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▶ **To cite this version:**

Pierre Cahuc, Francis Kramarz, Sandra Nevoux. When Short-Time Work Works. 2018. hal-03393127

HAL Id: hal-03393127

https://hal-sciencespo.archives-ouvertes.fr/hal-03393127

Preprint submitted on 21 Oct 2021

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SciencesPo
DEPARTMENT OF ECONOMICS

Discussion Paper

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SCIENCES PO ECONOMICS DISCUSSION PAPER

No. 2018-03

When Short-Time Work Works

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July 2018

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Abstract

Short-time work programs were revived by the Great Recession. To understand their operating mechanisms, we first provide a model showing that short-time work may save jobs in firms hit by strong negative revenue shocks, but not in less severely-hit firms, where hours worked are reduced, without saving jobs. The cost of saving jobs is low because short-time work targets those at risk of being destroyed. Using extremely detailed data on the administration of the program covering the universe of French establishments, we devise a causal identification strategy based on the geography of the program that demonstrates that short-time work saved jobs in firms faced with large drops in their revenues during the Great Recession, in particular when highly levered, but only in these firms. The measured cost per saved job is shown to be very low relative to that of other employment policies.

Keywords: short-time work, unemployment, employment.
JEL codes: E24, J22, J65.

1 Introduction[1]

Also called short-time compensation, short-time work is a public program intended to preserve jobs at firms or establishments experiencing temporarily-low revenues, by providing wage support to the employees the firm wishes to keep with reduced work hours. The 2008-2009 Great Recession gave OECD countries the opportunity to expand on such short-time work programs: whereas the OECD average take-up rate was less than 0.2% in the fourth quarter of 2007, just before the Recession, it increased six-fold, to 1.3 %, in the fourth quarter of 2009. The United-States followed this pattern, with the number of participants in short-time work jumping from 48,924 in 2007 to 288,618 in 2009.[2] Promotion of short-time work by U.S. States was further boosted by the Job Creation Act of 2012, resulting in 22 States receiving Federal subsidies for this policy in 2016.[3] However, despite short-time work increasing in popularity, even in recent academic work,[4] very little is known about its *causal impact* on employment.

Our paper contributes to fill this gap by taking advantage of the massive expansion of the French short-time work program during the Great Recession. From the end of 2008, the Ministry of Labor not only expanded the policy's budget, but also wrote circulars and directives, in order to promote the use of short-time work as rapidly as possible. As a result, the share of employees on short-time work increased from 0.3%, in 2007 just before the Great Recession, to 4% in 2009, the year of program expansion (Figure 1). Subsidies per non-worked hour and subsidies per employee were respectively multiplied by 1.4 and by 2.5 between these two dates (Figure 2). The cost of the policy trebled, multiplied by a factor of 20. By precisely analyzing the program, both in its principles and in its practical implementation, we show to what extent, and explain why, *short-time work works*, both from a theoretical and an empirical perspective. We *first* develop a directed search and matching model with multi-worker firms, which shows when and why short-time work saves jobs; then, we develop an empirical strategy that takes full advantage of the details and mechanics of the program administration, as well

[1]We thank Katharine Abraham, Joseph Altonji, Geoffrey Barrows, Russell Cooper, Denis Fougère, Andrea Garnero, Alexander Hijzen, Pedro Portugal, Rune Vejlin and André Zylberberg for helpful comments. We also thanks participants in seminars at Aarhus University, Bank of Italy, Banque de France, CREST, Ecole Polytechnique, IZA, OECD, University of Louvain la Neuve.

[2]Hijzen and Venn (2011), Hizjen and Martin (2013).

[3]Department of Labor (2016)

[4]See Baller et al. (2016), Cooper et al. (2017), Giroud and Mueller (2017), Houseman et al. (2017), Niedermayer and Tilly (2017) and the literature surveyed below.

as the remarkable data sources this administration generates to identify the *causal effect* of the program. It turns out that estimation results fully match theoretical predictions.

On the theoretical side, we demonstrate how short-time work saves jobs when firms face a sharp drop in their revenues. We also show that firms facing a limited decrease in revenues are likely to use short-time work to reduce hours for jobs at no risk of being destroyed. In fact, short-time work is shown to be particularly helpful for credit-constrained firms which use the program to partly finance the jobs they need to hoard during a very negative shock.[5] Despite the potential windfall effects just mentioned for mildly-hit or credit-unconstrained firms, the cost per saved job is shown to be small compared with other employment policies. In contrast to wage subsidies paid independently of hours worked, short-time work gives firms the right incentives to use subsidies for jobs at risk of being destroyed rather than other jobs, insofar as they pay a fraction of the remuneration of non-worked hours. To put it differently, because firms will select those jobs at risk of being destroyed for inclusion within short-time work programs, low-productivity jobs that may need financial support to survive during recessions are targeted much more precisely than what most other policies such as wage subsidies can do. Hence, short-time work can help in sustaining employment in recessions at a small cost. Our model shows that short-time work may indeed raise the total number of hours worked for the firms using short-time work when hit by *large* negative productivity shocks.

On the empirical side, we use administrative data providing remarkably detailed information about short-time work use, employment, and financial characteristics for all French establishments at annual frequency over the period 2007-2011. To deal with the selection of firms into short-time work, we document the role of the local administration in charge of managing the policy at the local (*département*) level. The local administration duties comprise informing firms about the policy, the management of applications, and the payment of short-time work subsidies to firms. Their autonomy in management creates strong behavioral heterogeneity, in particular in their response time to applications, across the 95 *départements* of mainland France before the Great Recession. This administrative response time is shown to play a key role in the implementation of short-time work. We also document how the policy diffuses from one firm to another at the *local* level. Geographical proximity of short-time work users before the recession is shown to favor the use of short-time work in 2009, controlling for the response

[5] See Caggese et al. (2018) and Giroud and Mueller (2017) for their very interesting discussion of the impact of financial constraints on labor hoarding.

time of the administration. In particular, short-time work use diffuses in 2009 from those multi-establishment firms which used short-time work in 2008 because they were located in a *département* with a short response time. Hence, firm-to-firm diffusion, even though unknown in its exact details, appears to have a key role. This diffusion may stem from firm-to-firm information transmission.[6] It may also arise from a *"not going alone"* effect, which reduces the negative signal (for potential financial difficulties) associated with using short-time work *vis à vis* the firm's employees, the firm's trading partners, or the firm's creditors. Because a) the response time of the *département before* 2009 has an impact on short-time work use in 2009 of single-establishment and multi-establishment firms and b) short-time work use diffuses from multi-establishment firms to the other firms, we construct the following instruments for the use of short-time work *in 2009* – for firms which did *not* use short-time work in the two years preceding 2009 – a) the 2008 response time to short-time work applications in the firm's *département* and b) by the (physical) distance of the firm to the closest *multi-establishment* firm which used short-time work *in 2008*. Hence, we claim that the results that are summarized now are *causal*.

First and foremost, short-time work has a clear positive impact on employment and survival of firms facing the largest potential drop in their revenue, in particular when these firms are highly levered. By contrast, short-time work has no effect on employment and survival of the other firms. As a result, about half of the short-time work users in 2009 benefit from windfall effects since they received short-time work subsidies for jobs at no risk of being destroyed. Nevertheless, short-time work saved jobs overall and also limited the drop in the total number of hours worked. For every worker on short-time work, 0.2 jobs are saved and the total volume of hours increases by 10% of her usual number of hours worked. Fully in line with our model's predictions, despite the windfall effects mentioned above, the cost per saved job (i.e. the total amount of subsidy needed to save a job) by short-time work in 2009 is estimated to be equal to 7% of the average labor cost, hence very low when compared with other such employment policies. Because the government saves about 25% of the average labor cost when a low-wage individual moves from non-employment to employment,[7] short-time work caused a reduction of

[6] Houseman et al. (2017) find that lack of awareness of short-time work option is a major barrier to short-time work take-up in the U.S. See Nevoux et al. (2017) for an analysis of the firm-to-firm diffusion of short-time work in France.

[7] See Cahuc *et al.* (2018) who show that this figure is relevant for France in 2009, i.e. the time period under study.

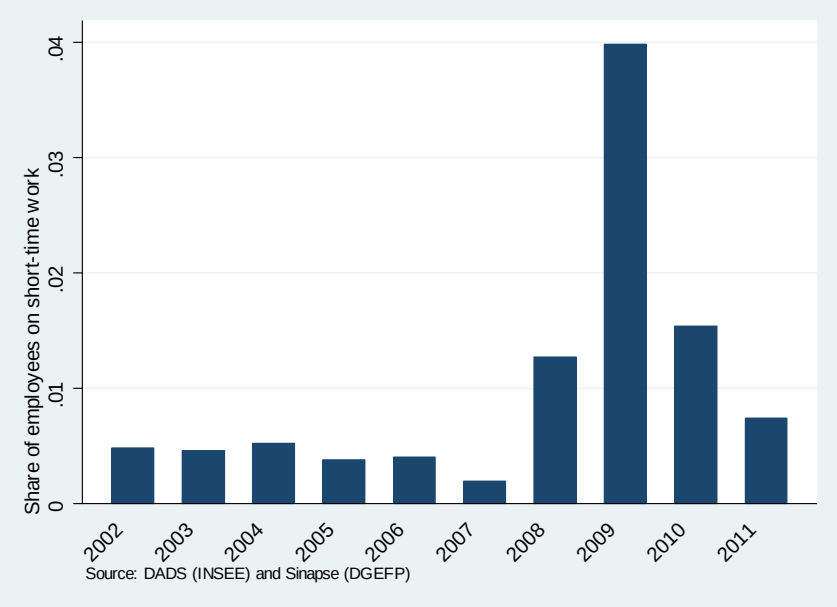

Figure 1: Proportion of short-time work employees
Sources: *DADS* (*INSEE*) and *Sinapse* (*DGEFP*). **Scope:** ◇ Mainland France excluding Corsica. ◇ Market sectors excluding agriculture. ◇ Establishments using short-time work for economic reasons.

public expenditures in 2009. Moreover, we do not find that short-time work mainly saved jobs in structurally weak firms unable to recover after the recession. On the contrary, short-time work allowed highly levered firms, likely to face credit constraints in times of collapsing financial markets, to engage in labor hoarding and recover rapidly in the aftermath of the Recession. This suggests that short-time work, when limited in scope and duration, is effective at saving jobs during deep recessions.

Relation with previous literature: On the *theoretical* side, Burdett and Wright (1989) and Van Audenrode (1994) have shown short-time work to be favorable to employment at the cost of distorting downwards the number of hours worked per employee, to improve welfare by mitigating those distortions caused by public unemployment insurance (Braun and Bruegemann, 2017), and to be welfare-improving when firms do not fully insure employees against income shocks (Niedermayer and Tilly, 2017). Cooper et al. (2017) analyze short-time work in a random search and matching model with multi-worker firms. They show that short-time work deteriorates the allocative efficiency of the labor market, resulting in significant output losses because of a reduction in the vacancy filling rate. By introducing within-firms jobs heterogene-

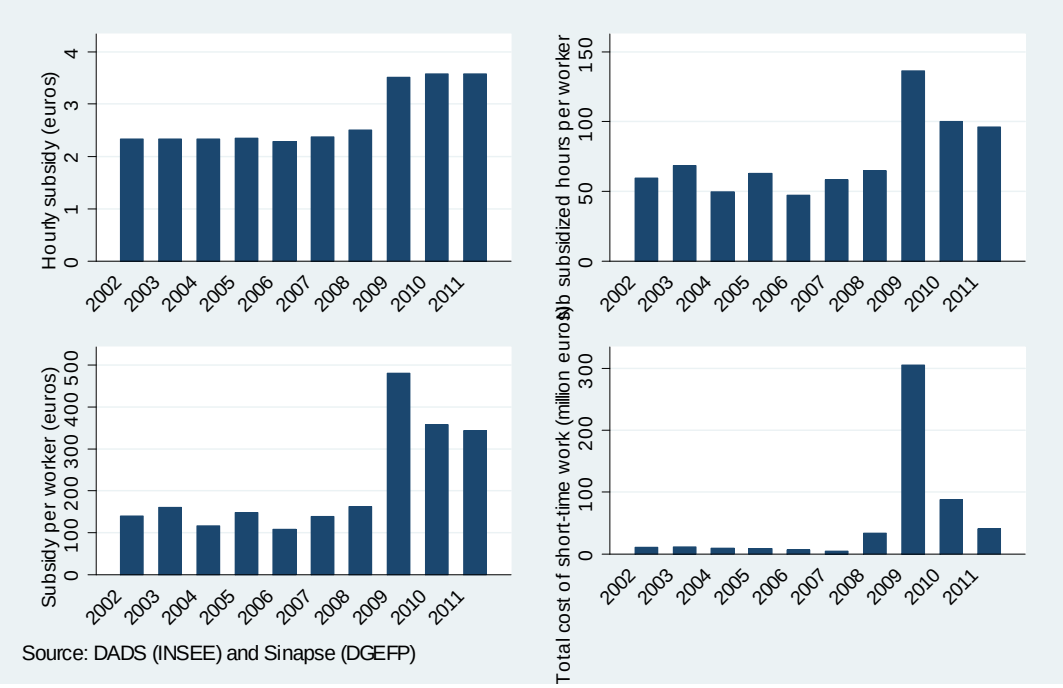

Figure 2: Hourly short-time work subsidy (top left), individual number of short-time work hours (top right), individual short-time work subsidy (bottom left) and total short-time work subsidy (bottom right)

Sources: *DADS* (*INSEE*) and *Sinapse* (*DGEFP*).

Scope: ◇ Mainland France excluding Corsica. ◇ Market sectors excluding agriculture. ◇ Establishments using short-time work for economic reasons.

ity and capital market imperfections, features absent from Cooper et al. but central to our analysis, our directed search and matching model (also with multi-worker firms) brings two contributions. First, short-time work sustains employment at low cost when compared with either wage or hiring subsidies because short-time work more effectively targets jobs at risk of being destroyed. Second, short time work can prevent inefficient job destructions (within those credit-constrained firms faced with large drops in revenue).

On the *empirical* side, macroeconomic evaluations, using cross-country data,[8] or cross-state data in the U.S.[9] have generally identified a positive impact on employment. Their conclusions are mostly drawn from a small number of observations, limiting their identification ability. Microeconomic evaluations are scarce and mostly use firm-level sources in Germany or in France. In Germany, all analyses rely on the IAB Establishment Panel, an annual survey with approximately 16,000 firms, representing 1% of all firms and 7% of all employees, interrogated in 2003, 2006 and 2009. Resulting estimates depend heavily on the method used to correct for selection into short-time work, with no obvious lesson.[10] The main reason for the lack of consensus on the impact of short-time work in Germany seems to be the inadequacy of data to deal with the selection-into-the-program problem. This literature analyzes the impact of short-time work on employment by running regressions where employment growth is explained by short-time work use and by a set of control variables including the revenue growth of the firm. But it has long been acknowledged that the correlation between employment and revenue is very weak overall and heterogeneous across firms. To avoid bias induced by selection of firms with specific adjustment of employment into short-time work, this literature uses, in line with Boeri and Bruecker (2011), the prior experience of firms with the program when trying to instrument short-time work. As stressed by Bellmann et al. (2015), this is questionable since empirical evidence shows that firms which use short-time work tend to adjust employment *more strongly* when output falls than firms which do not use short-time work. This behavior of short-time work users may result from technical constraints: firms have more incentives to use short-time work if their production process implies that it is more costly to store production

[8] Boeri and Bruecker (2011), Brey and Hertweck (2016), Cahuc and Carcillo (2011), Hijzen and Martin (2013), Hijzen and Venn (2011), Van Audenrode (1994).

[9] Abraham and Houseman (1994).

[10] Balleer *et al.* (2016), Boeri and Bruecker (2011), Niedermayer and Tilly (2017) find positive effects of short-time work on employment. Bellmann and Gerner (2011), Bellmann *et al.* (2015), Kruppe and Scholz (2014) find no effects of short-time work on employment.

or to find productive activities for incumbent employees when demand drops. Hence, it is not surprising to see no positive effects of short-time work on employment if the selection of firms into the program is not properly accounted for. Instrumenting program use with prior experience does not fully solve this selection issue and is likely to lead to underestimating the potential positive impact of short-time work on employment. Indeed, most contributions using this instrument find no positive effect on employment. In France, Calavrezo *et al.* (2010) face a similar difficulty. The data are more extensive, since they use administrative data covering the universe of French establishments over the period 2000-2005. Selection into short-time work is modelled using propensity score matching. Their results tend to show that establishments authorized to use short-time work are more likely to go bankrupt. The richness of our data allows us to overcome the main difficulties encountered by these studies by relying on the *départemental* heterogeneity in the 2008 response time to short-time work applications and on the firm-to-firm diffusion of the program to identify the *causal and heterogeneous* effects of short-time work. The beneficial effects are shown to be particularly strong for firms facing deteriorated profitability and finances which have been able to engage in labor hoarding and recover rapidly in the aftermath of the Recession thanks to short-time work.[11] This finding must be set in relation to the recent evidence contained in Giroud and Mueller (2017) who suggest that financial constraints impaired firms' ability to engage in labor hoarding during the same Great Recession in the U.S.

