***		0.0881***	
	(0.002)		(0.002)		(0.002)	
$n_{it} \equiv ln(N_{it})$	0.661***	0.843***	0.643***	0.815***	0.702***	0.850***
	(0.003)	(0.002)	(0.004)	(0.002)	(0.004)	(0.003)
$h_{it} \equiv ln(H_{it})$	0.542***	0.650***	0.537***	0.642***	0.630***	0.720***
	(0.005)	(0.003)	(0.005)	(0.003)	(0.005)	(0.004)
n_{it}^2			0.0252***	0.0392***	0.0217***	0.0259***
			(0.002)	(0.001)	(0.002)	(0.001)
h_{it}^2			0.00215	−0.00771***	−0.00954***	−0.00651***
			(0.002)	(0.001)	(0.002)	(0.001)
$n_{it}\, h_{it}$			0.0304***	0.0326***	0.0110***	0.0176***
			(0.002)	(0.002)	(0.003)	(0.002)
n_{it}^3					−0.00625***	0.00128***
					(0.001)	(0.000)
h_{it}^3					−0.0128***	−0.0131***

Table 5. Continued

	First-order approximation		Second-order approximation		Third-order approximation	
	Productivity	Labour cost	Productivity	Labour cost	Productivity	Labour cost
					(0.000)	(0.000)
$n_{it}^2 h_{it}$					−0.00302**	0.00955***
					(0.001)	(0.001)
$n_{it}\, h_{it}^2$					−0.0103***	−0.00633***
					(0.001)	(0.001)
Controls:	**year and industry(NAICS 4-digit)**					
R^2	0.35	0.6	0.36	0.6	0.37	0.62
Implied elasticities along the effective labour isocost/isoquant + test of alignment						
$\sigma;\gamma$	0.82	0.77	0.54	0.64	0.63	0.72
Prob = 1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Prob $\sigma = \gamma$	0.0566		0.0000		0.0000	

Source: Bel-first.
*$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
Standard errors in parentheses.

$$\gamma(H,N) \equiv \frac{H}{N}\frac{C_H}{C_N} \approx \frac{\lambda + \chi_1 h + \chi_3 n}{\theta + \chi_2 n + \chi_3 h} \qquad [18]$$

$$\sigma(H,N) \equiv \frac{H}{N}\frac{Q_H}{Q_N} \approx \frac{\pi + \psi_1 h + \psi_3 n}{\beta + \psi_2 n + \psi_3 h} \qquad [19]$$

In particular, with a true cost function [4] $C(N,H) = FF + N(wH + F)$ and using [10]

$$\gamma(H,N) \equiv \frac{H}{N}\frac{C_H}{C_N} = \frac{\lambda + \chi_1 h + \chi_3 n}{\theta + \chi_2 n + \chi_3 h} \approx \frac{1+\varepsilon}{1+rF} \qquad [20]$$

or equivalently, if unit wages do not vary with hours (i.e. $\varepsilon = 0$) we get and estimation for the share of fixed costs in total labour cost of an employee as:

$$1 - \gamma(H,N) = \frac{F}{F + w(H)H} \approx \frac{\lambda + \chi_1 h + \chi_3 n}{\theta + \chi_2 n + \chi_3 h}. \qquad [21]$$

Note that expressions [18], [19] boil down to [respectively] λ/θ $[\pi/\beta]$ when χ*'s* $[\psi$*'s*$]$ are null (i.e. first-order polynomial approximation also equivalent to the Cobb–Douglas specification).

Note finally that all our estimates allow for firm-level unobserved heterogeneity (i.e. residuals $\mu_{it} = \omega_i + \rho_{it}$; (and similarly for the residual of the cost function), with ω_i being a time-invariant firm-level unobserved term potentially correlated with outcome variables and labour ones. In subsequent developments we also allow for simultaneity bias; i.e.

Table 6. Econometric estimation of the (relative) importance of quasi-fixed labour costs. Breakdown by type of contract (full-time, part-time, and interim)

	FE (first diff.)			
	All types of workers	**Full-time workers**	**Part-time workers**	**Interim workers**
n_{it}	0.815***	0.862***	0.938***	0.974***
	(0.002)	(0.003)	(0.003)	(0.002)
h_{it}	0.642***	0.657***	0.845***	0.946***
	(0.003)	(0.004)	(0.004)	(0.005)
n_i^{t2}	0.0392***	0.0308***	0.00744***	0.00388*
	(0.001)	(0.002)	(0.002)	(0.002)
h_{it}^2	−0.00771***	0.00261*	−0.0147***	0.00112
	(0.001)	(0.001)	(0.001)	(0.004)
$n_{it}\ h_{it}$	0.0326***	0.0378***	−0.00553	−0.00274
	(0.002)	(0.002)	(0.003)	(0.005)
Controls:	**year and firm fixed effects**			
R^2	0.6	0.56	0.56	0.86
Implied elasticities along the effective labour isocost				
γ	0.645	0.660	0.846	0.946
prob = 1	0.000	0.000	0.000	0.000

Source: Bel-first.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
Standard errors in parentheses.
Note that only large firms are required to report information on temporary workers' hours and cost separately (large firms are firms with more than 100 workers, or firms exceeding two of the following thresholds: 50 FTE workers, 7,300,000€ turnover, 3,650,000€ total balance sheet).

$\mu_{it} = \omega_{it} + \rho_{it}$ with ω_{it} being a time-variant unobserved term (corresponding, e.g., to partially anticipated demand chocks) also potentially correlated simultaneously to output and labour decisions (Ackerberg *et al.*, 2015; Levinsohn and Petrin, 2003).

4.2 Results

4.2.1 All industries pooled. A first set of key results are presented in Table 5. Estimated coefficients using firm-level mean-centred variables — not only corresponding to equations [12], [13] but also order 1 simplifications or order 3 generalizations — are reported in the upper part of the table, whereas the implied elasticities $\gamma(N_{it},H_{it})$ [18] $\sigma(N_{it},H_{it})$ [19] along (respectively) the isoquant and the isocost are reported in the lower part of the table. Focusing on the latter, we can see that they are systematically (and statistically significantly) less than 1. For instance, the model delivers a value of $\sigma = 0.80$, in line with results of the literature on the elasticity of output to hours (Anxo and Bigsten, 1989; Cahuc *et al.*, 2014; Cette *et al.*, 2015; Leslie and Wise, 1980). The FE effects model using first-differenced data are presented in the Table 5 (lower part) deliver estimates that are qualitatively similar, suggesting an absence of a serious problem with serial correlation of the residuals in our panel data.[28]

In Table 6, we exploit the fact that our data permit replicating the labour cost analysis (using FE-first differences) for three types of employment contracts: full-time

Table 7. Econometric estimation of the (relative) importance of quasi-fixed labour costs. Breakdown by broadly defined industries (Manufacturing, Wholesale and Retail, and Accommodation and Restaurants)

	FE (first diff.)			
	All industries	**Manufacturing**	**Wholesale and Retail**	**Accommodation and Restaurants**
n_{it}	0.815***	0.775***	0.841***	0.822***
	(0.002)	(0.005)	(0.005)	(0.007)
h_{it}	0.642***	0.594***	0.732***	0.780***
	(0.003)	(0.006)	(0.007)	(0.009)
n_i^{t2}	0.0392***	0.0568***	0.0456***	0.0185***
	(0.001)	(0.002)	(0.003)	(0.003)
h_{it}^2	−0.00771***	−0.00730***	0.0169***	−0.00947
	(0.001)	(0.002)	(0.002)	(0.007)
$n_{it}\ h_{it}$	0.0326***	0.0548***	0.0644***	0.00862
	(0.002)	(0.003)	(0.003)	(0.007)
Controls:	**year and firm fixed effects**			
R^2	0.6	0.64	0.53	0.79
Implied elasticities along the effective labour isocost				
γ	0.645	0.596	0.736	0.781
$prob = 1$	0.0000	0.000	0.000	0.000

Source: Bel-first.
$*p < 0.05$, $** p < 0.01$, $*** p < 0.001$.
Standard errors in parentheses.

(forming the largest part of the total), part-time, and interim/temporary.[29] Two interesting results emerge. First, all types of contracts are associated with quasi-fixed labour costs as all estimated γ are statistically less than 1. Fixed costs appear significantly higher for full-time employees[30] : at least 34 per cent compared to 15.4 per cent and 5.4 per cent for part-timers and interims, respectively. This result is in line with the model's prediction that job positions that are associated with higher quasi-fixed costs should be filled with full-time workers, whereas part-timers should only be hired when quasi-fixed costs are relatively low. Results regarding temporary workers should be interpreted with caution, as the data for such workers is much weaker: only a small proportion of firms report the presence of temporary workers and the reporting is based on hours invoiced by the interim company.

In Table 7, we explore the varying importance of quasi-fixed labour costs across broadly defined (NACE1) and contrasted industries: manufacturing, retail, and accommodation/restaurants. The analysis is done separately for the three industries, using FE-first differences. Conditional on hourly wage elasticity (ε) to be uniformly distributed, fixed costs appear to be significantly higher in manufacturing (at least 40 per cent) compared to retail and accommodation/restaurants (26 per cent and 21 per cent, respectively). These differences can reflect differences in the labour cost structure between sectors due to, e.g., historically different institutional arrangements of the type listed in Section 2. For further results on industry-by-industry results, see Section 4.2.2 below.

Table 8. Econometric estimation of the productivity of hours and of the (relative) importance of quasi-fixed labour costs. Fixed effect as *mean centring* + accounting for simultaneity bias

	LP[a]		ACF[b]	
	Productivity	**Labour costs**	**Productivity**	**Labour costs**
n_{it}	0.645***	0.827***	0.756***	0.925***
	(0.004)	(0.002)	(0.006)	(0.003)
h_{it}	0.475***	0.640***	0.564***	0.697***
	(0.008)	(0.004)	(0.063)	(0.062)
Controls:	**year and firm fixed effects [and (log of) capital in productivity equation]**			
Implied elasticities along the effective labour isocost/isoquant				
$\sigma;\ \gamma$	0.74	0.77	0.74	0.75
Prob = 1	0.000	0.000	0.002	0.000
Prob $\sigma = \gamma$	0.409		0.776	

Source: Bel-first.
*$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
[a]Levinsohn-Petrin; [b]Ackerberg, Caves & Frazer.
Standard errors in parentheses.
Cobb–Douglas specification of $Q(N,H)$ and $C(N,H)$.

Figure 3. Industry-by-industry estimation of γ and σ. Second-order polynomial specification of $Q(N,H)$ and $C(N,H)$

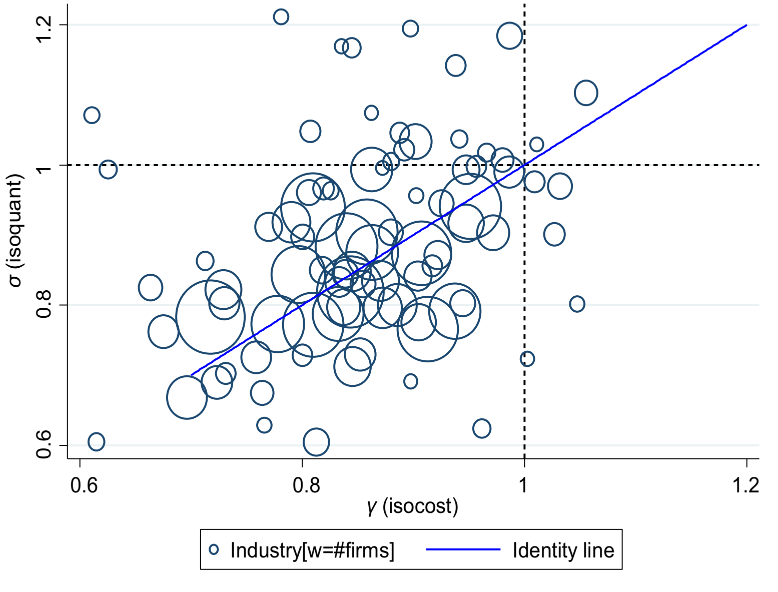
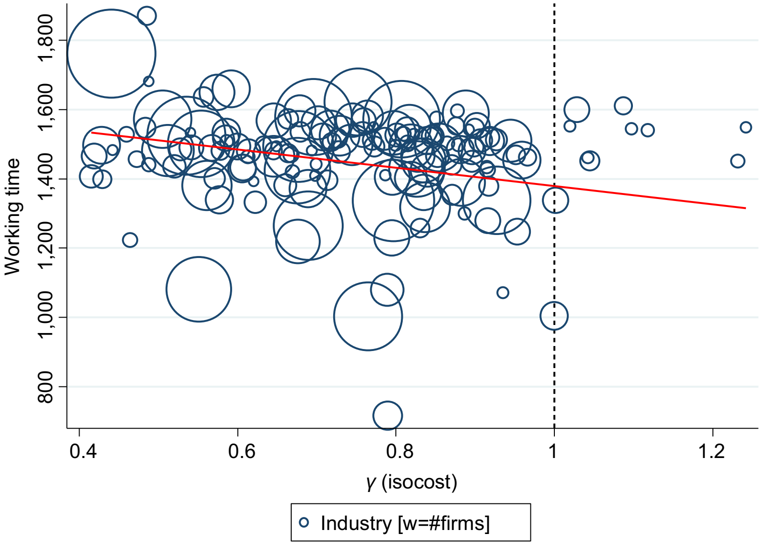