The next Section presents the short-time work policy. Then, principles of the model are given in Section 3 (proofs are relegated to a Model Appendix). The data sources are detailed in Section 4. The identification strategy is explained in Section 5 and the estimation results are presented in Section 6. Lessons are drawn in Section 7, our conclusion.

2 The Policy

The regulations of short-time work have changed multiple times since the inception of the policy, in 1951. In the following, we present the rules prevailing in 2009.

All private establishments located in France and all their employees are eligible for short-time work. There are six potential valid motives when asking for short-time work: (i) economic situation; (ii) modernization, restructuring and transformation; (iii) problems in the provision of

[11] See Biddle (2014) for a discussion of the efficiency of labor hoarding.

raw materials; (iv) accident; (v) exceptionally adverse weather conditions; (vi) other exceptional circumstances. Our paper will restrict the focus to the first such motive.

When applying for short-time work, an establishment must specify the extent of its application; i.e. either a part or the totality of the establishment; either a reduction or a temporary suspension of activity. Then, short-time work applies to hours unworked below the weekly legal duration (35 hours, or below the weekly collectively-agreed or contractual duration when it is below 35 hours). The yearly number of subsidized hours per employee and per year cannot exceed 800 (1,000 hours in the industries most severely hit by the great recession; in particular the textile and automobile industries). For any employee, periods of short-time work cannot exceed 6 consecutive months (and 6 weeks in the case of total suspension of activity). Otherwise, she becomes unemployed, even though her contract still holds.

Under short-time work, each hour worked is paid using the employee's previous gross hourly wage as a reference. The short-time work benefit amounts to 60% of this reference, with a lower limit of 6.84€, corresponding to 78% of the minimum wage. The monthly sum of the wage and of the benefit cannot be inferior to the monthly minimum wage and cannot exceed the reference wage. The benefits are paid the same way as wages are paid in France, i.e. on a monthly basis by the establishment. The establishment is then reimbursed by the State. It receives a subsidy of 3.84€ per hour and per employee in establishments within firms with 250 employees or less, and of 3.33€ per hour and per employee for establishments within firms with 251 employees or more.

To be allowed to benefit from short-time work, the establishment initiates a procedure which includes three steps: application, examination, and consumption. First, the establishment and its works council discuss the possibility of using short-time work and at the end of this consultation, the works council issues a written recommendation. The establishment fills out the short-time work application form (including the establishment identification number, industry, type, contact details, number of employees) as well as the short-time work demand (area, reason, period, number of covered employees, number of hours and corresponding level of subsidies). Then, the establishment sends the form with the recommendation together with a document proving its economic difficulties to the Local (*département* level) Agency in charge of Labor Relations (*DIRECCTE*), who are the public authorities in charge of managing short-time work in the *département*.

Second, the local public authority examines the short-time work application, most particularly its validity. The *DIRECCTE* may ask the labor inspection authority to examine the exact situation of this establishment. Then, it decides whether to reject or grant the application (in which case it specifies the authorization period, the number of covered employees, number of hours, and the corresponding level of subsidies) and informs the establishment of its decision.

Third, when the application is granted, the establishment may use short-time work within the limits set by the local authority. In case it is used, the establishment sends the local authority a reimbursement form (including the number of employees and hours that effectively used short-time work during the month, and the corresponding level of short-time work subsidies). Once received, the local authority checks the validity of the request and pays the establishment the corresponding sum.

As stressed above, the large expansion in short-time work at the start of the great recession, displayed in Figure 1, resulted from a deliberate effort of public decision-makers who enacted laws, expanded the budget, and released circulars and directives to boost short-time work usage. In December 2008, the maximal number of short-time work hours per employee per year increased from 600 to 800; the maximal short-time work duration in case of total suspension of activity was expanded from 4 to 6 weeks. In January 2009, the per-hour employee benefit increased from 50 to 60% of the previous gross hourly wage. Simultaneously, the subsidy received by the establishment was expanded.[12] In May 2009, *long-term short-time work* was created. An establishment was allowed to use long-term short-time work for support with minimum length of 3 months up to a maximum of 12 months. Under long-term short-time work, the per-hour employee benefit was set to 75% of the previous gross hourly wage. The establishment received an additional subsidy, jointly financed by the State and the unemployment insurance system.[13]

Furthermore, several ministerial circulars and directives were sent to local authorities, calling for an easier access to the policy. In particular, local authorities were asked to interpret the eligibility conditions in a flexible way, resulting in an increased acceptance of applications. Indeed, during the great recession, the fraction of applications rejected by the *DIRECCTE* declined by a factor of 2, as shown by Figure 3.

[12] The subsidy received by the establishment increased from 2.44 to 3.84€ for those belonging to firms with 250 employees or less, and from 2.13 to 3.33€ for those belonging to firms with 251 employees or more.

[13] On top of the "standard" subsidy, the state pays 1.90€ per hour up to the 50th long-term short-time work hour of a given employee and the unemployment insurance system pays 3.90€ beyond the 50th hour.

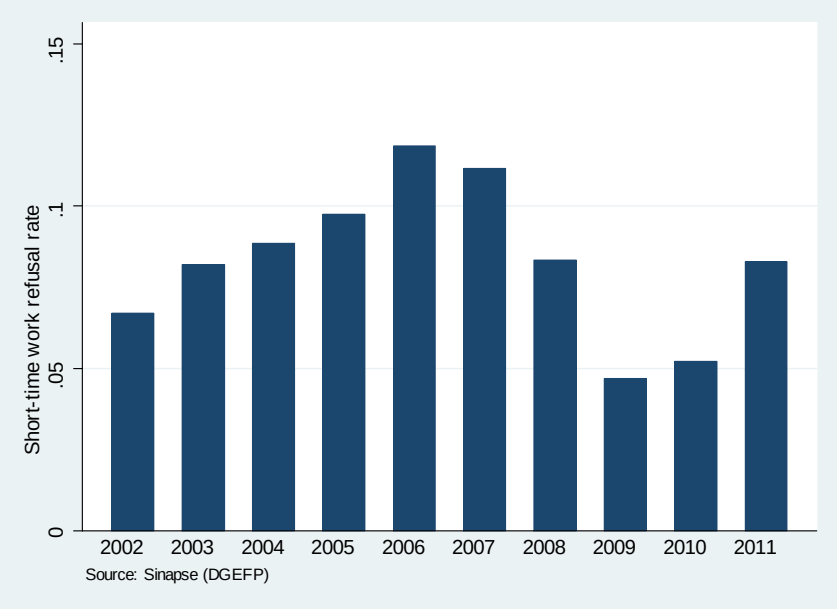

Figure 3: Short-time work refusal rate.
Sources: *DADS* (*INSEE*) and *Sinapse* (*DGEFP*).
Scope: ◇ Mainland France excluding Corsica. ◇ Market sectors excluding agriculture. ◇ Establishments using short-time work for economic reasons.
Definition: Short-time work refusal rate is defined as the number of short-time work applications that are refused divided by the total number of short-time work applications.

After 2009, the policy experienced no major change until 2012.[14] However, in response to a second economic slowdown and to the associated requests formulated by businesses' and workers' unions, reforms were implemented in March 2012, again expanding access to short-time work.

3 Model

This section presents a model allowing us to understand why short-time work works and, more to the point, why it has a precisely targeted impact on hours worked and employment in times of recession.

3.1 Framework

The framework is a one-period static directed search and matching model with multi-worker firms and endogenous job destruction.[15] There are two goods: labor and a final output produced with labor only. There is a large number of firms and a large number of workers. All workers are unemployed and all firms have zero employees at the start of the period. The preferences of workers are represented by the utility function $c - \phi(h)$, where c stands for the consumption of the final output and h for the number of hours worked. ϕ is an increasing, convex and twice continuously derivable function. Each firm can create v job vacancies at an increasing and convex cost $C(v)$. These job vacancies and unemployed workers are matched together according to a constant returns to scale matching function, $M(u, v)$, strictly increasing with respect to the u unemployed workers and the v vacant jobs within the firm's labor pool. In consequence, the probability to fill a vacancy and to find a job is respectively equal to $m(\theta) = M(1/\theta, 1)$ and $\theta m(\theta)$, where $\theta = v/u$ is the labor market tightness of the labor pool of the firm. Workers' mobility between labor pools is perfect. Job seekers are assumed to have perfect information on each labor pool and their search activity to be directed towards their preferred one.

The output per filled job is equal to the product of two independent random variables, z and ε. z is firm-specific and ε is job-specific. Their realization is discovered by firms and workers once the jobs have been filled. The distribution of ε is identical in all firms. The

[14] The only change over this period was the increase in the maximal number of short-time work hours per employee per year from 800 to 1,000 hours, in 2010.

[15] See Moene (1997) for the seminal directed search model and Kaas and Kircher (2015) for a directed search model with multi-worker firms.

cumulative distribution function of output per worker, $y = z\varepsilon$, denoted by $G(y) = \Pr[z\varepsilon < y]$, is continuously differentiable on its support $[y_{\min}, \infty)$. In this framework, firms are ex-ante identical, but ex-post heterogeneous.

Each vacancy is linked to a non-renegotiable contract posted by the firm, which stipulates the wage $w(y)$, the hours worked $h(y)$ contingent on the realization of productivity y, and Ω is the set of productivity draws for which the job is not destroyed. When a match between a job seeker and a vacancy occurs, the contract is signed. Then, the realizations of z and ε are observed and the contract is implemented.

In this set-up, short-time work allows firms and employees to receive subsidies to compensate for the hours not worked when hours worked are below a threshold $\bar{h}$. The short-time work subsidy depends on hours worked rather than productivity y which cannot be observed by public authorities. Subsidies per employee are equal to $\sigma \max(\bar{h} - h, 0)$. Short-time work subsidies are financed by a lump sum tax paid by firms.[16]

3.2 Labor Market Equilibrium

The hypothesis of directed search by workers and perfect mobility between pools implies that the expected utility of a job seeker, W_u, is equal across labor pools. Hence, the expected utility W_u of a person in search of work, the expected utility of an employee in any labor pool, denoted by W, and the associated labor market tightness θ satisfy the no-arbitrage condition:[17]

$$W_u = \theta m(\theta) W + [1 - \theta m(\theta)] [b - \phi(0)], \forall(\theta, W), \tag{1}$$

where b denotes the gains of an unemployed person and where

$$W = \int_{y \in \Omega} \left[w(y) + \sigma \max\left[\bar{h} - h(y), 0\right] - \phi(h(y)) \right] \mathrm{d}G(y) + \int_{y \notin \Omega} [b - \phi(0)] \, \mathrm{d}G(y). \tag{2}$$

The no-arbitrage condition (1) defines a relation between the expected utility W linked to the contract posted by each firm and the labor market tightness in its labor pool. In this equation, W_u, the expected utility of unemployed workers, is considered as given by each firm.

[16] Since the values of z and ε are discovered once the jobs have been created, the expected lump sum tax is identical for each firm, implying that the amount of subsidies has no impact on job creation when it is financed with the lump sum tax. This assumption, made for the sake of simplicity, allows us to isolate the impact of short-time work on job destruction.

[17] The labor market tightness θ and the expected utility W are labor pool specific. Indexes for labor pools are not used to save on notation.

Differentiation of the no-arbitrage condition shows that the relation between the expected utility linked to the contract offered by the firm and the labor market tightness in its labor pool is negative:

$$\frac{\mathrm{d}\theta}{\mathrm{d}W} = -\frac{\theta}{(1-\eta)\left[W - b + \phi(0)\right]} < 0, \tag{3}$$

where $\eta = -\theta m'(\theta)/m(\theta) \in (0,1)$ is the elasticity of the matching function with respect to unemployment. Equation (3) means that labor pools that offer better labor contracts also have lower labor market tightness, and more job seekers. Equation (3) also shows that tightness reacts more to changes in the contract's expected utility when the elasticity η of the matching function w.r.t. unemployment is larger.

Each firm solves the maximization program:

$$\max_{v,w(y),\Omega,h(y)\geq 0} vm(\theta)\Pi - C(v), \tag{4}$$

where θ satisfies equation (1), and where

$$\Pi = \int_{y\in\Omega} \left[yh(y) - w(y) + \sigma \max\left[\bar{h} - h(y), 0\right]\right] \mathrm{d}G(y), \tag{5}$$

is the expected value of a filled job.

In this framework (see Appendix A.1 for the solution), the number of vacant jobs is determined by equalizing their marginal costs to their marginal returns:

$$C'(v) = m(\theta)\Pi, \tag{6}$$

and the optimal labor contracts have the following properties. First, the expected utility of employees increases with the expected profit generated by filled jobs:

$$W - [b - \phi(0)] = \frac{\eta}{1-\eta}\Pi. \tag{7}$$

Second, each employee is laid off if the productivity falls below a threshold denoted by $\tilde{y}$, and, finally, the number of hours of work, $h(y)$, increases with productivity y.

3.3 The Effect of Short-Time Work on Hours Worked and Employment

The effect of short-time work on hours worked can be analyzed from the relation $h(y)$ between hours worked and productivity, as stipulated in the equilibrium labor contract. Figure 4 displays

the relation between the number of hours worked and productivity with short-time work ($\sigma > 0$) and without short-time work ($\sigma = 0$).

In the presence of short-time work, the number of hours worked drops below the threshold level of hours $\bar{h}$ under which hours not worked can be subsidized. Short-time work reduces the number of hours worked over the interval $[\tilde{y}, \bar{y})$, where $\tilde{y}$ denotes the threshold value of productivity below which jobs are destroyed absent short-time work. The drop in hours worked increases with the subsidy σ. However, short-time work also diminishes the number of layoffs, since the threshold value of productivity below which jobs are destroyed is lowered by short-time work. Figure 4 displays a situation in which there are layoffs since the threshold level of productivity below which jobs are destroyed, denoted $\tilde{y}_1$ when the firm uses short-time work, is strictly positive. Nevertheless, it is possible to have situations without layoff, if the amount of short-time work subsidy at zero hours worked, equal to $\sigma\bar{h}$, is bigger than the unemployment benefit b. Hence, it can be optimal to keep jobs with zero hours worked if the short-time work subsidy σ is large enough.[18]

All in all, short-time work can significantly reduce job destruction in firms facing bad realizations of their firm-specific productivity shock z, i.e. when many jobs are at risk of being destroyed (i.e. $y = z \times \varepsilon < \tilde{y}$). This result is illustrated on the bottom part of Figure 5 which displays the situation of a *low-productivity firm*, for which the probability that the productivity lies below the reservation value $\tilde{y}$ below which jobs are destroyed in the absence of short-time work is high. Absent short-time work, this firm destroys all jobs with productivity below $\tilde{y}$. Short-time work saves all jobs of specific productivity $y \in [\tilde{y}_1, \tilde{y})$; all surviving jobs of productivity $y < \bar{y}$ use short-time work. Short-time work has a clear and significant impact on employment in a low-productivity firm. For the worse realizations of the firm-specific productivity shock z, some firms may have no profitable job absent short-time work, meaning that short-time compensation may help them survive. However, the situation is very different in a *medium-productivity firm*, displayed in the middle graph of Figure 5, where a large share of jobs use short-work but where short-time work saves very few jobs. The main impact of short-time work is to reduce the number of hours worked with very little effect on employment. As for a *high-productivity firm*, case displayed in the upper graph of Figure 5, the probability of using short-time work is very small because the probability that y finds itself below $\bar{y}$ is very small.[19]

[18] see Appendix A.1.

[19] It can be easily checked that a random search model with bargaining on wages and hours worked or a model

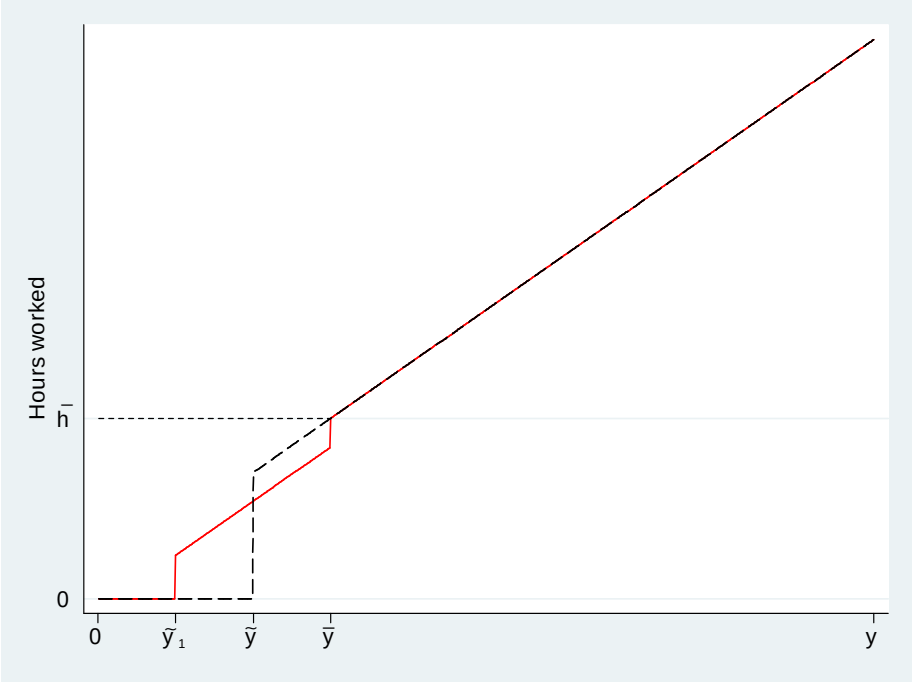

Figure 4: The relation between productivity y and hours worked with short-time work (continuous red line) and without short-time work (dashed black line).