Table 9. Econometric results — impact of industry-level elasticity on working hours and prevalence (share) of part-time work contract; using industry-by-industry estimated $\hat{\sigma}^j$; $\hat{\gamma}^j$ [FE (first diff.) and second-order polynomial specification of $Q(N,H)$ and $C(N,H)$]

	Productivity		Labour costs	
	Working hours	**Share part-time contracts**	**Working hours**	**Share part-time contracts**
$\hat{\sigma}^j$; $\hat{\gamma}^j$	−0.163***	0.0848***	−0.115***	0.00512***
	(0.001)	(0.001)	(0.001)	(0.001)
Controls	Year fixed effect, output (log)			

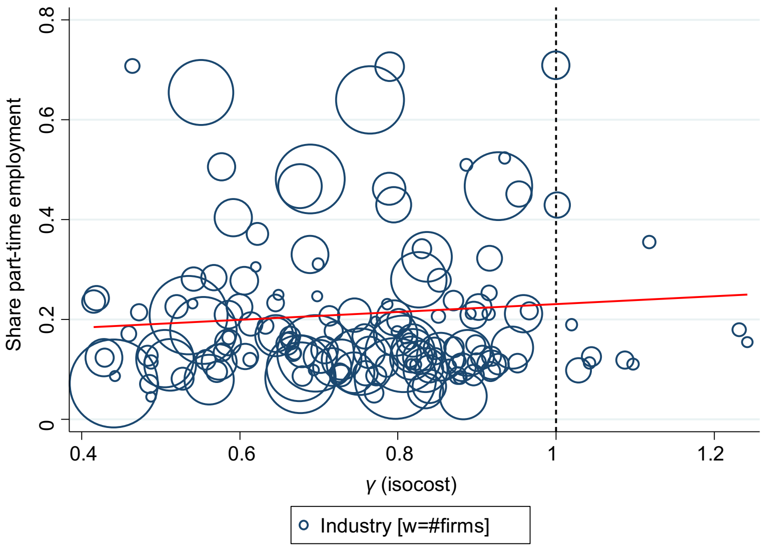
Source: Bel-first.
$^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.
Standard errors in parentheses.

Figure 4. Working hours in 2015 as a function of industry-level estimated isocost elasticity ($\hat{\gamma}^j$)



In Table 8, we present the results when endogeneity stems both from fixed effects (unobserved time-invariant firm heterogeneity) and simultaneity (unobserved, final demand-related, short-run shocks that can affect simultaneously outcomes variables and the level of labour inputs).[31] To control for that risk we implement the more structural approach developed by Levinsohn and Petrin (2003) and more recently by Ackerberg *et al.* (2015) (ACF hereafter), which primarily consists of using intermediate inputs (materials and other supplies) to proxy short-term shocks. Results are qualitatively very similar to the ones reported in previous tables where we control only for fixed effects. Even though this suggests γ that simultaneity is a relatively benign problem in our data, coefficients in Table 8 are our most robust and thus preferred ones. Referring to Table 8's

Figure 5. Share of part-time work in 2015 as of industry-level estimated isocost elasticity ($\hat{\gamma}^j$)



ACF results,[32] the tentative conclusion would be that quasi-fixed labour costs account for at least 23 per cent of total labour costs. As far as we know, this has never been estimated econometrically so far.

More generally, it should be noted for all tables that our contribution resides principally in the correct estimation of elasticities along the isoquant (σ) and the isocost (γ) to be both significantly lower than one. Estimations along the isoquant are not new and should be understood as the demonstration that our database yields results aligned with the existing empirical literature. On the other hand, results regarding the isocost have not been shown before and represent an important contribution to the literature on labour demand.

4.2.2 Industry-level analysis and the impact of quasi-fixed costs on the demand for hours. In this section, we derive distinct estimates of $\gamma(N,H)$ and $\sigma(N,H)$ for each of the NACE 3-digit industries in our dataset with the aim of assessing equation [11]; namely of a positive relationship between (estimated) quasi-fixed labour costs and the demand for hours. The latter will be proxied by the firm-level number of hours and the share of workers on a part-time contract. We first estimate our productivity and labour cost equations separately for each industry.[33] Results are reported in Table A.1 (Appendix A) and can be visualized on Figure 3. The latter suggests that the two estimates are strongly correlated but not necessarily perfectly aligned. Values of $\widehat{\sigma;\gamma} < 1$ hint at the presence of quasi-fixed labour costs whose effect dominates those of longer hours on unit wage ($\varepsilon \geq 0$). Note that most of the large industries (representing more firms and revealed by the size of the circles on Figure 3) display elasticities that are significantly less than 1; an indication of the relative importance of quasi-fixed labour costs.

More related to the point at the core of this paper, using these estimates $\hat{\gamma}$ and $\hat{\sigma}$ as predictors of (conditional) labour demand equation [11] yields the theoretically expected results (see Table 9, left part). The higher $\hat{\gamma}$ is (i.e. the lower the estimated share of quasi-fixed costs), the lower the average annual number of hours is (Table 9, col. 3 and Figure 4), and also the higher the share of workers with a part-time contract (Table 9, col. 4 and Figure 5).

4.2.3 About the alignment of isoquant ($\hat{\sigma}$) and isocost ($\hat{\gamma}$) elasticities. One of the originalities of the paper is the conjoint study of the relationship between hours, productivity, and labour costs. Given this, it is important to spend some time discussing the alignment of σ and γ. Theoretical developments exposed in Section 1 suggest that firms should choose working hours (and the number of workers) such that these two elasticities are equal). As is visible at the bottom of Tables 5–7, we do not verify alignment systematically. This said, some of our results are synonymous with alignment.

First, it is the case of our LP- ACF estimates (Table 8) as the hypothesis that $\hat{\sigma} = \hat{\gamma}$ is accepted with a probability of, respectively, 0.41 and 0.78. The main econometric challenge is probably to come up with a robust estimation of the production function (and thus of what happens along this isoquant as captured by estimated σ). The estimation of the labour cost function is not trivial but intrinsically less complicated, at it is less prone to biases (in particular to short-run endogeneity/simultaneity biases). Hence, it probably not by chance that we get the alignment with LP, and even more with ACF as these are methods that have been designed to overcome the limitations of OLS or fixed-effect methods.

Second, if we consider our industry-by-industry estimates (Figure 3), as we state on page 20, they are not aligned on a one-by-one case, but are strongly and significantly correlated. Thus, statistically, an industry by a lower/higher σ is very likely to have a lower/higher γ. The absence of a perfect alignment could reflect data or estimation limitations (particularly of σ as suggested above), or could point at a functioning of firms/industries that is synonymous with (partial) short-sightedness and/or tâtonnement.

Third, also in Table 2, one should note that industry-by-industry estimated σ and γ have a very similar predictive capacity as to the share of part-time work and the duration of work. In other words, industries with lower/higher σ *tend to be those with* lower/higher γ but also lower/higher share of part-time worker or higher/lower duration of work.

5. Further evidence about quasi-fixed labour costs

5.1 Econometric analysis of worker-level wage data to estimate labour costs

In this section, we use PIAAC 2012 data[34] on average gross wage per hour (*GWH*) and hours of work per week (*H*) from the individuals who work as employees in the private, for-profit segment of the economy. By definition, PIAAC aims at delivering comparable international data. It is analysed here with the aim of assessing how Belgian quasi-fixed labour costs compare with the situation in other countries. PIAAC contains only individual-level data so there is no way one can replicate the productivity & labour cost analysis of the previous sections. And as in the above sections, the objective is to infer the presence (and the importance) of quasi-fixed labour costs *F* from the parameters of an econometric models regressing labour cost on hours.

As in Section 4.1 we assume that $GWH(H) = (wH + F)/H = w + F/H$. We do not observe unit wage w or fixed labour cost F. But elasticities can be retrieved by the estimation of a linear[35] approximation of the log of $GWH(H)$ i.e.:

$$gwh_{ik} \approx A_k + \phi_k h_{ik} + \lambda_k \pi_{ik} + v_{ik}, \tag{22}$$

where gwh_{ik} is the (log of) the average gross wage per hour reported by worker i in country k and h_{ik} the (log) of number of hours per week the worker declares. Assuming the actual process generating wages is $GWH = w + F/H$; [ignoring individual and country indices] we have that

$$\frac{\partial gwh}{\partial h} = \frac{\partial \ln(GWH)}{\partial \ln(H)} = \frac{-\frac{F}{H^2} + w'(H)}{\frac{F}{H^2} + \frac{w(H)}{H}} \approx \phi, \tag{23}$$

which is negative (i.e. gross wage per hour goes down with hours) if $F > 0$ and if $w'(H)$ is relatively small or null. In the particular case where $w'(H) \approx 0$ [i.e. no or little rise of the wage rate with hours] it is immediate to show that $\delta gwh/\delta h = -F/(F + wH) \approx \phi$. This means that the estimation of [22] delivers coefficients that can be used to estimate the share of quasi-fixed labour costs. Indeed, — ϕ is a lower bound proxy of the importance of quasi-fixed costs.

Of course, the level of hourly gross wage of an individual worker reflects many things that have little to do with the number of working hours. As PIAAC is not a panel, there is no way to resort to fixed effects (FE) to account for unobserved heterogeneity. What we do is to specify π_{ik} as a vector of controls comprising many of the determinants of wage: educational attainment, gender, labour market experience, labour market experience squared, occupation (ISCO 2008 2-digit), and industry (ISIC 2-digit). We also include the respondent's average test score in literacy, numeracy, and problem solving. The hope is that this rather rich set of controls allows for a proper identification of actual gross wage/hours elasticity ϕ, and thus of the (relative) importance of quasi-fixed labour costs.

Results (Appendix B, Table A.2) clearly hint at the presence of quasi-fixed labour costs. With an estimated $\phi = -0.18$ for Belgium, we may conclude that fixed costs are at least equal to 18 per cent of total gross wage of a typical private- and for-profit economy employee. This is slightly below the 20–23 per cent that we found using firm-level data. But remember that PIAAC is only about gross wages, whereas Bel-first, firm-level data used in previous section is about total payroll cost, with the possibility that some of elements constituting the difference (e.g. severance payments, in-kinds) drive fixed costs' share upwards.

5.2 International descriptive/accounting evidence about the share of quasi-fixed labour cost, and their impact on the demand for hours

Another assessment of our Section 3 econometric estimates of the share of quasi-fixed labour costs coming from the comparison with *direct* estimates of that share, based on accounting/descriptive data from other countries than Belgium. In general, authors consider both 'one-time' fixed costs (i.e. recruitment, training, severance) and 'recurrent' fixed labour costs i.e. employer-funded unemployment, medical insurance or retirement plans (social security), remuneration of non-worked days (annual holiday, sick or maternity leave), and other in-kind employee benefits (stocks, cars, phones).

Hart (1984) suggests that for both the United States and the United Kingdom it is reasonable to put quasi-fixed labour costs at roughly 20 per cent of total cost. For Ehrenberg (2016), the [US] data suggest that around 19 per cent of total compensation (about 60 per cent of nonwage costs) is quasi fixed. Martins (2004), in a study for Portugal, estimates quasi-fixed costs at 25 per cent of labour costs, with social security payments being the dominant quasi-fixed cost item. Of course, the actual sources of quasi-fixed costs in the above countries could differ from those underpinning the Belgian result. For instance, health care insurance contributions by firms seem to be a key source of 'fixity' in the US. Less so in Belgium, where severance payments, assimilated days or in-kinds/perks probably play a greater role. Yet, it is still worth underlying that the overall estimates published by these authors is surprisingly close to our estimate for Belgium, at about 20 per cent.

Finally, there is a small literature that used descriptive estimates of quasi-fixed labour costs as predictor of firms' demand for hours (paralleling what we do in Section 4.2). Cutler and Madrian (1998) find that increases in health insurance costs during the 1980s increased the hours worked by covered workers. Montgomery and Cosgrove (1993) and Buchmueller (1999) show that a smaller proportion of hours are worked by part-time employees in firms offering more generous fringe benefits to full-time workers. Finally, Dolfin (2006) uses US data on the cost of recruiting, search, hiring, training, and firing; and shows that, ceteris paribus, the higher that cost the higher the average number of hours. The results of these studies are consistent with our results in Section 4.2. based on inferred/econometric measures of quasi-fixed labour costs. More generally, they accord with the idea of substitution of hours for workers in response to rising quasi-fixed labour costs, as predicted by a theory of labour demand.