Notes: $\diamond$ $\bar{h}$ stands for the threshold number of hours worked below which short-time work applies. $\diamond$ $\tilde{y}$ stands for the threshold value of productivity below which jobs are destroyed absent short-time work. $\diamond$ $\tilde{y}_1$ stands for the value of this threshold when there is short-time work.

The mechanisms allowing short-time work to be more effective during recessions, apart from more frequent drops in productivity in such times, become transparent once the following (two) points are made.

First, financial constraints are typically more severe during recessions. Financial constraints increase the costs of funding capital and labor services. To see their impact simply, let us assume that each job has a continuation value, at the end of the period, normalized to zero when there is no financial constraint – the situation under scrutiny until now – and negative when there are financial constraints. In this framework, the expected profit Π of each job is reduced by the amount $c \geq 0$, which stands for the costs induced by financial constraints. It is easy to check, from equation (6), that these costs reduce job creation. They also increase job destruction because they decrease the option value of jobs.[20] This result is consistent with the empirical findings of Giroud and Mueller (2017) who show that financial constraints impaired firms' ability to engage in labor hoarding during the Great Recession in the United-States. In this context it is clear, from Figure 6, that financial constraints, which shift $\tilde{y}$ to the right, imply that short-time work saves more jobs in firms that face more stringent financial constraints, for given level of productivity. Financial constraints can also affect productivity negatively, through their negative impact on investment.[21] In this case, financial constraints shift the productivity distributions to the left (without moving the threshold $\tilde{y}$) on Figure 6, which entails higher short-time work take-up and more jobs saved by short-time work.

Second, an important disadvantage of short-time work is its negative impact on hours worked. However, short-time work can increase the total number of hours worked through its positive effect on employment. This situation arises if the reservation productivity, $\tilde{y}$, lies in a region where the slope of the density of the distribution of productivity y is negative.[22] For standard distributions, with a single mode, this means that the reservation productivity

of collective bargaining where utilitarian trade-unions bargain wages and hours worked at the firm level would yield the same qualitative results.

[20] Notice that c raises the reservation productivity $\tilde{y}$ without changing the shape of the relation between productivity and hours worked $h(y)$. More precisely, the job surplus $s(y)$ defined equation (A3) in Appendix A.1 is reduced by c which implies that $h(y)$, defined by equation (A4), does not depend on c. The reservation productivity $\tilde{y} = \{y | s(y) = 0\}$ increases with c.

[21] According to empirical studies, exogenous credit ratings downwards which reduce access to credit have negative impact on investment, especially for firms that have large financial needs to fund their investment, Almeida et al. (2017), Derien et al. (2016). Giroud and Mueller (2017) also find that more levered firms raise less debt and cut back more on investment during the Great Recession in the United States.

[22] See Appendix A.3.

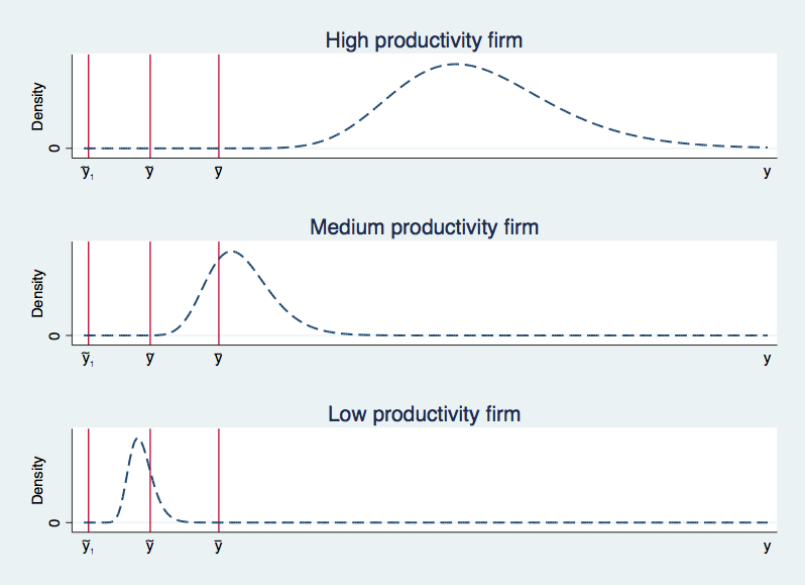

Figure 5: The effects of short-time work according to the productivity of firms

Notes: $\diamond$ $\bar{y}$ stands for the threshold value of productivity $y = \varepsilon \times z$ below which short-time work is used $\diamond$ $\tilde{y}$ stands for the threshold value of productivity below which jobs are destroyed in the absence of short-time work. $\diamond$ $\tilde{y}_1$ stands for the threshold value of productivity below which jobs are destroyed when there is short-time work. $\diamond$ ε has a log-normal distribution with parameters $(4, 0.2)$. $\diamond$ $z = 1, 0.4, 0.15$ for high, medium, low productivity firm respectively.

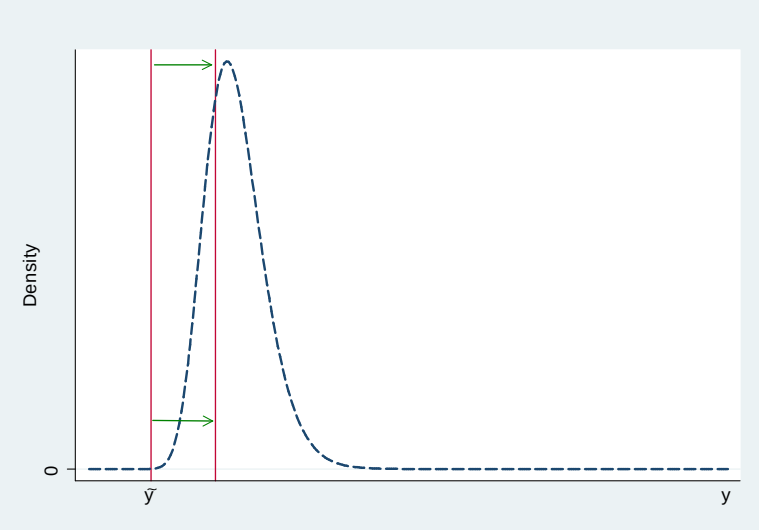

Figure 6: The effects of financial constraints on the reservation productivity $\tilde{y}$.

Note: This figure displays the impact of more stringent financial constraints, which move the reservation productivity $\tilde{y}$ to the right, as shown by the green arrows.

is above the mode (but possibly lower than the median and the mean if the distribution is log-normal, for instance), as displayed in the bottom graph of Figure 5, which represents the low-productivity firms case. Such situations are again more likely to arise during recessions when negative aggregate shocks hit firms and when financial constraints are more stringent. Hence, short-time work is more likely to raise the total number of hours worked during recessions than in normal times.

3.4 The Cost per Job Saved

Short-time work generates windfall gains for both workers and firms insofar as short-time work is used by workers whose job would not have been destroyed in the absence of this policy. However these windfall gains are smaller than for usual job subsidies policies which do not allow the government to target effectively low-productivity jobs, because short-time work provides subsidies to jobs with productivity below $\bar{y}$ whereas wage subsidies or hiring subsidies provide support to jobs *independently* of their productivity. Such subsidies are often conditional on the type of worker, for instance when they target unskilled workers, low-wage workers, or the long-term unemployed, or when they target specific firms, such as small firms; but subsidies do not depend on the realization of a productivity shock, an outcome rarely verifiable by the government. By contrast, short-time work allows the government to target low-productivity jobs because firms and workers choose to allocate fewer hours to these jobs and only these jobs. Seen from this perspective, short-time work is a more effective tool than job subsidies when the aim is to sustain employment in recessions.

We show in Appendix A.2 that the ratio between the number of jobs saved by short-time work and by job subsidies, respectively, for an identical cost per employee (or equivalently an identical expenditure) is given by equation

$$\frac{\text{Number of jobs saved by short-time work}}{\text{Number of jobs saved by job subsidies}} = \frac{Nm(\theta)v\left[1-G(\tilde{y})\right]}{Nm(\theta)v\int_{\tilde{y}}^{\bar{y}}\frac{\bar{h}-h(y)}{\bar{h}-h(\tilde{y})}\mathrm{d}G(y)} \tag{8}$$

where N denotes the number of firms in the economy. The numerator of the right hand side term is the number of employees and the denominator is the weighted sum of employees using short-time work, each of these employees being weighted by his number of short-time work hours relative to the maximum number of short-time work hours per employee in the economy. The ratio between the number of jobs saved by short-time work and the number of jobs saved

by job subsidies is clearly larger than one, for two reasons. First, short-time work is used by a fraction of employees, those who face large drops in productivity. Hence, job subsidies are paid for all $Nm(\theta)v\left[1-G(\tilde{y})\right]$ employees whereas short-time compensation is provided for a subset $Nm(\theta)v\left[G(\bar{y})-G(\tilde{y})\right]$, where $\bar{y}$ – the threshold value of productivity below which short-time work is used – is generally smaller than the highest productivity level. Second, short-time work subsidizes non-worked hours only. Non-worked hours increase when productivity drops because the number of hours worked increases with productivity. As a consequence, the sum of weights $\left[\bar{h}-h(y)\right]/\left[\bar{h}-h(\tilde{y})\right]$ in the integral of equation (8) is smaller than one, implying that the denominator is smaller than $Nm(\theta)v\left[G(\bar{y})-G(\tilde{y})\right]$.

Taken together, these two mechanisms imply that the cost per job saved by short-time work is potentially much lower than the cost per job saved by job subsidies. In 2009, short-time work was used by about 4% of employees (see Figure 1). Thus, according to equation (8), the cost per job saved by short-time work should be about 25 times lower than the cost per job saved by job subsidies (provided to all jobs). Obviously, job subsidies are also targeted either to specific categories of workers (the low-skilled, say) or to specific categories of firms (often small firms). But targeting subsidies on broad categories is not effective at *targeting jobs at risk of being destroyed*. From this perspective, our model stresses that the cost per job saved/created by short-time work is potentially much smaller than the cost per job saved/created using job subsidies.

4 Data

In order to assess the effect of short-time work on survival, employment, and hours worked in French establishments, we merge several data sources.

4.1 Data Sources

4.1.1 Sinapse-Chômage Partiel

To measure short-time work in all its components, *administrative and economic*, we use *Sinapse-Chômage Partiel*, a source produced by the Statistical Department of the French Labor Ministry (*DARES*) in collaboration with the Employment and Vocational Training Agency (*DGEFP*). Data were collected for the years 2007 to 2014 by the *DIRECCTE*. To do so, a software called

Aglae-Chômage Partiel creates a record for each short-time work application received from an establishment located in the *département*. The record allows information to be acquired at each step of the short-time work application process. Then, two data sets are made out of these applications. In one, all variables generated by the application process are included: application identification number of the establishment,[23] information on the applying establishment (identification number, name, city, labor pool, *département*, *région*, industry, weekly legal and collective work duration, number of employees); the nature of the reduction in hours (identification number, reason, area, repeated use, hourly short-time work subsidy, maximum number of short-time work hours per employee and per year, works council recommendation, labor inspection recommendation, application date); authorized short-time work (decision status, decision date, authorization period, number of authorized short-time work employees in total and by occupation and work duration, number of authorized short-time work hours and the associated amount of subsidies). In the second data set, variables on monthly consumption are included: identification number, short-time work consumption month and its sequential number relative to the first month of the authorization period, number of monthly employees effectively under short-time work, number of short-time work consumed hours and the associated amount of subsidies.

4.1.2 DADS-Établissements

The *Déclaration Annuelle de Données Sociales* (*DADS*) is produced by the French National Institute for Statistical and Economic Studies (*INSEE*). Each establishment reports the gross wage, inclusive of employer and employee-paid payroll taxes, and net wage for each of its employee, to the tax authority. *INSEE* then processes these variables to yield various aggregates, at the individual, establishment, and firm levels. In what follows we use the establishment version which allows us to measure the industry, the city, employment, hours, and the wage bill for each establishment in our matched sample.

The *DADS* provides quite reliable information on employment and labor contract types. However, information on hours worked is less precise inasmuch as about 20% of employees are paid on a daily basis. Moreover, when the *DADS* information is not transmitted in the relevant format through the automated Unified Social Data Reporting (*DADS-U*) system, information

[23] Insofar as information is available at the establishment level, but not at the individual level, it is not possible to idenfify the workers on short-time work.

about the number of hours is absent, and the number of hours worked is imputed. Therefore, the quality of information on hours is not sufficient to directly evaluate the impact of short-time work on the hours worked.

4.1.3 FICUS and FARE

The *INSEE*-Section "Production of Annual Firms' Statistics" (*ESANE*) produces the so-called *FICUS* (until 2007) and *FARE* (since 2008) data sets using the financial and fiscal accounts sent by all French firms to the fiscal authority. The variables are constructed using the annual tax returns and other administrative sources based on these accounts. The above data sets contain, among other things, the firm identification number and precise information about the balance sheet.

4.1.4 Geo-coded Data

In order to precisely locate all French establishments, we use the *Système d'Identification des Entreprises et des Établissements* (*SIENE*), the *Système Informatique pour le Répertoire des Entreprises et des Établissements* (*SIRENE*) and the *Système d'Identification au Répertoire des Unités Statistiques* (*SIRUS*). The *SIENE*, the *SIRENE* and the *SIRUS* are three administrative datasets produced by the *INSEE* which provide information about the geographic location of all French establishments. Thanks to these four data sources, we create a unified dataset containing the address, the zipcode and the city of all establishments that we geocode using the software *ArcGIS* and matching with the *BD ADRESSE* (a dataset produced by the French National Institute for Information about Geography and Forest (*IGN*) and containing all geocoded French addresses). This process generates the geographic coordinates of all establishments in the format *Lambert 93* which enables us to compute the Euclidean distance between establishments.

4.2 Descriptive Statistics

Using the firm (*SIREN*) and the establishment identification number (*SIRET*), we merge the above data sources. Table 1 displays the characteristics of firms using short-time work for economic reasons in 2009 and those of firms which do not use short-time work in the same year. We restrict our attention to single-establishment firms essentially because accounts are

only available at the firm level whereas the rest of our sources are establishment-level when our theory needs a measure of the shock that hits the entity. We also concentrate on the establishments using short-time work for the first time in 2009, i.e. which did not use short-time work in 2007 or 2008, to avoid establishments using short-time work repeatedly in order to cope with the seasonal fluctuations they face. As shown by Table 1, firms using short-time work are older, have more employees, pay higher wages, have a lower share of temporary jobs and a lower worker turnover; their employment growth rate and their revenue growth rate are also lower. Leverage is slightly lower in firms using short-time work. However, the propensity to use short-time work increases with leverage conditional on the sector and the age of the firm. Conditional on these two variables, leverage is 4.3 percentage points higher (with standard error equal to 0.002) in firms using short-time work. Table 2 shows that the short-time work take-up varies widely across sectors. It is higher in manufacturing industries (6.4%) and to a less extent in construction (1.1%) than in other sectors.

5 Empirical Strategy and Identification

Our model shows that the effect of short-time work on employment depends on the shocks affecting the revenue of the firm: short-time work "*really saves*" jobs for those firms faced with a large drop in revenue. Hence, we evaluate the impact of short-time work in 2009 in firm i by estimating the following regression:

$$L_i = \alpha_0 + STW_i\alpha_1 + Y_i\alpha_2 + X_i\alpha_3 + \varepsilon_i \tag{9}$$

where the dependent variable, L_i, denotes the employment growth rate (employment corresponds to the number of employees on the 31st of December). We also explore the effects of short-time work on the survival rate of firms (a firm survives in year t if and only if it has a positive number of employees on the 31st of December of year t), on the share of permanent jobs, on the growth rate of permanent jobs and on the growth rate of temporary jobs. STW_i is an indicator variable equal to one if the firm uses short-time work for economic reasons and to zero otherwise. Y_i denotes the revenue growth rate of firm i. X_i is a vector of control variables,[24] and ε_i is an error term.