6. Concluding remarks

Hours worked tend to not only vary across individuals but also — on average — across firms, and even within firm over time. Why? Over the past decades, most economists have privileged the idea that shorter versus longer hours (leaving labour market regulations aside) had primarily to do with the preferences of individuals. In this work, echoing Pencavel (2016)'s question of 'Whose Preferences Are Revealed in Hours of Works?', we explore the role of employers' preferences for working time; and in particular the role of quasi-fixed labour costs. By quasi-fixed labour costs, we mean any expense that is associated with employing a worker but is independent of his/her hours of work (such as the costs of in-kind benefits, hiring and training new workers, firing workers,[36] taxes, or insurance payments that are not proportional to the duration of work).

We consider a setup where firms decide simultaneously on working hours and the number of workers. We find that despite an obvious productivity gain from reducing working hours, firms facing large quasi-fixed labour costs choose a higher level of hours to cover such quasi-fixed labour costs.

We estimate that increasing hours by 1 per cent would only increase output (value added) by 0.8 per cent, thus in line with the hypothesis of decreasing marginal return to working hours, and that of imperfect substitutability between hours and workers in the production process. What is more — and to our knowledge this is a novelty — we were able to retrieve the relative share of quasi-fixed labour costs: 20–23 per cent of a worker's cost could be independent from hours. These econometric results suggest that the typical for-profit firm located in Belgium faces financial incentives to raise hours beyond the point where the average labour productivity starts declining. These explain why *ceteris paribus* some industries (i.e. those with higher quasi-fixed labour costs) are characterized by longer hours and a lower propensity to employ people on a part-time basis. We also find evidence that quasi-fixed labour costs are more important among people with a full-time contract than among those with a part-time or interim contract. Again, this could explain employers' reluctance to let the former reduce their working hours, even when they accept a strictly proportional reduction of their wage.[37]

In short, when it comes to working time policies — often presented as crucial to accommodate the varying needs and desires of contemporary individuals — policymakers should not overlook firms' preferences and their determinants. For instance, in the context of pension reforms aimed at extending people's careers, they should check that the quasi-fixed costs of employing older workers are limited. If not, employers might be reluctant to endorse part-time/flexitime work arrangements most older individuals aspire to (Harris Interactive & Dychtwald, 2005).

Appendix

A. Estimation of elasticities by industry

Table A1. Estimation of elasticities, by industry (NACE 3)

NACE 3-digit	Nobs	γ^j	*Prob* $\gamma^j = 1$	σ^j	*Prob* $\sigma^j = 1$
103_Processing and preserving of fruit and vegetables	330	1.03	0.0000	1.08	0.0000
106_Manufacture of grain mill products, starches and starch products	135	0.85	0.0000	0.92	0.1221
108_Manufacture of other food products	916	0.95	0.0000	0.74	0.0000
110_Manufacture of beverages	357	0.71	0.0000	0.82	0.0000
131_Preparation and spinning of textile fibres	207	0.87	0.0000	1.00	0.8482
132_Weaving of textiles	257	0.66	0.0000	0.70	0.0000
139_Manufacture of other textiles	544	0.82	0.0000	0.73	0.0000
141_Manufacture of wearing apparel, except fur apparel	312	0.92	0.0000	0.91	0.0000
162_Manufacture of products of wood, cork, straw and plaiting materials	566	0.83	0.0000	0.80	0.0000
171_Manufacture of pulp, paper and paperboard	193	0.95	0.0080	0.83	0.0000
172_Manufacture of articles of paper and paperboard	394	0.88	0.0000	0.90	0.0000
181_Printing and service activities related to printing	986	0.82	0.0000	0.64	0.0000
201_Manufacture of basic chemicals, fertilizers, and nitrogen compounds, plastics and synthetic rubber in primary forms	821	0.73	0.0000	0.65	0.0000
204_Manufacture of soap and detergents, cleaning and polishing preparations, perfumes, and toilet preparations	195	0.90	0.0000	0.66	0.0000
212_Manufacture of pharmaceutical preparations	294	0.61	0.0000	0.75	0.0000

Table A1. Continued

NACE 3-digit	Nobs	γ^j	*Prob* $\gamma^j = 1$	σ^j	*Prob* $\sigma^j = 1$
222_Manufacture of plastics products	1169	0.85	0.0000	0.81	0.0000
233_Manufacture of clay building materials	105	0.86	0.0000	0.74	0.0041
236_Manufacture of articles of concrete, cement, and plaster	853	0.74	0.0000	0.65	0.0000
241_Manufacture of basic iron and steel and of ferro-alloys	212	0.77	0.0000	0.84	0.0036
252_Manufacture of tanks, reservoirs, and containers of metal	192	0.92	0.0000	0.87	0.0000
255_Forging, pressing, stamping, and roll-forming of metal; powder metallurgy	207	0.68	0.0000	0.99	0.4761
256_Treatment and coating of metals; machining	1007	0.84	0.0000	0.68	0.0000
257_Manufacture of cutlery, tools, and general hardware	121	0.67	0.0000	0.83	0.0545
261_Manufacture of electronic components and boards	162	0.66	0.0000	0.89	0.3448
262_Manufacture of computers and peripheral equipment	44	0.77	0.0083	0.90	0.8064
263_Manufacture of communication equipment	137	0.82	0.0570	1.00	0.9506
265_Manufacture of instruments and appliances for measuring, testing, and navigation; watches and clocks	178	0.72	0.0000	0.78	0.0000
271_Manufacture of electric motors, generators, transformers and electric distribution, and control apparatus	232	0.93	0.0000	1.07	0.0000
279_Manufacture of other electrical equipment	139	0.63	0.0000	1.17	0.0000
281_Manufacture of general — purpose machinery	268	0.91	0.0000	0.93	0.0236
282_Manufacture of other general-purpose machinery	736	0.72	0.0000	0.72	0.0000
283_Manufacture of agricultural and forestry machinery	152	0.88	0.0000	0.93	0.4027
289_Manufacture of other special-purpose machinery	430	0.92	0.0000	1.19	0.0000
291_Manufacture of motor vehicles	90	0.61	0.0550	0.69	0.0475
293_Manufacture of parts and accessories for motor vehicles	332	0.61	0.0000	0.68	0.0000
331_Repair of fabricated metal products, machinery, and equipment	391	0.84	0.0000	0.92	0.0000
332_Installation of industrial machinery and equipment	172	0.90	0.0000	0.76	0.0000
370_Sewerage	95	0.88	0.0000	0.81	0.0000
381_Waste collection	106	0.81	0.0000	0.70	0.0000
412_Construction of residential and non-residential buildings	3368	0.80	0.0000	0.72	0.0000
421_Construction of roads and railways	1127	0.88	0.0000	0.90	0.0000
422_Construction of utility projects	645	0.84	0.0000	1.05	0.0000
429_Construction of other civil engineering projects	196	0.77	0.0000	1.16	0.0554
431_Demolition and site preparation	566	0.84	0.0000	0.75	0.0000
432_Electrical, plumbing and other construction installation activities	2580	0.68	0.0000	0.61	0.0000
461_Wholesale on a fee or contract basis	359	0.90	0.0000	0.71	0.0000