[24]The control variables include past mean hourly wage, the past number of hours worked per employee, the past job turnover, the past share of temporary jobs, the age of the firm, the leverage of the firm and (728)

To estimate consistently equation (9), several identification issues must be resolved. First, because short-time work also has an impact on the revenue growth rate Y_i, we must deal with a simultaneity problem. To do so, we predict the revenue growth rate of firm i by the leave-one-out mean growth rate of revenues in the industry and commuting zone ("Zone d'Emploi"), denoted by $\bar{Y}_i$,[25] as well as by its short-time work use:

$$Y_i = b_0 + STW_i b_1 + \bar{Y}_i b_2 + X_i b_3 + \varepsilon_{1i} \tag{10}$$

Second, and even more important, short-time work use is also likely to be correlated with the error term ε_i of equation (9) because unobserved confounding variables can influence employment growth, revenue growth, and short-time work take-up. In particular, firms have more incentives to use short-time work if it is more costly to store production or to find productive replacement activities for incumbent workers when the demand drops. This problem is potentially magnified by the small and heterogeneous correlation between the firm's revenue growth rate and its employment growth rate. To understand why this is likely to induce biases when estimating (9) by OLS, let us first note that the (Pearson) correlation coefficient between the two variables is very small, equal to 0.07 in 2008. Furthermore, this coefficient is also heterogeneous across industries. To show this, consider Figure 7 that reports the take-up rate of short-time work in 2009 (y-axis) and the correlation of the revenue growth rate with the employment growth rate of the firm in 2008 (x-axis) *by industry*. This Figure demonstrates the extreme heterogeneity across industries of the adjustment of employment to fluctuations in revenue. Industries where the correlation is large in 2008 tend to also have a larger short-time work take-up in 2009. This result confirms that of Bellmann et al. (2015, p 196), who find that firms which use short-time work tend to adjust employment more strongly when output falls than firms which do not use short-time work. Indeed, if firms using short-time work more intensively are also those more likely to adjust employment downwards when their revenue drops, the OLS estimates for short-time work in equation (9) are biased downwards.

In the following paragraphs, we present our instrumental variable strategy to deal with the above problems.

industry fixed effects to control for potential sector-specific trends. We also include indicator variables to account for regulations which may differently influence the adjustment of employment depending on the size of the firm in the previous year (10, 50, 250, and 1,000 employees).

[25] Namely, we compute for each sector $\times$ commuting zone cell the revenue growth rate as $\sum_{j \neq i}(Y_{j,2009} - Y_{j,2008})/Y_{j,2008}$ where $Y_{j,t}$ denotes revenue of firm j in year t belonging to the same sector and commuting zone as firm i.

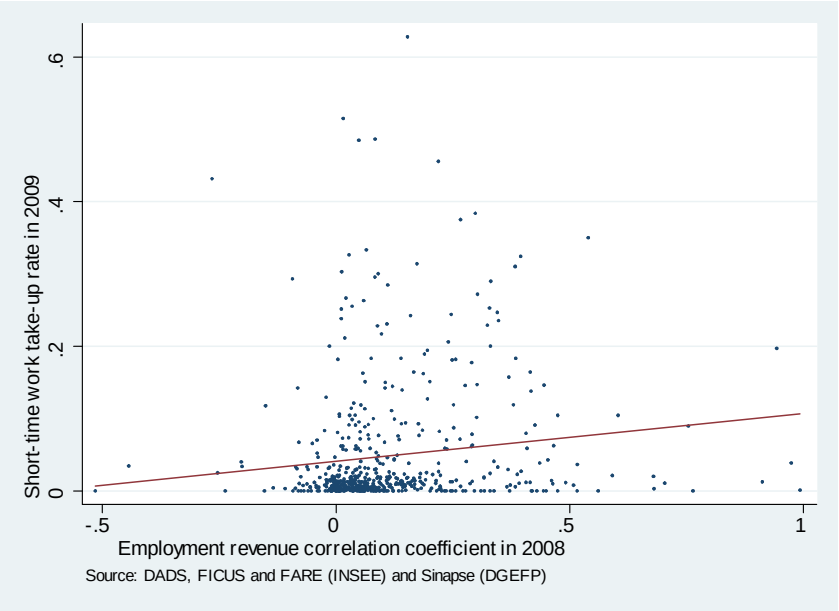

Figure 7: Proportion of short-time work establishments in 2009 (vertical axis) and employment revenue correlation coefficient in 2008 (horizontal axis)

Sources: *DADS*, *FICUS* and *FARE* (*INSEE*) and *Sinapse* (*DGEFP*).

Scope: ◇ Mainland France excluding Corsica. ◇ Market sectors excluding agriculture.

Definition: The employment revenue correlation coefficient is defined as the correlation between the revenue growth rate and the employment growth rate.

Notes: ◇ The proportion of short-time work establishments and the employment revenue correlation coefficient are computed at the sector level. ◇ The equation corresponding to the linear regression is: $STW_i = \underset{(.004)}{.040} + \underset{(.021)}{.066}\rho_i$, $R^2 = .015$ and $N = 552$ where i denotes the sector, STW_i denotes the proportion of short-time work establishments and ρ_i denotes the employment revenue correlation coefficient.

To construct our instruments, we rely on a detailed analysis of the administrative environment leading to the granting of short-time work subsidies. More precisely, we identify two main channels explaining the short-time work take-up in 2009.

First, *we analyze the role played by the response time of the local administration to firms' applications.* The DIRECCTEs – the *départemental* agencies in charge of labor relations – play a key role in administering the implementation of short-time work regulations. They are in charge of processing the applications and the payment of short-time work subsidies. As will be shown, this creates heterogeneity in the response time to short-time work applications across *départements*. A long response time can be a signal of bad management. It may also reflect stringent adherence to requirements in granting short-time work subsidies, meaning that the local administration takes a long time to examine the applications, to ask for complementary documents proving the economic difficulties of the establishment, and to ask the labor inspection authority to assess the exact situation of the establishment. Whatever its origin, good or bad management, a long response time will negatively affect short-time work use in bad times when establishments need to react promptly to a sharp drop in their revenue. Figure 8 shows the large amount of cross-sectional (across *départements*) variation in the 2008 response time to short-time work applications, even though short-time work was barely in use then. The fraction of response times above 14 workdays – which corresponds to the median response time in 2008 – goes from 0% (in 10 *départements*) to 90% (in one *département*) when the same fraction in the average *département* is equal to 38%. Although several ministerial circulars and directives were sent to local authorities, calling for easier access to the policy in 2009, Figure 9 shows that the *départements* where the response time was longer in 2008 are also those that still had a longer response time in 2009. Therefore, firms could anticipate that, even during the Great Recession, accessing short-time work in some specific and known *départements* would be difficult.

Figure 10 indeed clearly shows that there is a negative correlation between the response time of the *départemental* administration and the short-time work take-up before the Recession, in 2008. This relation holds even controlling for a large set of potential confounding factors, including (728) sector fixed-effects and the average *départemental* employment growth to ensure that this relation is not driven by congestion effects induced by differences in *départemental* employment growth. Figure 10 displays a strong negative relation between the short-time work take-up rate *in 2009* and the response time of the *départemental* administration *in 2008*. The

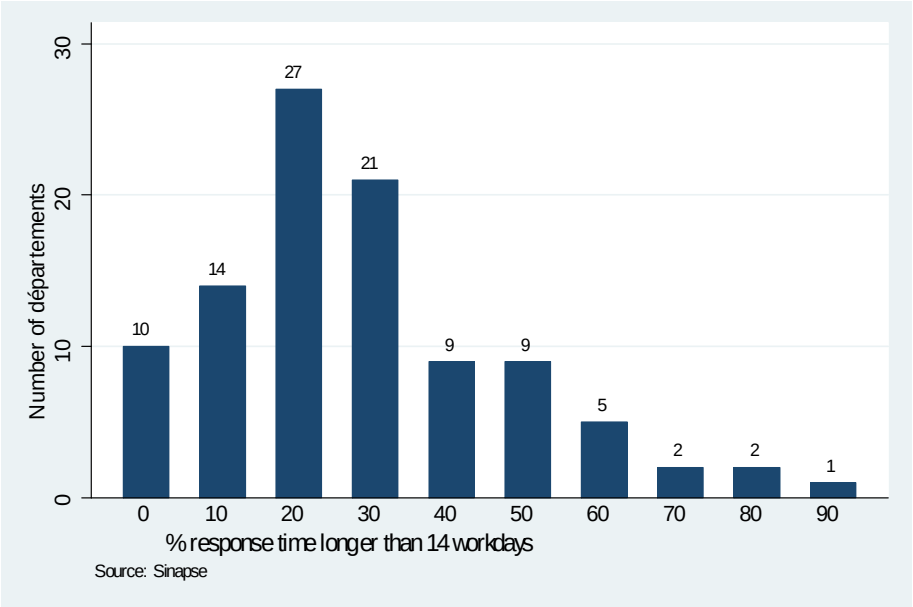

Figure 8: Number of *départements* (vertical axis) and proportion of short-time work applications whose response time is longer than 14 days (horizontal axis) in 2008

Source: *Sinapse* (*DGEFP*).

Scope: ◇ Mainland France excluding Corsica. ◇ Market sectors excluding agriculture. ◇ Establishments using short-time work.

Definition: Response time is defined as the number of workdays elapsed between the receipt date and the decision date regarding the short-time work application.

Reading: 27 *départements* had 20% of short-time work applications whose response time is longer than 14 days in 2008.

short-time work take-up rates in 2009 are twice as high as in the *départements* belonging to the lowest ventile (bottom five centiles) of our measure of response time in 2008 as in those belonging to the highest ventile (top five centiles).

Second, *we analyze the diffusion mechanism across establishments of short-time work applications.* It emerges that applications to the policy made by multi-establishment firm are related to, potentially even caused by, the response time of the *départemental* administration just studied. Table 3 shows that multi-establishment firms used short-time work more frequently in 2008, before the Recession, in their establishments located in the *départements* where the response time was shorter in the same year. This result holds conditional on a large set of establishment characteristics including the average hourly wage, the share of temporary jobs, the average number of annual hours worked per worker, the revenue growth in the commuting zone,

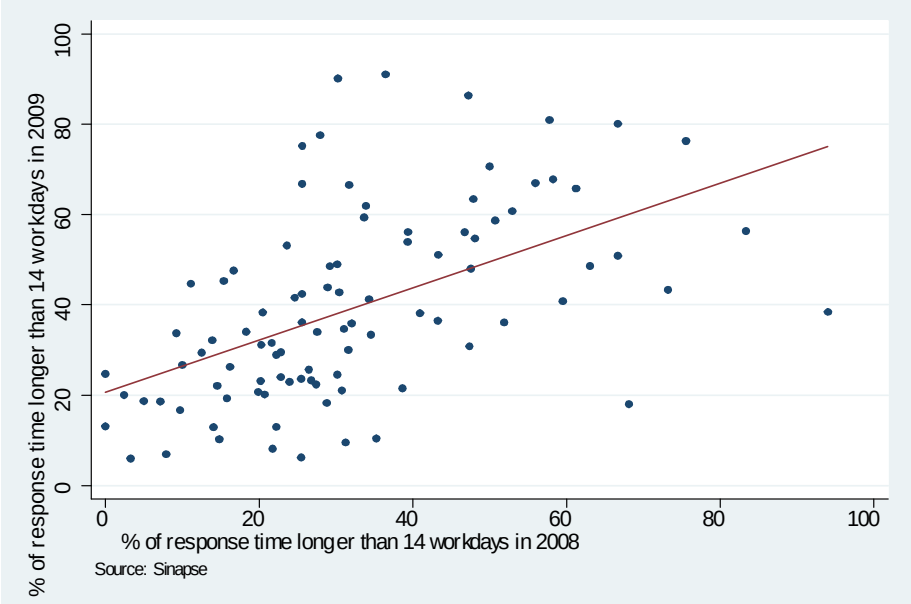

Figure 9: Proportion of short-time work applications whose response time is longer than 14 days in 2009 (vertical axis) and in 2008 (horizontal axis)

Source: *Sinapse* (*DGEFP*).

Scope: ◇ Mainland France excluding Corsica. ◇ Market sectors excluding agriculture. ◇ Establishments using short-time work.

Definition: Response time is defined as the number of workdays elapsed between the receipt date and the decision date regarding the short-time work application.

Notes: ◇ The proportion of short-time work applications whose response time is longer than 14 days is computed at the *département* level. ◇ The equation corresponding to the linear regression is: $y_i = \underset{(3.7)}{20} + \underset{(.09)}{.058} x_i$, $AdjR^2 = .27$ and $N = 94$ where i denotes the *département*, y_i denotes the proportion of short-time work applications whose response time is longer than 14 days in 2009 and x_i denotes the proportion of short-time work applications whose response time is longer than 14 days in 2008.

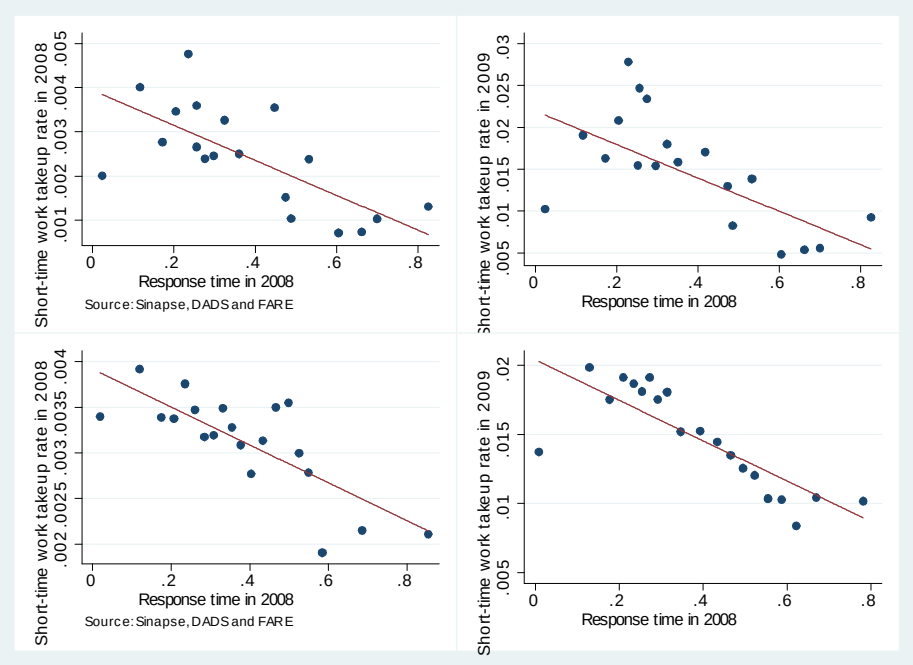

Figure 10: Proportion of short-time work establishments in 2008 (left) and in 2009 (right) (vertical axis) and proportion of short-time work applications whose response time is longer than 14 days in 2008 (horizontal axis)

Sources: *DADS*, *FICUS* and *FARE* (*INSEE*) and *Sinapse* (*DGEFP*).

Scope: ◇ Mainland France excluding Corsica. ◇ Market sectors excluding agriculture.

Notes: ◇ Each graph represents a binscatter which groups the variable on the horizontal axis into equal-sized bins, computes the mean of the variables on the horizontal and vertical axes within each bin, and creates a scatterplot of these data points. ◇ Top graphs report the mean of the short-time work take-up rates whereas the bottom graphs report the mean conditional on the revenue growth rate, the leverage rate, the hourly gross wage, the number of hours worked per worker, the turnover rate, the share of temporary jobs, the number of employees, the age of the firm and (728) sector-specific fixed effects, départemental employment growth.

Definitions: ◇ Response time is defined as the number of days elapsed between the receipt date and the decision date regarding the short-time work application. ◇ The revenue growth rate is defined as the difference in the revenue between 2009 (respectively 2008) and 2008 (respectively 2007), divided by the absolute value of the revenue in 2008 (respectively 2007). ◇ The leverage rate is defined as the level of debt divided by the level of assets, in the previous year. ◇ The hourly gross wage is defined as the total labor cost divided by the total number of hours worked, in the previous year. ◇ The number of hours worked per worker is defined as the total number of hours worked divided by the average number of employees, in the previous year. ◇ The turnover rate is defined as the total number of employees divided by the average number of employees, in the previous year. ◇ The share of temporary jobs is defined as the number of employees under non-permanent contracts divided by the total number of employees, in the previous year. ◇ The number of employees is defined as an indicator variable of the number of employees on the 31st of December of the previous year (10, 50, 250, and 1,000 employees). ◇ The age is defined as the difference between 2009 (respectively 2008) and the year of creation of the firm.

and industry fixed effects. Indeed, the information transmission mechanism across establishments is likely to be very different for single and multi-establishment firms: multi-establishment firms may be presumed to rely pretty heavily on within-firm between-establishments information from their own (firm-level) human resources departments as well as direct flows between establishments. As for single-establishment firms, the analysis follows.

Let us see how the behavior of single-establishment firms in 2009 is influenced by the past response time of the local administration and by the 2008 choices of geographically neighboring establishments belonging to a multi-establishment firm. To do this, we study the following equation which models the decision of a firm i – which did not use short-time work in 2007 or in 2008 – to use short-time work in 2009:[26]

$$STW_i = a_0 + RP_i a_1 + DM_i a_2 + \bar{Y}_i a_3 + X_i a_4 + \eta_i \tag{11}$$

where RP_i denotes the share of response time to short-time work applications longer than 14 workdays of the *départemental* administration of firm i in 2008; DM_i stands for the distance to the closest establishment, belonging to a multi-establishment firm, which used short-time work in 2008. Equation (11) states that the short-time work take-up of firm i depends on these two variables, on the leave-one-out revenue mean growth rate of the industry $\times$ commuting zone cell of firm i, and on the other variables X_i likely to influence employment growth in equation (9). Table 5 shows that the short-time work use of single-establishment firms in 2009 is negatively correlated with the response time of the *départemental* administration in 2008 *and* with the distance to the closest establishment, belonging to a multi-establishment firm, which used short time work in 2008.

Hence, the impact of the response time of the *départemental* administration on the short-time work use of single-establishment firms is amplified by multi-establishment firms, whose choice of using short-time work more intensively in *départements* with shorter response times diffuses to single-establishment firms. This phenomenon is illustrated on Figure 11 which displays the diffusion of short-time work in two *départements*, Savoie and Rhône, from December 2008 to December 2009, among firms belonging to the industrial mechanics industry. The red squares of the first map represent the establishments belonging to multi-establishment firms applying for short-time work in December 2008. The green diamonds of the second map add

[26] Henceforth, firms which used short-time work in 2007 or 2008 are excluded from the sample to avoid repeat users who have previously benefited from the treatment.

the single-establishment firms operating in 2008. The blue triangles of the third map add the single-establishment firms applying for the first time for short-time work for economic reasons between the 1st and the 15th of January 2009, and so on. As time goes by, some green diamonds located close to the red squares progressively turn into blue triangles, highlighting the spatial diffusion of short-time work use from multi-establishment firms to single-establishment ones. Hence, short-time work clearly spreads to single-establishment firms located close to establishments belonging to multi-establishment firms which applied for short-time work in 2008. The diffusion is more intense in Rhône in which the response time of the administration is shorter (15% of response times are longer than 14 workdays, versus 24% in Savoie). Although not displayed here, this result is not specific to the sector of industrial mechanics nor to these *départements* but holds for all manufacturing firms. Obviously, this Figure is only illustrative insofar as the geographical spread of short-time work may be influenced by confounding variables. To shed more light on the diffusion process, we analyze the relation between the date of short-time work take-up of single establishment firms in 2009 and their distance to establishments belonging to multi-establishment firms which used short-time work in 2008. We group the single establishment firms by quartiles of distance to establishments belonging to multi-establishment firms which used short-time work in 2008. Since the short-time work take-up is concentrated at the beginning of 2009,[27] we look at whether single establishment firms located closer to establishments belonging to multi-establishment firms which used short-time work in 2008 use short-time work more frequently in the first quarter of 2009 than later in the same year. Table 4 shows that the probability that single establishment firms which belong to the first quartile[28] use short-time work in the first quarter of 2009 is 5 percentage points higher relative to single establishment firms which belong to the other quartiles. This relation is robust to the inclusion of many potential confounding variables including the revenue growth rate of the firm in 2009, the quarterly employment growth rate of its sector (accounting for 728 sectors) and the *départemental* response time.

These results confirm that short-time work take-up diffuses from firm-to-firm, even though the details are unknown. The diffusion may arise from the transmission of information. It may

[27] The share of single establishment firms using short-time work in the first, second, third and fourth quarter of 2009 is 0.45, 0.27, 0.13 and 0.15 respectively.

[28] The average distance in the first quartile is equal to 1.1 kilometers and the maximum distance in this quartile is 2.2 kilometers.

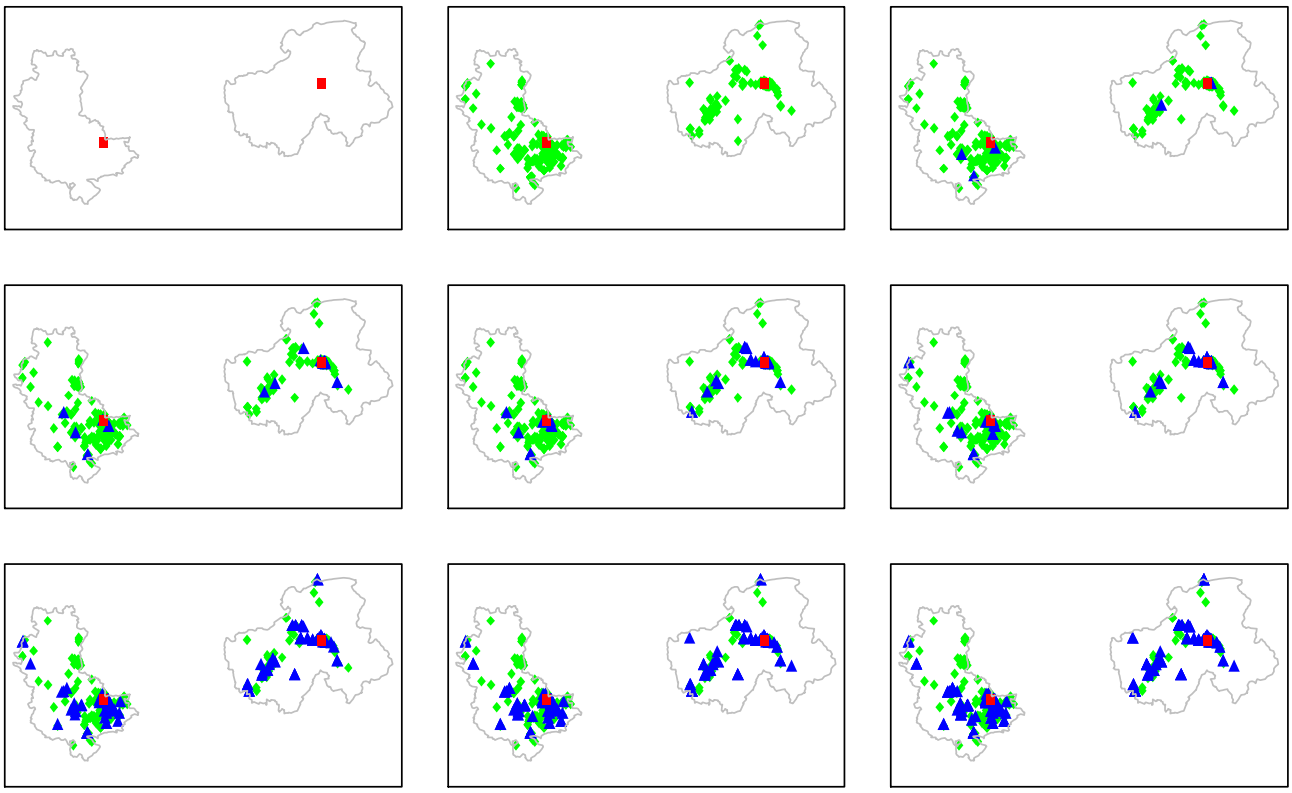

Figure 11: The diffusion of short-time work in Rhône (left-hand side *département* on each map) and Savoie (right-hand side *département* on each map) from December 2008 to December 2009

Sources: *DADS* (*INSEE*) and *Sinapse* (*DGEFP*).

Scope: ◇ *Départements* of Rhône and Savoie (belonging to the same *région* Rhône-Alpes and separated by the *département* of Isère). ◇ Sector of industrial mechanics.

Notes: ◇ The red squares stand for the establishments, belonging to a multi-establishment firm, which applied for short-time work in December 2008. ◇ The blue triangles stand for the establishments, belonging to a single-establishment firm, which applied for the first time for short-time work for economic reasons between the 1st of January 2009 and the 15th of January 2009 (map 3, i.e. first row, third column), between the 1st of January 2009 and the 31st of January 2009 (map 4, i.e. second row, first column), between the 1st of January 2009 and the 15th of February 2009 (map 5), between the 1st of January 2009 and the 28th of February 2009 (map 6), between January 2009 and May 2009 (map 7), between January 2009 and October 2009 (map 8), between January 2009 and December 2009 (map 9). ◇ The green diamonds stand for the establishments, belonging to a single-establishment firm and operating in 2009.

also arise from a reluctance to be the only establishment to apply, whereas some coordination may reduce the potential negative signal associated with a short-time work application for the firm's employees, its trading partners, and its creditors, as such an application makes known the financial difficulties a firm is facing.

Hence, the 2009 short-time work use is correlated with two variables that are very unlikely to have an impact on how the firm adjusts employment when its demand falls: the 2008 response time of the *départemental* administration to short-time work applications and the distance to the closest establishment, belonging to a multi-establishment firm, which used short-time work in 2008. Therefore, these two variables are used as instruments for short-time work. Equations (10) and (11) imply that short-time work use and the revenue growth rate are explained by equations

$$STW_i = \beta_0 + RP_i\beta_1 + DM_i\beta_2 + \bar{Y}_i\beta_3 + X_i\beta_4 + \eta_i \quad (12)$$

$$Y_i = \gamma_0 + RP_i\gamma_1 + DM_i\gamma_2 + \bar{Y}_i\gamma_3 + X_i\gamma_4 + \xi_i \quad (13)$$

Assuming that the error term of equation (9) is correlated neither with the response time to short-time work applications of the *départemental* administration of firm i in 2008 nor with the distance to the closest establishment, belonging to a multi-establishment firm, which used short time work in 2008, nor with the revenue growth rate in the industry and commuting zone, as well as the other exogenous variables (i.e. $\mathbb{E}\left(\varepsilon_i|RP_i, DM_i, \overline{Y}_i, X_i\right) = 0$), equation (9) can be consistently estimated by two-stage least squares, using RP_i, DM_i and $\bar{Y}_i$ as instruments for the firm's decision to take up short-time work and for its revenue growth rate.

The estimates of the first-stage equations (12) and (13) presented in Table 5 show that short-time work used in 2009 is strongly correlated with the instruments. Besides these instruments, several features of the firms exert an influence on short-time work use. Firms with higher labor turnover and a higher share of temporary contracts in 2008 used short-time work less frequently in 2009. It is likely that these firms had less need to rely on short-time work when they were hit by negative shocks on their revenue because they could adjust labor rapidly and at a lower cost. Larger firms, firms with higher leverage, and firms in which the average number of annual hours of work was higher in 2008 used short-time work more frequently in 2009.

6 Effects of Short-Time Work

We start by analyzing the global firm-level impact of short-time work before looking at heterogeneous effects. This heterogeneity is measured by the magnitude of the fall in revenues during the Great Recession, as suggested by our model. Then, we use our results to compute the cost per job saved by the short-time work policy.

6.1 Global Effects

Table 6, rows 1 and 2, presents the impact of short-time work on employment growth and on the death of firms in 2009. Column (OLS) shows that the ordinary least squares estimate of short-time work from equation (9) is negative and strongly significant for employment growth. This result confirms our previous discussion: firms using short-time work have less opportunity to smooth the activities of their employees and to store production when their demand falls. As a result, those firms, also more likely to use this scheme, have a greater propensity to lay off their employees. Hence, the negative sign and the strong significance of the estimate suggest that the ordinary least squares estimates are strongly biased downwards.

The instrumental variables estimates of the impact of short-time work on employment, presented in Table 6, column (IV), are very different from those obtained by ordinary least squares. The IV estimate of the impact of short-time work on employment growth is positive and not significantly different from zero. However, short-time work has a positive impact on the share of permanent jobs, suggesting that short-time work makes it easier to keep employees with permanent contracts, as their labor services can be adjusted at the intensive margin. The above IV result that short-time work has no (causal) statistically significant effect on aggregate employment should not surprise us: our theoretical framework has clearly demonstrated that the effect of short-time work on employment is, by design, heterogeneous, with no effect for firms which faced a small drop in their revenue but a potentially large and positive effect for those firms that faced a large fall in revenues.

6.2 Heterogeneous Effects

To highlight our model's predictions – short-time work has heterogeneous effects across firms, depending on the magnitude of the shock that hits them, with jobs saved only in firms hit by

a very negative shock – we stratify the firms in quintiles according to their (predicted) revenue growth rate in 2009, as estimated using equation (13).[29]

Table 7 shows that short-time work is concentrated in the (first) quintile of firms with the lowest predicted revenue growth rate. There, the take-up is three times larger than in the second quintile and 6.5 times larger than in the fifth quintile. Nevertheless, 47% of those firms using short-time work do not belong to the first quintile. This first quintile mostly comprises larger and older firms (see Table 8).

6.2.1 Heterogeneous Effects in 2009

To assess how short-time work affects firms faced with different economic shocks, Tables 9 and 10 report both the first and the second stages of our instrumental variables estimation of equation (9), for *each quintile of the predicted revenue growth rate of firms*.

The estimates for the first stage reported in Table 9 show that the instruments are jointly significant at every quintile. In line with the model (see Figure 5), firms belonging to the bottom quintiles, for which the demand for short-time work is stronger, are more sensitive to the response time of the administration. Results in Table 10 show that the estimated second-stage coefficients are significantly different from zero for both the growth of employment and the growth of permanent jobs *only within the lowest quintile of predicted revenue growth*. In all other quintiles, estimated coefficients are never signicantly different from zero and their magnitude decreases with the predicted revenue growth. More precisely, short-time work raises employment growth by about 16 percentage points in the first quintile – with a 95% confidence interval equal to $[6\%, 26\%]$– , which corresponds to one half of the standard deviation of employment growth in that quintile. As firms belonging to this first quintile are much larger than other firms, short-time work saved about 11% of jobs of all firms which used short-time work – with a 95% confidence interval equal to $[4\%, 18\%]$.[30] This implies that every worker

[29] In this equation, the revenue growth rate of each firm is explained by the leave-one-out revenue growth rate of its industry × commuting zone cell, industry fixed-effects to control for potential industry-specific trends, and several firm-specific variables including the past share of temporary jobs, the past mean hourly wage, the past number of hours worked per employee, the past labor turnover, the past firm leverage, and the age of the firm.

[30] Let us denote by $\mathbb{E}(\Delta \ell_i)/\ell_i$ the expected employment growth rate in firm i, where ℓ_i denotes employment in firm i on 31 December 2008. According to equation (9), the impact of short-time work on the expected employment change in firm i is $\mathbb{E}(\Delta \ell_i) = \hat{\alpha}_1 \ell_i$. Therefore, total employment change in the first quintile is equal

on short-time induces 0.17 saved job on average[31] – with a 95% confidence interval equal to $[0.06, 0.29]$. This order of magnitude is in line with other evaluations.[32]

Results in Table 10 also show that short-time work saves permanent jobs but has no impact on temporary jobs. As a result, the share of permanent jobs increases in firms using short-time work, relative to other firms; this is in line with the empirical literature that uses cross-country data.[33]

As results in Table 10 (row 5) demonstrate, short-time work reduces the death probability for firms in the first quintile, and only those. The effect is economically significant: the death rate of firms benefiting from short-time work decreases by 9% points, one-third of the standard deviation of the death rate in the first quintile (mean equal to 6.4%). This positive effect, which also contributes to save jobs, disappears above this lowest quintile.

In order to assess how robust these (heterogeneous) effects are, Tables 11 to 14 report the results when the distribution of firms is stratified in terciles rather than in quintiles. Table 13 reports the first-stage results: the instruments are very significant at every tercile. A comparison of the IV estimates of the impact of short-time work on employment growth in Tables 14 and 10 indicates that the coefficient is significantly larger in the first quintile than in the first tercile. Accounting for the difference in the number of firms using short-time work in the first tercile and in the first quintile, these results point to a similar number of jobs created, with a point estimate equal to 10% of the total number of jobs in firms that used short-time work – with a 95% confidence interval equal to $[1\%, 19\%]$– versus 11% of jobs for all firms that used short-time work – with a 95% confidence interval equal to $[4\%, 18\%]$ – when firms are stratified in

to $\hat{\alpha}_1 \sum_{i \in Q_1} \ell_i$ where Q_1 denotes the set of firms using short-time work that belong to the first quintile of the predicted revenue growth rate. There are $185,676$ jobs in 2008 in the firms using short-time work that belong to the first quintile and $74,538$ in the short-time work users that belong to the other quintiles. This implies that short-time work increases employment in all firms that use short-time work by $\hat{\alpha}_1 \times 185,676/260,214 = 0.113$ taking $\hat{\alpha}_1 = 0.158$ from the first Column of Table 10.

[31] We divide the number of jobs created by short-time work in 2009 by the number of short-time work employees in 2009 to get this number. Note that this figure is consistent with the claim that short-time work saved about 11% of jobs of all firms which used short-time work because all employees are not necessarily on short-time work in firms using short-time work.