Table A1. Continued

NACE 3-digit	Nobs	γ^j	*Prob* $\gamma^j = 1$	σ^j	*Prob* $\sigma^j = 1$
466_Wholesale of other machinery, equipment, and supplies	2996	0.81	0.0000	0.68	0.0000
467_Other specialized wholesale	3004	0.70	0.0000	0.80	0.0000
469_Non-specialized wholesale trade	328	0.76	0.0000	0.68	0.0000
471_Retail sale in non-specialized stores	2442	0.69	0.0000	0.77	0.0000
472_Retail sale of food, beverages, and tobacco in specialized stores	641	0.80	0.0000	0.60	0.0000
475_Retail sale of other household equipment in specialized stores	1571	0.83	0.0000	0.61	0.0000
476_Retail sale of cultural and recreation goods in specialized stores	254	0.62	0.0000	0.69	0.0000
477_Retail sale of other goods in specialized stores	2339	0.93	0.0000	0.74	0.0000
521_Warehousing and storage	966	0.82	0.0000	0.93	0.0000
551_Hotels and similar accommodation	1262	0.84	0.0000	0.79	0.0000
552_Holiday and other short-stay accommodation	73	0.94	0.0000	0.66	0.0000
561_Restaurants and mobile food service activities	2401	0.76	0.0000	0.70	0.0000
562_Event catering and other food service activities	531	0.79	0.0000	0.86	0.0000
612_Wireless telecommunications activities	153	1.09	0.0000	0.75	0.0000
620_Computer programming, consultancy, and related activities	2317	0.75	0.0000	0.74	0.0000
631_Data processing, hosting, and related activities; web portals	156	0.65	0.0000	1.05	0.0271
642_Activities of holding companies	609	0.65	0.0000	0.80	0.0000
661_Activities auxiliary to financial services, except insurance, and pension funding	700	0.69	0.0000	0.72	0.0000
682_Renting and operating of own or leased real estate	633	0.80	0.0000	0.77	0.0000
683_Real estate activities on a fee or contract basis	158	0.97	0.0000	0.70	0.0000
692_Accounting, bookkeeping and auditing activities; tax consultancy	342	0.90	0.0000	0.91	0.0000
702_Management consultancy activities	996	0.80	0.0000	0.89	0.0000
711_Architectural and engineering activities and related technical consultancy	1096	0.89	0.0000	0.78	0.0000
731_Advertising	575	0.75	0.0000	0.82	0.0000
741_Specialized design activities	79	1.12	0.0000	1.00	0.9483
743_Translation and interpretation activities	52	1.24	0.0004	0.95	0.4670
773_Renting and leasing of other machinery, equipment, and tangible goods	323	0.81	0.0000	0.61	0.0000
802_Security systems service activities	67	0.80	0.3075	0.86	0.5561
811_Combined facilities support activities	119	0.92	0.0000	0.81	0.0000
813_Landscape service activities	248	0.73	0.0000	1.01	0.7703
829_Business support service activities n.e.c.	713	0.96	0.0036	0.62	0.0000
872_Residential care activities for mental retardation, mental health, and substance abuse	77	0.89	0.0000	1.16	0.3031
889_Other social work activities without accommodation	388	1.00	0.9982	1.05	0.0000
931_Sports activities	334	0.95	0.0000	0.66	0.0000
932_Amusement and recreation activities	188	0.83	0.0000	0.94	0.0003
952_Repair of personal and household goods	98	1.23	0.0000	0.66	0.0000
960_Other personal service activities	979	0.68	0.0000	0.64	0.0000

B. Econometric results for the PIAAC dataset

Table A2. Econometric Results-Worker-level (cross-sectional) analysis. Conditional impact of (log of) hours on (log of) average hourly gross wage (computed as the ratio [weekly] gross wage/hours). Belgium (Flanders)

	BEL
h	−0.180***
	(0.024)
Experience	0.027***
	(0.002)
Experience^2	−0.000***
	(0.000)
Schooling years	0.034***
	(0.004)
Score (log of)$	0.179**
	(0.059)
Female	−0.095***
	(0.020)
Other controls	Occup (ISCO 2008 2-digit) indus(ISIC 2-digit) fixed effects
Estimates of the wage/hours elasticity	
$\delta gwh/\delta h = -F/(F + wH) \approx \phi$ si $W'(H)=0$	−0.180***
Prob $\phi = 0$	0.000

Source: PIAAC-OECD 2012.
Standard errors in parentheses.
$The respondent's average test score in literacy, numeracy and problem solving.
*$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Notes

[1] Workers' preferences regarding hours have largely been studied in previous work (see, e.g., Barzel, 1973; Freeman and Gottschalk, 1998) and more recent one by Rogerson, Keane & Wallenius (2009, 2011, 2012).

[2] For example, in his survey on labour supply, Heckman (1993) concludes that most of the variability in labour supply can be explained by extensive margins (i.e. worker flows into and out of the labour market), whereas intensive margins (i.e. changes in hours worked) are extremely small. Using job-mover data, Altonji and Paxson (1986, 1988, 1992) or Senesky (2004) suggest that choices of wages and hours are available only as a 'package'; therefore, a worker is not able to change work hours flexibly unless he or she changes jobs.

[3] The relative importance of the demand for labour has also been highlighted by Bryan (2007) and Stier and Lewin-Epstein (2003).

[4] The sequence of choice has been documented before and it seems realistic to think that capital/labour ratio decisions are subject to a different timing than hours/workers decisions. Would this assumption be lifted, the final signs of derivatives would be indeterminate and depend on capital, workers, and hours complementarity (Hart, 1984).

[5] $dL = 0 = L_H\, dH + L_N dN$.