[32] This result can be compared to Boeri and Bruecker (2011) who find that a short-time work employee saved about 0.35 jobs during the Great Recession in Germany – with a 95% confidence interval equal to $[0.04, 0.70]$. The impact on employment is larger than in France, although less precisely estimated (the number of observations is smaller in Germany). The stronger impact on employment in Germany is likely due to the larger drop in hours worked of short-time work employees, which reached 40% on average, versus 7% in France. As a short-time work employee experiences a reduction in her hours worked by 40% and created 0.35 jobs in Germany, short-time work has had a very uncertain impact on the total number of hours in this country according to this evaluation.

[33] Cahuc and Carcillo (2011), Hijzen and Venn (2011).

quintiles instead of terciles. Again, the employment effects are concentrated onto permanent jobs. Assessing robustness with respect to firms' survival, Table 10 shows that short-time work significantly reduces the death rate of firms in the lowest quintile, whereas the estimate is negative but not significantly different from zero in the first tercile (p-value = .102 - see Table 14). These results confirm that short-time work improves the survival of firms hit by very strong negative shocks, and only those.

6.2.2 Heterogeneous Effects After 2009

At this stage, two stories about short-time work can be told. In the first, the policy helps firms with limited access to financial markets, hit by transitory negative shocks, to recover and grow in the following years. In the second, however, short-time work helps structurally weak firms, without recovery potential, to keep jobs that will soon be destroyed. In order to assess which story is most credible, we analyze the impact of the take-up of short-time work *in 2009* on firms' outcomes at the end of 2011. We estimate the same model as before, considering changes in dependent variables from 2008 to 2011 instead of 2008 to 2009. Since 38% of firms which used short-time work in 2009 used-short time work again in 2010 or 2011, we control for repeated use. We also control for the commuting zone $\times$ sector leave-one-out mean of the revenue growth rate from 2009 to 2010 and from 2010 to 2011.

Table 15 reports the results of the instrumental variable estimation of equation (9) in which the dependent variable is either the growth rate from December 2008 to December 2011 of the indicated variable or the death of the firm over the same period. Firms in the first quintile of the predicted revenue growth in 2009, for which short-time work had positive employment effects in 2009, also grow faster from 2008 to 2011, suggesting that short-time work helped them to recover faster, potentially because they retained their workforce despite the negative shock. There are no statistically significant positive effects for the firms which belong the other quintiles of predicted revenue growth in 2009. Table 16 shows the robustness of this result by reporting estimates for a stratification of firms into terciles. Again, firms faced with the largest drop in predicted revenue in 2009 have faster employment growth in the following years than firms belonging to the same tercile and which did not use short-time work.

Therefore, short-time work appears to be used by firms faced with a temporary negative shock rather than by structurally weak firms. Indeed, Figure 12, confirms this view. The

profitability and the financial situation of short-time work users was much more deteriorated, in 2009, than that of non users. But it improved more rapidly for the former than for the latter, coming back to its pre-2009 level as early as 2011, as shown in Table 17 (for firms belonging to the lowest quintile of the predicted revenue growth in 2009). These results are consistent with those of Giroud and Mueller (2017) and Caggese et al. (2018) who find that firms with weak balance-sheets or facing more stringent financial constraints cut more jobs in response to negative demand shocks, but are not less profitable in the long run. They are also consistent about the role that Giroud and Mueller (2017) mention played by short-time work, in helping labor hoarding for firms faced with strong (temporary) drops in revenues and stringent financial constraints.

6.3 Cost per Job Saved

In this Section, we provide an evaluation of the cost per job saved in 2009. On average, each employee on short-time work in 2009 reduced her working time by 123 hours and employers received 3.70 euros per subsidized non-worked hour, or 460 euros per employee on short-time work. This amount is small when compared to the average annual labor costs – 38,600 euros – in firms which used short-time work.

To compute the cost per job saved thanks to short-time work, we divide the total amount of subsidies received by all firms in 2009 by the number of jobs saved in 2009 in the first quintile of the distribution of predicted revenue growth, assuming that no job has been created in the other quintiles. This approach yields a conservative evaluation of the impact of short-time work on job creation consistent with the results displayed by Table 10.[34] The costs per job saved in 2009 amount to 2619 euros, which corresponds to 6.8% of the average annual labor costs in our set of firms – with a 95% confidence interval equal to $[4.2\%, 18.4\%]$. This sum is extremely small compared to the costs (per job created) of wage subsidies, usually estimated to lie between 100% and 200% of annual labor costs.[35] As shown by our theoretical model, the specific strength of short-time work is its targeting of employees at risk of losing their job in

[34] Using the stratification of firms by tercile instead yields similar results.

[35] The cost per job created of a permanent wage subsidy amounts to the labor cost divided by the absolute value of the elasticity of labor demand with respect to labor cost (Cahuc *et al.* (2018)). Assuming that this elasticity lies between -1 and -0.5 (Hamermesh (2014)), the cost per job created of a wage subsidy lies between 100% and 200% of the labor cost.

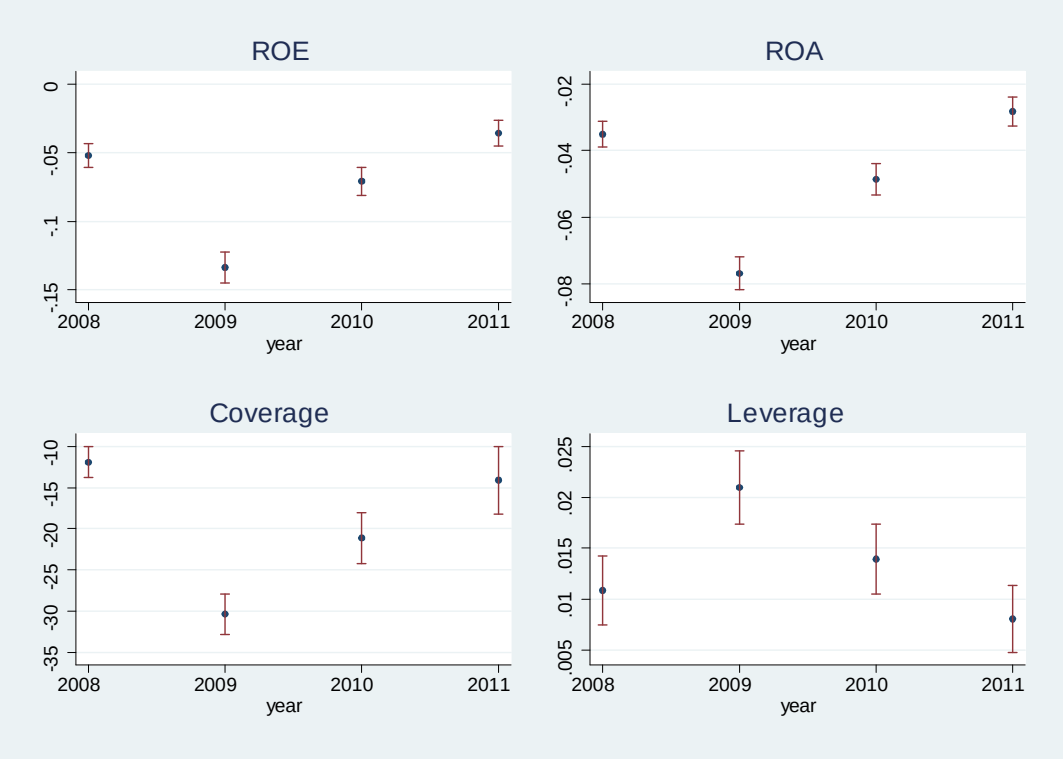

Figure 12: Profitability and financial situation over 2008-2011 of firms using short-time work in 2009.

Sources: *DADS, FARE* (*INSEE*) and *Sinapse* (*DGEFP*).

Notes: ◇ ROE: return on equity equal to EBITDA/Total Equity ◇ ROA: return on assets, equal to EBITDA/Total Assets ◇ Coverage: EBTIDA/Interest expense ◇ Leverage: Total debt / Total Assets; ◇ Each graph displays the difference in the value of the corresponding index between firms using short-time work in 2009 and other firms, conditional on sector and firm age. The I-bars report the 95 percent confidence interval. Standard errors are clustered at the sector × *département* level.

firms where these employees' marginal product falls below their marginal labor cost, whereas wage subsidies are usually given to all firms' employees (who belong to some targeted category based on age or past labor market experience, for instance) even if their marginal productivity is actually well above their marginal labor cost. Short-time work turns out to have been more effective at creating jobs than hiring subsidies during the Great Recession in France, even though hiring subsidies also targeted marginal jobs.[36] Since available evidence suggests that the government saves about 25% of the average labor cost when a low-wage individual goes from non-employment to employment,[37] we posit that short-time work allowed the government to reduce public expenditure.

Windfall effects associated with short-time work are much smaller than those induced by wage subsidies policies. To assess the size of these windfall effects, consider short-time work subsidies paid to firms outside the lowest quintile of the predicted revenue growth rate in 2009. These firms, representing about half of all firms with positive short-time work take-up in 2009, only used 25% of the total number of subsidized hours in 2009 and received 25% of the total amount of subsidies. Such numbers are consistent with our theoretical model since the drop in hours worked is smaller for jobs that would not have been destroyed absent short-time work than for jobs that would have been destroyed absent short-time work, as shown by Figure 4.

We also evaluate the impact of short-time work on the total amount of hours worked and compare it to our model's prediction. To do so, we assume that the average number of annual hours worked for jobs saved by short-time work is identical to the average number of annual hours worked in other jobs. Then, we compute the number of hours of work for the jobs saved by short-time work. Subtracting the number of hours consumed by short-time work employees from this number, we get the impact of short-time work on the total number of hours worked. Results show that for every employee on short-time work in 2009, the total volume of hours worked increased by 10% – with a 95% confidence interval equal to $[-1\%, 21\%]$ – of her usual annual number of hours. Hence, the direct reduction in the volume of hours worked due to short-time work is more than offset by the creation of jobs induced by short-time work. This means that short-time work not only saved jobs but also limited the drop in total hours.[38]

[36] Cahuc *et al.* (2018) assess the impact of hiring subsidies in France during the Great Recession and find that the cost per job created by a hiring credit in France in 2009 amounts to about 25% of the labor cost of a job.

[37] See Cahuc *et al.* (2018). This figure is also valid for France in 2009.

[38] As a short-time work employee experienced a reduction in her hours worked by 40% and created 0.35 jobs in Germany, short-time work has had a very uncertain impact on the total number of hours in this country

Although it might seem surprising that short-time work, a subsidy to a reduction in hours worked, raises the total number of hours worked for some, this result in again fully line with our model[39] when, in recessions, negative shocks hit a large fraction of firms.

7 Conclusion

Germany, from being the sick man of Europe in the start of the 2000s, became its Superstar in the 2010s (Dustmann et al., 2014). Hence, French politicians have repeatedly tried to copy certain German policies, without much success. Apprenticeship, seen as the way out of the France's high youth unemployment rate, has never taken off on the west side of the Rhine. Hartz-style reforms, seen as the way out of an inflexible labor market, have mostly generated mass protests and strikes. Short-time work, seen as the way to preserve employment in the face of negative economic shocks, is an exception. Used in France before the Great Recession, albeit much less than in Germany, it was successfully expanded when the Great Recession hit France. All regulations and institutions managing short-time work were already in place and allowed increased funding to be directed to firms that applied to the program. The structure and functioning of these institutions are central in our empirical strategy, allowing us to construct instrumental variables for the use of short-time work. The conclusions of this empirical analysis are pretty straightforward: short-time work preserved employment and limited the decrease in the number of hours worked during the Great Recession. Permanent jobs, rather than temporary ones, benefited from the policy. The policy helped highly levered firms, hit by transitory negative shocks, to recover and even grow in the aftermath of the crisis. The cost of saving those jobs was low, even very low compared to other job-preserving policies previously used in France, such as wage subsidies, creation of public jobs, or hiring subsidies. Furthermore, only those firms that faced a large negative shock benefited from this policy whereas (we show that) the policy had no discernable effect on firms faced with smaller shocks.

Hence, short-time work had desirable properties when the Great Recession hit. But the effectiveness of short-time work hinges on its design. From this perspective, our results suggest ways to optimize short-time work schemes.

First, the scheme should be targeted at firms facing large drops in their revenues, and faced

according to the evaluation of Boeri and Bruecker (2011).

[39] See above, Section 3.3.

with credit constraints. A way to screen firms might be to subsidize short-time work for a sufficiently large number of non-worked hours per employee rather than subsidizing from the first non-worked hour below the usual contractual number of hours worked, as is the case in France, since employees whose hours worked are reduced by small amounts are less at risk of seeing their jobs destroyed.

Second, introducing experience rating should reduce the windfall effects, as stressed by Burdett and Wright (1989). When financial markets are imperfect, short-time work may be useful to firms in temporary distress. However, if firms can use short-time work at no cost, some firms may decide to make the policy their usual tool when faced with certain repetitive shocks rather than search for other ways to overcome such temporary but recurring difficulties.

Finally, short-time work was never used by a large fraction of French firms: quite the contrary since the take-up was at most 1% even in the depths of the Great Recession. Even though short-time work had positive employment effects for a fraction of this 1% of firms, extending its scope is likely to reduce its effectiveness. As stressed by Cooper *et al.* (2017), extending the short-time work policy is likely to decrease allocative efficiency on the labor market, resulting in significant output losses.

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A Appendix

A.1 Competitive Equilibrium Contract

This Appendix determines the solution to program (4) which defines the optimal number of vacancies and the optimal contract $\{w(y), h(y), \Omega\}$. Since the equilibrium value of the labor market tightness θ in each labor pool is determined by the no-arbitrage condition (1), it is clear that θ in each labor pool does not depend on the number of vacant jobs v posted by the firm. It is determined by the expected utility W associated with the contract posted by the firm. Therefore, maximization of $vm(\theta)\Pi - C(v)$ with respect to v yields equation (6).

In order to find the optimal contract, it is convenient to solve the program of the firms in two stages. In the first stage, we determine the profit maximizing expected utility W associated with the contract posted by the firm. In the second stage, we determine the properties of the optimal contract.

First, let us define the expected job surplus

$$S = W - [b - \phi(0)] + \Pi. \tag{A1}$$

The definition of the expected job surplus implies that $\Pi = S - W + [b - \phi(0)]$. Therefore, for any value of S the firm chooses the expected utility W that solves

$$\max_{W} m(\theta) \left[S - W + [b - \phi(0)]\right],$$

where θ satisfies the no-arbitrage condition (1). The solution is

$$W - [b - \phi(0)] = \eta S, \tag{A2}$$

where $\eta = -\theta m'(\theta)/m(\theta) \in (0, 1)$ is the elasticity of the matching function with respect to unemployment. Using the definition (A1) of the surplus, this solution can also be written $\Pi = (1 - \eta)S$. Since the expected profit of the firm is proportional to the expected job surplus at the optimum, the optimal contract necessarily maximizes the expected job surplus.

In the second stage, let us maximize the expected job surplus with respect to Ω and $h(y) \geq 0$. Let us denote by $\mu(y)$ the multiplier associated with the constraint $h(y) \geq 0$. The Lagrangian of this maximization problem is

$$\mathcal{L} = S + \int_{y \in \Omega} \mu(y) h(y) \mathrm{d}y.$$

The expected surplus can be written, using equations (2) and (5):

$$S = \int_{y \in \Omega} s(y) \mathrm{d}G(y),$$

where

$$s(y) = yh(y) - \phi(h(y)) + \sigma \max\left[\bar{h} - h(y), 0\right] - [b - \phi(0)] \tag{A3}$$

stands for the surplus of jobs of productivity y. Maximization of the Lagrangian with respect to $h(y)$ yields

$$\frac{\partial \mathcal{L}}{\partial h(y)} = 0 \Rightarrow h(y) = \begin{cases} \phi'^{-1}(y) & \text{if } y \geq \bar{y} \\ \phi'^{-1}(y - \sigma) & \text{if } y_0 \leq y < \bar{y} \\ 0 & \text{if } y < y_0 \end{cases} \tag{A4}$$

where $\bar{y} = \left\{y | \phi'(\bar{h}) = y\right\}$ and $y_0 = \left\{y | \phi'(0) = y\right\}$.

Now, let us determine the optimal productivity set Ω. The envelope theorem implies that $s'(y) = h(y) \geq 0$ at the optimum. This means that $s'(y)$ is either positive or equal to zero.

Let us first consider the case where $s'(y) = 0$. We know from equation (A4) that this case is possible only if there exists $y \leq y_0$ such that $h(y) = 0$. When $h(y) = 0$, equation (A3) yields $s(y) = \sigma\bar{h} - b$. If $\sigma\bar{h} - b > 0$, it is optimal to keep all jobs whatever the realization of y since it suffices to set $h(y) = 0$ to get a positive job surplus. In this case, the firm keeps workers who work zero hour when their productivity drops below the threshold y_0.