[6] Driven by overtime wage premia or a higher incidence of employer-paid sick leave when H rises.

[7] Mathematically, the sign of the slope (or derivative) of the average productivity is determined by the difference/ratio between the average productivity and the marginal productivity: $d(g(H)/H)/dH = g'(H)/H - g(H)/H^2) = [g'(H) - g(H)/H]/H$. If $g'(H) < g(H)/H$ (i.e. if $\sigma(H) < 1$) we

necessarily have a negative slope for the average productivity, meaning that we are beyond its maximum. And marginal productivity of hours is declining (Figure 1, upper part).

[8] Prorata the likelihood of dismissal/separation.

[9] Paid sickness leaves represent a large cost for firms. In fact, in the Belgian system, sickness leave is highly comparable to paid holiday in terms of cost for the firm. The first 30 days of each sick leave are paid for by the employer; and days of absence due to sickness still entitle workers to the associated yearly premium, paid holidays, pension and health insurances. After 30 consecutive days, the replacement wage is paid for by the social security and the worker may lose some of the perks. On average in Belgium, 50 per cent of employees take at least 1 day of sick leave per year. Among those, sick leaves last on average 13 days but the average number of days paid by the firm is around 5 days. The percentage of workers taking at least one sick day is similar among blue and white collars, but the average leave length is quite different, 8 days for white collar (five paid for by the firm), 16 days for blue collar (seven paid for by the firm). The share of workers taking at least one day of sick leave also strongly increases with the size (number of workers) of the firm: from 32 per cent for firms of one to four workers up to 60 per cent for the largest firms (above 1,000 workers) Securex (2011).

[10] Formally, the consequences of H_2/H_1 being non-constant are that the average labour cost per hour becomes $C/H_1 = F/H_1 + w(1 + \alpha(H_1))$ and the derivative with respect to hours worked $\mathrm{d}(C/H_1)/\mathrm{d}H_1 = -F/H_1^2 + w\mathrm{d}\alpha(H_1)/\mathrm{d}H_1$. So if $\mathrm{d}\alpha(H_1)/\mathrm{d}H_1 < 0$, the deflating effect of longer hours of work H_1 is magnified.

[11] Belgium is characterized by a very large fiscal wedge on labour. One way for companies and workers to reduce payment is to resort to in-kind benefits.

[12] 2015 figures suggest that 15 per cent of all employed workers in Belgium benefit from a company car.

[13] Akin full-time workers, part-time workers are fully eligible.

[14] *Min*{6 hours, typical day-shift number of hours}.

[15] http://www.bvdinfo.com/Products/Company-Information/National/Bel-First.aspx.

[16] We remove the primary sector (agriculture and mining) as well as the public/non-profit industry (NACE 1-digit codes ‘A’, ‘B’, ‘O’, ‘P’, ‘T’, ‘U’).

[17] The analysis has also been performed on 2005–2014 data without any impact on the conclusions.

[18] Such as Volvo, Arcelor, Audi, GSK, Electrabel, Colruyt, Delhaize, Carrefour, AIB-Vinçotte and 10 large interim firms (Randstad, Adecco, Start People, T-Groep, Tempo Team, Daoust, Manpower).

[19] European industrial activity classification (Nomenclature scientifique des Activité économiques dans la Communauté Européenne).

[20] North American Industry Classification System (NAICS).

[21] Account 648 ‘Other Personnel Expenses’.

[22] By contrast, the cost of workers in a pre-retirement scheme is not counted anymore when fully retired. If partially retired (‘aménagement de fin de carrière’), they count as part-time workers; and the worker replacing them for the other part-time is counted.

[23] Unemployment with complement paid by the former employer (‘complément d’entreprise’); account 624 Retirement and survival pensions.

[24] Unlike hours found in the social security database, Belfirst data on hours do not suffer from the ‘assimilation’ bias: i.e. hours that are assimilated to worked hours in the definition of social (e.g. pension) rights. The only serious issue with Bel-first is thus the underestimation of worked hours due to unpaid overtime (something this seems to be common among white-collar workers).

[25] Even after removing outliers: i.e. firms declaring hours per worker to be, on average over all workers, below 100 or above 3,000 annual hours, mostly due to encoding errors.

[26] The Programme for the International Assessment of Adult Competencies (PIAAC).

[27] Not to be confounded with the traditional [production] cost function i.e. a function of input prices and output quantity.

[28] Although both mean-centering (Table 5) and first-differencing (FD) (Table 5) aim at the same thing (remove a fixed effect) they do not necessarily generate the same results. The main difference stems from the way they transform the OLS residuals and a problem known in the literature on panels as ‘serial correlation’ (i.e. the fact luck in 1 year might correlate (or not) with luck in other years).

Both mean-centering and FD rely on some assumptions. In short, FD is more appropriate when there is serial correlation, while mean-centering is more appropriate (in the sense that it is more effective at removing the time-invariant fixed effect) in the absence of serial correlation. This justifies implementing both methods, even if it is to observe that they generate similar results.

[29] Interims are workers who, from a legal point of view, are employed by interim agencies and 'sold' to the firm where we observe them, for short periods of time (hence, the fact that they are also referred to as 'temporary' workers) and the accomplishment of a speγcialized task.

[30] And this in spite of the fact that wage elasticity (ε) — which leads to an underestimation of the share quasi-fixed labour costs Equation [10] — could be higher for full-timers due to overtime premia.

[31] For instance, the simultaneity of a negative shock (due to the loss of a major contract) and a reduction in hours worked, causing reverse causality: from productivity drop to hours contraction. Alternatively, focusing on the estimation of the labour cost function, the simultaneity between a positive shock (e.g. the landing of a big contract, triggering an overall rise of wages) and a rise of the number of hours worked, also causing a reverse causality problem [in particular a shock-driven rise of hourly wage elasticity (ε) that may translate into γ being underestimated].

[32] See Vandenberghe (2017) for a full presentation of the LP and ACF proxy-variable idea, and (Vandenberghe *et al.*, 2013) for how it can be combined with fixed effects.

[33] Using second-order polynomial approximations, fixed effect as first differences.

[34] The OECD led Programme for the International Assessment of Adult Competencies (PIAAC).

[35] The estimation was conducted using quadratic and cubic approximations. Results were qualitatively similar to that reported hereafter.

[36] Recruitment, training or firing costs typically intervene as fixed labour costs *pro rata* firms' turnover rate.

[37] And do not demand that the hourly wage gets revised upwards to preserve total remuneration.

References

Ackerberg D. A., Caves K. and Frazer G. (2015) 'Identification Properties of Recent Production Function Estimators', *Econometrica* 83: 2411–2451.

Altonji J. G. and Paxson C. H. (1986) 'Job Characteristics and Hours of Work' in Ehrenberg R. G. (ed.) *Research in Labor Economics*, Vol. 8, Greenwich: Westview Press: 1–55.

Altonji J. G. and Paxson C. H. (1988) 'Labor Supply Preferences, Hours Constraints and Hours-Wage Tradeoffs', *Journal of Labor Economics* 6: 254–276.

Altonji J. G. and Paxson C. H. (1992) 'Labor Supply, Hours Constraints and Job Mobility', *Journal of Human Resources* 27(2): 256–278.

Anxo D. and Bigsten A. (1989) 'Working Hours and Productivity in Swedish Manufacturing', *The Scandinavian Journal of Economics* 91(3): 613–619.

Barzel Y. (1973) 'The Determination of Daily Hours and Wages', *The Quarterly Journal of Economics* 87(2): 220–238.

Bryan M. L. (2007) 'Workers, Workplaces and Working Hours', *British Journal of Industrial Relations* 45(4): 735–759.

Buchmueller T. (1999) 'Fringe Benefits and the Demand for Part-Time Workers', *Applied Economics* 31: 551–563.

Cahuc P., Carcillo S., Zylberberg A. and McCuaig W. (2014) *Labor Economics*, Cambridge, MA: MIT Press.

Cette G., Dromel N., Lecat R. and Paret A.-C. (2015) 'Production Factor Returns: The Role of Factor Utilization', *Review of Economics and Statistics* 97(1): 134–143.

Collewet M. and Sauermann J. (2017) 'Working Hours and Productivity', IZA Discussion Papers No 10722, Institute for the Study of Labor.

Cutler D. and Madrian B. (1998) 'Labor Market Response to Rising Health Insurance Costs: Evidence on Hours Worked', *RAND Journal of Economics* 29: 509–530.

Dixon R. and Freebairn J. (2009) 'Models of Labour Services and Estimates of Australian Productivity', *Australian Economic Review* 42(2): 131–142.

Dixon R., Freebairn J. and Lim G. C. (2005) 'An Employment Equation for Australia', *Economic Record* 81(254): 204–214.

Dolfin S. (2006) 'An Examination of Firms' Employment Costs', *Applied Economics* 38(8): 861–878.

Donaldson D. and Eaton C. (1984) 'Person-Specific Costs of Production: Hours of Work, Rates of Pay, Labour Contracts',*Canadian Journal of Economics*, 17, 441–449.

Ehrenberg R. G. (2016) *Modern Labor Economics: Theory and Public Policy*, 12th edn, Abingdon, Oxon; New York: Routledge.

Feldstein M. S. (1967) 'Specification of the Labour Input in the Aggregate Production Function', *The Review of Economic Studies* 34(4): 375–386.

Freeman R. B. and Gottschalk P. (1998) *Generating Jobs: How to Increase Demand for Less-Skilled Workers*, New York, NY: Russell Sage Foundation.

Hamermesh D. S. (1993), *Labor Demand*, Princeton, NJ: Princeton University Press.

Harris Interactive & Dychtwald K. (2005) 'The Merrill Lynch New Retirement Survey. A Perspective from the Baby Boom Generation', http://agewave.com/what-we-do/landmark-research-and-consulting/research-studies/new-retirement-survey/.

Hart R. A. (1984) *The Economics of Non-Wage Labour Costs*, London, George Allen & Unwin.

Heckman J. J. (1993) 'What has Been Learned About Labor Supply in the Past Twenty Years?', *The American Economic Review* 83(2): 116–121.

Hicks J. R. (1932) *The Theory of Wages*, 2nd edn, London: Macmillan [1963].

Keane M. and Rogerson R. (2012) 'Micro and Macro Labor Supply Elasticities: A Reassessment of Conventional Wisdom', *Journal of Economic Literature* 50(2): 464–476.

Kuroda S. and Yamamoto I. (2013) 'Firms' Demand for Work Hours: Evidence from Matched Firm-Worker Data in Japan', *Journal of the Japanese and International Economies* 29: 57–73.

Leslie D. and Wise J. (1980) 'The Productivity of Hours in UK Manufacturing and Production Industries', *The Economic Journal* 90(357): 74–84.

Levinsohn J. and Petrin A. (2003) 'Estimating Production Functions Using Inputs to Control for Unobservables', *Review of Economic Studies* 70(2): 317–341.

Martins A. (2004) 'The Employment–Hours Trade-off: Theory and An Application to the Portuguese Case', *Labour: Review of Labour Economics and Industrial Relations*, 18: 465–502.

Montgomery M. and Cosgrove J. (1993) 'The Effect of Employee Benefits on the Demand for Part-Time Workers', *Industrial and Labor Relations Review* 47: 87–98.

Oi W. (1962) 'Labor as a Quasi-Fixed Factor', *Journal of Political Economy* 70: 538–555.

Pencavel J. (2015) 'The Productivity of Working Hours', *The Economic Journal* 125(589): 2052–2076.

Pencavel J. (2016) 'Whose Preferences Are Revealed in Hours of Work?', *Economic Inquiry* 54(1): 9–24.

Rogerson R. (2011) Individual and Aggregate Labor Supply with Coordinated Working Times. *Journal of Money, Credit and Banking*, 43, 7–37, 08.

Rogerson R. and Wallenius J. (2009) 'Micro and Macro Elasticities in a Life Cycle Model with Taxes', *Journal of Economic Theory* 144(6): 2277–2292.

Securex (2011) '*White Paper: Absentéisme Dans le Secteur Privé*'. Technical Report.

Senesky S. (2004) 'Testing the Inter-Temporal Labor Supply Model: Are Jobs Important?', *Labour Economics* 121(6): 749–772.

SPF Economie (2012) '*Enquête Quadriennale sur le Coût de la Main D'oeuvre'*. Technical Report.

Stier H. and Lewin-Epstein N. (2003) 'Time to Work: A Comparative Analysis of Preferences for Working Hours', *Work and Occupations* 30(3): 302–326.

Vandenberghe V. (2017) 'The Productivity Challenge. What can be Expected from Better-Quality Labour and Capital Inputs', *Applied Economics* 49(40): 4013–4025.

Vandenberghe V., Rigo M. and Waltenberg F. (2013) 'Ageing and Employability. Evidence from Belgian Firm-Level Data', *Journal of Productivity Analysis* 40(1): 111–136.