In the more relevant empirical case where the maximum value of the short-time compensation $\sigma\bar{h}$ is smaller than the unemployment benefit b, $\sigma\bar{h} - b$ is negative and the constraint $h(y) \geq 0$ cannot bind, because it cannot be optimal to keep jobs which yield a negative surplus. In this case, we have $h(y) > 0$ and $s'(y)$ is strictly positive for all y. Maximization of $\mathcal{L}$ requires that if $y' \in \Omega$ all $y > y'$ also belong to Ω. Therefore, assuming that the bottom value of y, denoted by $y_{\min}$, satisfies $s(y_{\min}) < 0$, the optimal set of productivities for which the jobs are not destroyed is $\Omega = \{y | y > \tilde{y}\}$ where $\tilde{y} = \{y > y_{\min} | s(y) = 0\}$, which implies, using the definition (A3) of $s(y)$, that $\tilde{y}$ statisfies

$$\tilde{y}h(\tilde{y}) - \phi(h(\tilde{y})) - b + \phi(0) + \sigma \max\left[\bar{h} - h(\tilde{y}), 0\right] = 0. \tag{A5}$$

Equations (A4) and (A5) define the optimal contingent hours worked $h(y)$ and the reservation productivity $\tilde{y}$. Then, all wage functions $w(y)$ which satisfy condition (A2) can belong to the optimal contract. The shape of $h(y)$ and the reservation productivity are depicted on Figures 4 and 4.

A.2 Comparison of Job Subsidies and Short-Time Work Compensation

The model allows us to show that short-time work reduces job destruction at lower cost for the government than job subsidies which provided to all jobs and do not depend on hours worked. Let χ denote the subsidy per job. We compare the impact of short-time work compensation, equal to

$\sigma \max\left[\bar{h} - h(y), 0\right]$, to the subsidy χ per job in the neighborhood of $\sigma = \chi = 0$. Insofar as these two schemes have, by definition in the present context, the same impact on the expected labor cost of each firm, and then on the creation of vacant jobs, we do not need to account for their effects on job vacancies to compare their impact on employment.

The impact of the job subsidy χ on the threshold value of productivity $\tilde{y}$ below which jobs are destroyed is defined by equation (A5) which can be written, in presence of the job subsidy

$$\tilde{y}h(\tilde{y}) - \phi(h(\tilde{y})) - [b - \phi(0)] + \chi = 0, \tag{A6}$$

Equation (A6) implies, together with the envelope theorem, that $\mathrm{d}\tilde{y}/\mathrm{d}\chi = -1/h(\tilde{y})$. Therefore, since the density of jobs of productivity $\tilde{y}$ is equal to $vm(\theta)g(\tilde{y})$ in each firm, the subsidy χ creates

$$\frac{1}{h(\tilde{y})} N v m(\theta) g(\tilde{y}) \chi \tag{A7}$$

jobs in the economy, where N denotes the (exogenous) number of firms at the start of the period. Note that ex-post, once the productivity shocks z and ε have been realized, some firms may have zero employees, meaning that they are destroyed.

The impact of short-time work compensation can be computed from equation (A5), which defines $\tilde{y}$ when there is short-time work. Differentiation of equation (A5) implies that $\mathrm{d}\tilde{y}/\mathrm{d}\sigma = -\left[\bar{h} - h(\tilde{y})\right]/h(\tilde{y})$. Therefore, the short-time compensation equal to $\sigma \max\left[\bar{h} - h(y), 0\right]$ creates

$$\frac{\bar{h} - h(\tilde{y})}{h(\tilde{y})} N v m(\theta) g(\tilde{y}) \sigma \tag{A8}$$

jobs and costs $\sigma \int_{\tilde{y}}^{\bar{y}} \frac{\bar{h} - h(y)}{1 - G(\tilde{y})} \mathrm{d}G(y)$ per employee (including those who do not use short-time work in the firm).

Assume now that the cost per employee of the short-time compensation is equal to the job subsidy χ. This implies that $\sigma = \chi / \int_{\tilde{y}}^{\bar{y}} \frac{\bar{h} - h(y)}{1 - G(\tilde{y})} \mathrm{d}G(y)$. Substituting this expression of σ into equation (A8), we find that short-time work creates

$$\frac{\bar{h} - h(\tilde{y})}{h(\tilde{y}) \int_{\tilde{y}}^{\bar{y}} \frac{\bar{h} - h(y)}{1 - G(\tilde{y})} \mathrm{d}G(y)} N v m(\theta) g(\tilde{y}) \chi \tag{A9}$$

jobs. From equations (A7) and (A9) it can be deduced that the ratio between the number of job created by short-time work and by the job subsidy for an identical cost per employee (or equivalently an identical expenditure) is given by equation (8).

A.3 The effect of short-time work on total hours worked

This appendix computes the impact of the short-time work compensation σ on the total number of hours worked in the neighborhood of $\sigma = 0$ assuming that the number of job creations $vm(\theta)$ is given. This allows us to exhibit a sufficient condition to get a positive effect of short-time work on the total number of hours of work insofar as the short-time compensation (financed by a lump sum tax paid by all workers), which raises the expected value of filled jobs, increases job creation.

By definition, the total number of hours worked is

$$H = m(\theta)vN\left[\int_{\tilde{y}}^{\bar{y}} h(y)\mathrm{d}G(y) + \int_{\bar{y}}^{\infty} h(y)\mathrm{d}G(y)\right]$$

where $\bar{y} = \left\{y|h(y) = \bar{h}\right\}$, $\tilde{y}$ is the threshold value of productivity below which jobs are destroyed and N is the number of firms in the economy. From this definition, and the fact that $\mathrm{d}h(y)/\mathrm{d}\sigma = 0$ if $y \geq \bar{y}$, shown in Appendix A.1, we get

$$\frac{1}{m(\theta)vN}\frac{\mathrm{d}H}{\mathrm{d}\sigma} = -\frac{\mathrm{d}\tilde{y}}{\mathrm{d}\sigma}h(\tilde{y})g(\tilde{y}) + \int_{\tilde{y}}^{\bar{y}} \frac{\mathrm{d}h(y)}{\mathrm{d}\sigma}\mathrm{d}G(y).$$

From equation (A4), we know that $\mathrm{d}h(y)/\mathrm{d}\sigma = -\mathrm{d}h(y)/\mathrm{d}y$, and from equation (A5) we have $\mathrm{d}\tilde{y}/\mathrm{d}\sigma = -\left[\bar{h} - h(\tilde{y})\right]/h(\tilde{y})$, which implies that

$$\frac{1}{m(\theta)vN}\frac{\mathrm{d}H}{\mathrm{d}\sigma} = \left[\bar{h} - h(\tilde{y})\right]g(\tilde{y}) - \int_{\tilde{y}}^{\bar{y}} \frac{\partial h(y)}{\partial y}\mathrm{d}G(y).$$

Integration by parts gives

$$\frac{\mathrm{d}H}{\mathrm{d}\sigma} = -m(\theta)vN\int_{\tilde{y}}^{\bar{y}} \left[\bar{h} - h(\tilde{y})\right]\mathrm{d}g(y).$$

This expression is positive if $g'(y) < 0$ for $y \in [\tilde{y}, \bar{y}]$.

Table 1: Characteristics of firms with and without short-time work in 2009

	$STW = 1$	$STW = 0$
Revenue growth rate	$-.17$	$.05$
	(.00)	(.00)
Leverage rate	.25	.27
	(.00)	(.00)
Employment growth rate	$-.14$	$-.05$
	(.00)	(.00)
Hourly gross wage	14.21	13.81
	(.05)	(.07)
Hours worked per worker	1687.16	1617.36
	(3.42)	(1.08)
Turnover rate	1.33	1.67
	(.01)	(.00)
Share of temporary jobs	.11	.20
	(.00)	(.00)
Number of employees	20.32	6.95
	(.54)	(.03)
Age	18.5	13.49
	(.15)	(.01)
Observations	11,313	757,030

Sources: *DADS*, *FICUS* and *FARE* (*INSEE*) and *Sinapse* (*DGEFP*).

Scope: ♦ Mainland France excluding Corsica. ♦ Market sectors excluding agriculture. ♦ Single-establishment firms.

Definitions: ♦ The revenue growth rate is defined as the difference in the revenue between 2009 and 2008, divided by the revenue in 2008. ♦ The leverage rate is defined as the level of debt divided by the level of assets ♦ The employment growth rate is defined as the difference in the number of employees between the 31^{st} of December 2009 and the 31^{st} of December 2008, divided by the number of employees on the 31^{st} of December 2008. ♦ The hourly gross wage is defined as the total labor cost divided by the total number of hours worked. ♦ The number of hours worked per worker is defined as the total number of hours worked divided by the average number of employees. ♦ The turnover rate is defined as the total number of employees present at least one hour in the firm during the year divided by the average number of employees. ♦ The share of temporary jobs is defined as the number of employees under non-permanent contracts divided by the total number of employees. ♦ The number of employees is defined as the number of employees on the 31^{st} of December 2008. ♦ The age is defined as the difference between 2009 and the year of creation of the firm.

Notes: ♦ $STW = 1$ stands for the firms using short-time work for economic reasons in 2009; $STW = 0$ stands for the firms not using short-time work in 2009. ♦ Standard errors of the means are reported in parentheses.

Table 2: Short-time work take-up rate by industry in 2009

	STW take-up	Number of firms
Construction	.012 (.000)	206,705
Finance, insurance and real estate	.005 (.000)	45,800
Information and communication	.006 (.000)	27,040
Manufacturing and extractive industries	.064 (.001)	115,101
Specialized, scientific and technical services	.010 (.000)	111,375
Wholesale and retail trade, transport	.006 (.000)	439,034

Sources: *DADS* and *Sinapse* (*DGEFP*).

Scope: ♦ Mainland France excluding Corsica. ♦ Market sectors excluding agriculture. ♦ Single-establishment firms. ♦ Standard errors of the means are reported in parentheses.

Table 3: Determinants of the short-time work take-up of the establishments belonging to multi-establishment firms in 2008.

	Short-time work take-up
Share of response time>14 days	$-.226^{***}$
	(.048)
Commuting zone revenue growth rate	-3.412^{***}
	(.810)
Hourly gross wage	.003
	(.002)
Hours worked per worker	.000
	(.000)
Turnover rate	$-.003$
	(.002)
Share of temporary jobs	$-.057^{***}$
	(.002)
Sector-specific fixed effect	Yes
Firm-specific fixed effect	Yes
Adj-R^2	0.41
Observations	322,517

Sources: *DADS*, *FICUS* and *FARE* (*INSEE*) and *Sinapse* (*DGEFP*).

Scope: ♦ Mainland France excluding Corsica. ♦ Market sectors excluding agriculture.

Definitions: ♦ The dependent variable is equal to 100 if the establishment uses short-time work for economic reasons in 2009 and to 0 otherwise. ♦ The share of response time longer than 14 days is defined as the proportion of short-time work applications whose response time is longer than 14 days in the *département* of the establishment in 2008. ♦ The commuting zone revenue growth rate is defined as the average at the commuting zone level of the revenue growth rate, defined as the difference in the revenue between 2008 and 2007, divided by the absolute value of the revenue in 2007. ♦ The leverage is equal to 1 if the leverage rate, defined as the level of debts divided by the level of assets, belongs to the highest quartile, in 2007. ♦ The hourly gross wage is equal to 1 if the hourly gross wage, defined as the total labor cost divided by the total number of hours worked, is above the median wage, in 2007. ♦ The number of hours worked per worker is defined as the total number of hours worked divided by the average number of employees, in 2007. ♦ The turnover rate is defined as the total number of employees divided by the average number of employees, in 2007. ♦ The share of temporary jobs is defined as the number of employees under non-permanent contracts divided by the total number of employees, in 2007. ♦ The number of employees is defined as an indicator variable of the number of employees on the 31^{st} of December 2007 (10, 50, 250, and 1,000 employees). ♦ The age is defined as the difference between 2009 and the year of creation of the firm.

Notes: ♦ This table displays the ordinary least squares estimation of the short-time work take-up of establishments belonging to multi-establishment firms. ♦ The sector-specific fixed effects of the establishments are disaggregated in 728 sectors. ♦ The number of hours worked per worker, the turnover rate, the share of temporary jobs, the number of employees and the age are also included in the regressors. ♦ Robust standard errors are clustered at the sector x *département* level and reported between parentheses. ♦ p-values: * p<0.10, ** p<0.05, *** p<0.01.

Table 4: The probability of short-time work use in the first quarter of 2009 and the distance to multi-establishment firms

	(1)	(2)	(3)
Dep variable:	Short-time work use in first quarter of 2009		
Distance	$-.042^{***}$	$-.053^{***}$	$-.053^{***}$
	(.012)	(.012)	(.012)
Adj-R^2	0.001	0.014	0.014
Observations	12,304	12,304	12,304

Sources: *DADS*, *FICUS*, *FARE* (*INSEE*), *DMMO*, *Sinapse* (*DGEFP*).

Scope: ♦ Mainland France excluding Corsica. ♦ Market sectors excluding agriculture.

Definitions: ♦ The dependent variable is either equal to 1 if the single establisment firm uses short-time work in the first quarter of 2009 instead of later in the year or equal to zero otherwise. ♦ 'Distance' is either equal to 0 if the single establishment firm belongs to the first quartile of distance to establishments belonging to multi-establishment firms which used short-time work in 2008, or equal to 1 otherwise.

Notes: ♦ The results reported in column (1) do not include any covariate, ♦ Column (2) includes the following covariates: the revenue growth rate, the leverage rate, the hourly gross wage, the number of hours worked per worker, the turnover rate, the share of temporary jobs, the number of employees, the age and (728) sector-specific fixed effects, the *départemental* proportion of short-time work applications whose response time is longer than 14 days in 2008. The revenue growth rate is defined as the difference in the revenue between 2009 and 2008, divided by the absolute value of the revenue in 2008. The leverage rate is defined as the level of debt divided by the level of assets, in the previous year. The hourly gross wage is defined as the total labor cost divided by the total number of hours worked, in the previous year. The number of hours worked per worker is defined as the total number of hours worked divided by the average number of employees, in the previous year. The turnover rate is defined as the total number of employees divided by the average number of employees, in the previous year. The share of temporary jobs is defined as the number of employees under non-permanent contracts divided by the total number of employees, in the previous year. The number of employees is defined as an indicator variable of the number of employees on the 31st of December of the previous year (10, 50, 250, and 1,000 employees). The age is defined as the difference between 2009 (respectively 2008) and the year of creation of the firm. ♦ Column (3) adds the quarterly employment growth rate of the sector of the firm (728 sectors) to the covariates of column (2). ♦ OLS estimation. ♦ Robust standard errors are clustered at the sector x *département* level and reported between parentheses. ♦ p-values: * p<0.10, ** p<0.05, *** p<0.01.

Table 5: Determinants of the short-time work take-up and of the revenue growth rate of single-establishment firms in 2009.

	Short-time work take-up	Revenue growth rate
Share of response time>14 days	$-.953^{***}$ (0.113)	$-.151$ (0.363)
Distance to the past short-time work user	$-.007^{***}$ (.001)	$-.013^{***}$ (0.005)
Leverage	$.167^{***}$ (.032)	1.005^{***} (0.214)
Hourly gross wage	$.147^{***}$ (.033)	-1.237^{***} (0.155)
Hours worked per worker	$.205^{***}$ (.023)	-3.921^{***} (0.119)
Turnover rate	$-.191^{***}$ (.033)	$.607^{***}$ (0.128)
Share of temporary jobs	$-.136^{***}$ (.030)	1.355^{***} (0.120)
$10 \leq$ Number of employees < 50	1.724^{***} (.102)	-1.526^{***} (.177)
$50 \leq$ Number of employees < 250	1.724^{***} (.322)	-3.607^{***} (.355)
$250 \leq$ Number of employees < 1000	5.232^{***} (.023)	-7.205^{***} (1.093)
$1000 \leq$ Number of employees	8.180 (3.478)	22.54 (17.45)
Adj-R^2	.090	0.209
F	44.67	125.36
Prob $F > 0$	.000	.000
Observations	768,343	768,343

Sources: *DADS*, *FICUS* and *FARE* (*INSEE*) and *Sinapse* (*DGEFP*). **Scope:** ♦ Mainland France excluding Corsica. ♦ Market sectors excluding agriculture. **Definitions:** ♦ The first dependent variable is equal to 100 if the establishment uses short-time work for economic reasons in 2009 and to 0 otherwise. ♦ The second dependent variable is the revenue growth rate, defined as the difference in the revenue between 2009 and 2008, divided by the absolute value of the revenue in 2008, and expressed in percentage. ♦ The share of response time longer than 14 days is defined as the proportion of short-time work applications whose response time is longer than 14 days in the *département* of the establishment in 2008. ♦ The distance to the past short-time work user is defined as the distance to the closest establishment, belonging to a multi-establishment firm, which used short-time work in 2008. ♦ The leverage is equal to 1 if the leverage rate, defined as the level of debts divided by the level of assets, belongs to the highest quartile, in 2008. ♦ The hourly gross wage is equal to 1 if the hourly gross wage, defined as the total labor cost divided by the total number of hours worked, is above the median wage, in 2008. ♦ The number of hours worked per worker is defined as the total number of hours worked divided by the average number of employees, in 2008. ♦ The turnover rate is defined as the total number of employees divided by the average number of employees, in 2008. ♦ The share of temporary jobs is defined as the number of employees under non-permanent contracts divided by the total number of employees, in 2008. ♦ The number of employees is defined as an indicator variable of the number of employees on the 31^{st} of December 2008 (10, 50, 250, and 1,000 employees). ♦ The age is defined as the difference between 2009 and the year of creation of the firm. **Notes:** ♦ This table displays the ordinary least squares estimation of equations (12) and (13). ♦ The sector x commuting zone revenue growth rate, the leverage, the hourly gross wage, the number of hours worked per worker, the turnover rate, the share of temporary jobs, the number of employees, the age and the (728) sector-specific fixed effects are also included in the regressors. ♦ Robust standard errors are clustered at the sector x *département* level and reported between parentheses. ♦ p-values: * p<0.10, ** p<0.05, *** p<0.01. ♦ The F statistic in the first column tests the joint significance of the share of response time greater than14 days and the distance to the past short-time work user, the F statistic in the second column adds the leave out mean of the revenue growth rate in the industry and commuting zone by decile (coefficients not reported).

Table 6: Short-time work take-up, survival and employment growth of firms in 2009.

	OLS	IV
Death rate	-0.030^{***}	$-.0216$
	(.002)	(0.0432)
Employment growth rate	$-.028^{***}$	.051
	(.003)	(.069)
Share of permanent jobs	0.025^{***}	$.098^{**}$
	(.002)	(.047)
Relative growth rate of permanent jobs	$-.003$	.086
	(.003)	(.077)
Relative growth rate of temporary jobs	-0.017^{***}	$-.038$
	(.002)	(.058)
Observations	768,343	768,343

Sources: *DADS*, *FICUS* and *FARE* (*INSEE*) and *Sinapse* (*DGEFP*).

Scope: ♦ Mainland France excluding Corsica. ♦ Market sectors excluding agriculture.

Definitions: ♦ The death rate is equal to 1 if the firm has zero employee on the 31^{st} of December 2009 and 0 otherwise. ♦ The employment growth rate is defined as the difference in the number of employees between the 31^{st} of December 2009 and the 31^{st} of December 2008, divided by the number of employees on the 31^{st} of December 2008. ♦ The share of permanent jobs is defined as the number of permanent jobs divided by the total number of employees, on the 31^{st} of December 2009. ♦ The relative growth rate of permanent jobs is defined as the difference in the number of employees under permanent contracts between the 31^{st} of December 2009 and the 31^{st} of December 2008, divided by the total number of employees on the 31^{st} of December 2008. ♦ The relative growth rate of temporary jobs is defined as the difference in the employees under non-permanent contracts between the 31^{st} of December 2009 and the 31^{st} of December 2008, divided by the total number of employees on the 31^{st} of December 2008. ♦ See Table 5.

Notes: ♦ This table displays the estimation of the β_1 coefficient of equation (9) with ordinary least squares (column OLS) and instrumental variable (column IV). ♦ The instruments are the share of response time longer than 14 days, the distance to the past short-time work user, and the sector x commuting zone revenue growth rate. ♦ The leverage, the hourly gross wage, the number of hours worked per worker, the turnover rate, the share of temporary jobs, the number of employees, the age and the (728) sector-specific fixed effects are also included in the regressors. ♦ Robust standard errors are clustered at the sector x *département* level and reported between parentheses. ♦ p-values: * p<0.10, ** p<0.05, *** p<0.01.

Table 7: Characteristics of firms by quintile of their predicted revenue growth rate

Quintile	Number of firms	Short-time work rate (in percent)	Revenue growth rate $STW = 1$	Revenue growth rate $STW = 0$	p-value
1	153,669	3.92	−.26 (.00)	−.13 (.00)	.000
2	153,669	1.27	−.17 (.01)	−.04 (.00)	.000
3	153,668	0.9	−.14 (.01)	−.01 (.00)	.000
4	153,669	0.7	.09 (.01)	.04 (.00)	.000
5	153,668	0.6	.31 (.03)	.38 (.00)	.000

Sources: *DADS*, *FICUS* and *FARE* (*INSEE*) and *Sinapse* (*DGEFP*).

Scope: ♦ Mainland France excluding Corsica. ♦ Market sectors excluding agriculture.

Definitions: ♦ The short-time work rate is defined as the number of firms using short-time work for economic reasons divided by the total number of firms, in 2009. ♦ The revenue growth rate is defined as the difference in the revenue between 2009 and 2008, divided by the absolute value of the revenue in 2008.

Notes: ♦ This table displays the features of the quintiles of firms according to their revenue growth rate in 2009 predicted by equation (13). ♦ $STW = 1$ stands for the single-establishment firms using short-time work for economic reasons in 2009; $STW = 0$ stands for the single-establishment firms not using short-time work in 2009. ♦ The last column reports the p-value for the null hypothesis: Revenue growth rate ($STW = 0$) = Revenue growth rate ($STW = 1$). ♦ The standard errors of the means are reported in parentheses.

Table 8: Characteristics of firms using short-time work in 2009 by quintile of their predicted revenue growth rate

Quintile	Number of firms	Revenue	Number of employees	Age
1	6,020	4,393.72	27.15	22.97
		(19,144.53)	(.86)	(.22)
2	1,963	1,963.71	13.89	18.27
		(7,357.18)	(.94)	(.32)
3	1,397	1,319.05	10.51	13.86
		(4,529.2)	(.68)	(.32)
4	1,001	1,349.48	11.02	10.39
		(11,778.21)	(1.83)	(.35)
5	932	2,283.39	14.53	5.78
		(12,113.67)	(2.10)	(.31)

Sources: *DADS*, *FICUS* and *FARE* (*INSEE*) and *Sinapse* (*DGEFP*).

Scope: ♦ Mainland France excluding Corsica. ♦ Market sectors excluding agriculture. ♦ establishments using short-time work for economic reasons.

Definitions: ♦ The number of employees is defined as the number of employees on the 31^{st} of December 2008. ♦ The age is defined as the difference between 2009 and the year of creation of the firm.

Notes: ♦ This table displays the features of firms using short-time work in 2009 by quintile (among all firms, including short-time work users and other firms) of their revenue growth rate in 2009 predicted by equation (13). ♦ The standard errors of the means are reported in parentheses.

Table 9: Determinants of the short-time work take-up of firms in 2009 (first stage short-time work estimates of the instrumental variable estimation) by quintile of their predicted revenue growth rate

Quintile	1	2	3	4	5
Share of response time>14 days	-1.854^{***} (0.348)	$-.968^{***}$ (.0178)	$-.832^{***}$ (.0149)	$-.552^{***}$ (.0124)	$-.412^{***}$ (.0117)
Distance to the past short-time work user	$-.020^{***}$ (.004)	$-.001$ (.002)	$-.007^{***}$ (.002)	$-.006^{***}$ (.002)	$-.001$ (.002)
Adj-R^2	.14	.03	.02	.03	.02
F	23.24	14.83	19.37	12.42	6.24
Prob $F > 0$	.000	.000	.000	.000	.000
Observations	153,669	153,669	153,668	153,669	153,668

Sources: *DADS*, *FICUS* and *FARE* (*INSEE*) and *Sinapse* (*DGEFP*).

Scope: ♦ Mainland France excluding Corsica. ♦ Market sectors excluding agriculture.

Definitions: See Table 5.

Notes: ♦ This table displays the first stage short-time work estimates of the instrumental variable estimation of equation (9). ♦ The regressions are run by quintile of revenue growth rate of firms in 2009 predicted by equation (13). ♦ The commuting zone revenue growth rate, the leverage, the hourly gross wage, the number of hours worked per worker, the turnover rate, the share of temporary jobs, the number of employees, the age and the (728) sector-specific fixed effects are also included in the regressors. ♦ Robust standard errors are clustered at the sector x *département* level and reported between parentheses. ♦ p-values: * p<0.10, ** p<0.05, *** p<0.01. ♦ The F statistic for the joint significance of the two instrumental variables is reported.

Table 10: Short-time work take-up, survival and employment growth of firms in 2009 by quintile of their predicted revenue growth rate

Quintile	1	2	3	4	5
Death rate	$-.0876^{***}$	$-.040$	$.029$	$.237^{*}$	$.226$
	(.033)	(.087)	(.096)	(.127)	(.155)
Employment growth rate	$.158^{***}$	$.108$	$.058$	$-.129$	$-.309$
	(.051)	(.140)	(.167)	(.201)	(.273)
Share of permanent jobs	$.068^{**}$	$.145$	$.199^{*}$	$-.013$	$.235$
	(.032)	.090)	(.167)	(.149)	(.173)
Relative growth rate of permanent jobs	$.176^{***}$	$-.221$	$.193$	$-.237$	$-.187$
	(.053)	(.137)	(.164)	(.207)	(.280)
Relative growth rate of temporary jobs	$.007$	$-.082$	$.145$	$.001$	$-.154$
	(.039)	(.110)	(.144)	(.176)	(.228)
Observations	153,669	153,669	153,668	153,669	153,668

Sources: *DADS*, *FICUS* and *FARE* (*INSEE*) and *Sinapse* (*DGEFP*).

Scope: ♦ Mainland France excluding Corsica. ♦ Market sectors excluding agriculture.

Definitions: See Table 6.

Notes: ♦ This table displays the estimation of equation (9) with instrumental variable. ♦ The regressions are run by quintile of revenue growth rate of firms in 2009 predicted by equation (13). ♦ The endogenous variables are the short-time work take-up and the revenue growth rate. ♦ The instruments are the share of response time longer than 14 days, the distance to the past short-time work user, and the sector x commuting zone revenue growth rate. ♦ The leverage, the hourly gross wage, the number of hours worked per worker, the turnover rate, the share of temporary jobs, the number of employees, the age and the (728) sector-specific fixed effects are also included in the regressors. ♦ Robust standard errors are clustered at the sector x *département* level and reported between parentheses. ♦ p-values: * p<0.10, ** p<0.05, *** p<0.01.

Table 11: Characteristics of firms by tercile of their predicted revenue growth rate

Tercile	Number of firms	Short-time work rate (in percent)	Revenue growth rate $STW = 1$	Revenue growth rate $STW = 0$	p-value
1	256,115	2.90	−.25 (.00)	−.09 (.00)	.000
2	256,114	0.90	−.13 (.01)	−.01 (.00)	.000
3	256,114	0.61	.15 (.02)	.25 (.00)	.000

Sources: *DADS*, *FICUS* and *FARE* (*INSEE*) and *Sinapse* (*DGEFP*).

Scope: ♦ Mainland France excluding Corsica. ♦ Market sectors excluding agriculture.

Definitions: ♦ The short-time work rate is defined as the number of firms using short-time work for economic reasons divided by the total number of firms, in 2009. ♦ The revenue growth rate is defined as the difference in the revenue between 2009 and 2008, divided by the absolute value of the revenue in 2008.

Notes: ♦ This table displays the features of the terciles of firms according to their revenue growth rate in 2009 predicted by equation (13). ♦ $STW = 1$ stands for the single-establishment firms using short-time work for economic reasons in 2009; $STW = 0$ stands for the single-establishment firms not using short-time work in 2009. ♦ The last column reports the p-value for the null hypothesis: Rev growth rate (STW=0) = Rev growth rate (STW=1). ♦ The standard errors of the means are reported in parentheses.

Table 12: Characteristics of firms using short-time work in 2009 by tercile of their predicted revenue growth rate

Tercile	Number of firms	Revenue	Number of employees	Age
1	7,340	2,024.90 (21,776.36)	24.79 (.72)	18.35 (.19)
2	2,301	1,173.90 (10,492.39)	10.36 (1.51)	14.35 (.26)
3	1,572	962.46 (15,001.66)	13.80 (1.70)	7.97 (.26)

Sources: *DADS*, *FICUS* and *FARE* (*INSEE*) and *Sinapse* (*DGEFP*).

Scope: ♦ Mainland France excluding Corsica. ♦ Market sectors excluding agriculture.

Definitions: ♦ The number of employees is defined as the number of employees on the 31^{st} of December 2008. ♦ The age is defined as the difference between 2009 and the year of creation of the firm.

Notes: ♦ This table displays the features of firms using short-time work in 2009 by tercile (among all firms, including short-time work users and other firms) of their revenue growth rate in 2009 predicted by equation (13). ♦ The standard errors of the means are reported in parentheses.

Table 13: Determinants of the short-time work take-up of firms in 2009 (first stage short-time work estimates of the instrumental variable estimation) by tercile of their predicted revenue growth rate.

Tercile	1	2	3
Share of response time>14 days	-1.548^{***}	$-.754^{***}$	$-.475^{***}$
	(.245)	(.123)	(.097)
Distance to the past short-time work user	$-.0116^{***}$	$-.005^{***}$	$-.003^{**}$
	(.00295)	(.002)	(.001)
Adj-R^2	.12	.02	.03
F	27.30	21.15	13.36
Prob $F > 0$	.000	.000	.000
Observations	256,115	256,114	256,114

Sources: *DADS*, *FICUS* and *FARE* (*INSEE*) and *Sinapse* (*DGEFP*).

Scope: ♦ Mainland France excluding Corsica. ♦ Market sectors excluding agriculture.

Definitions: See Table 5.

Notes: ♦ This table displays the first stage short-time work estimates of the instrumental variable estimation of equation (9). ♦ The regressions are run by tercile of revenue growth rate of firms in 2009 predicted by equation (13). ♦ The commuting zone revenue growth rate, the leverage, the hourly gross wage, the number of hours worked per worker, the turnover rate, the share of temporary jobs, the number of employees, the age and the (728) sector-specific fixed effects are also included in the regressors. ♦ Robust standard errors are clustered at the sector x *département* level and reported between parentheses. ♦ p-values: * p<0.10, ** p<0.05, *** p<0.01. ♦ The F statistic for the joint significativity of the 2 explanatory variables is reported.

Table 14: Short-time work take-up, survival and employment growth of firms in 2009 by tercile of their predicted revenue growth rate

Tercile	1	2	3
Death rate	−.057	.009	.218
	(.035)	(.096)	(.141)
Employment growth rate	.125**	−.135	−.173
	(.054)	(.158)	(.247)
Share of permanent jobs	.084**	.139	.225
	(.033)	(.118)	(.158)
Relative growth rate of permanent jobs	.176***	−.197	.001
	(.056)	(.166)	(.271)
Relative growth rate of temporary jobs	−.018	−.154	−.238
	(.041)	(.141)	(.202)
Observations	256, 115	256, 114	256, 114

Sources: *DADS*, *FICUS* and *FARE* (*INSEE*) and *Sinapse* (*DGEFP*).

Scope: ♦ Mainland France excluding Corsica. ♦ Market sectors excluding agriculture.

Definitions: See Table 6.

Notes: ♦ This table displays the estimation of equation (9) with instrumental variable. ♦ The regressions are run by tercile of revenue growth rate of firms in 2009 predicted by equation (13). ♦ The endogenous variables are the short-time work take-up and the revenue growth rate. ♦ The instruments are the share of response time longer than 14 days, the distance to the past short-time work user, and the sector x commuting zone revenue growth rate. ♦ The leverage, the hourly gross wage, the number of hours worked per worker, the turnover rate, the share of temporary jobs, the number of employees, the age and the (728) sector-specific fixed effects are also included in the regressors. ♦ Robust standard errors are clustered at the sector x *département* level and reported between parentheses. ♦ p-values: * p<0.10, ** p<0.05, *** p<0.01.

Table 15: Short-time work take-up, survival and employment growth of firms in 2009-2011 by quintile of their predicted revenue growth rate in 2009

Quintile	1	2	3	4	5
Death Indicator	$-.201^{*}$	$-.326$	$-.352$	$.196$	$-.0.83$
	(.111)	(.222)	(.253)	(.297)	(.350)
Employment growth rate	$.443^{***}$	-0.283	$.402$	$-.258$	$.375$
	(.145)	(.301)	(.328)	(.423)	(.538)
Observations	153,594	153,593	153,593	153,593	153,593

Sources: *DADS*, *FICUS* and *FARE* (*INSEE*) and *Sinapse* (*DGEFP*).

Scope: ♦ Mainland France excluding Corsica. ♦ Market sectors excluding agriculture.

Definitions: ♦ The death indicator is equal to 1 if the firm has zero employee on the 31^{st} of December 2011 and 0 otherwise. ♦ The employment growth rate is defined as the difference in the number of employees between the 31^{st} of December 2011 and the 31^{st} of December 2008, divided by the number of employees on the 31^{st} of December 2008. ♦ See Table 5. ♦ The sector x *département* death rate is defined as the average at the sector x *département* level of the death rate, equal to 1 if the firm has zero employee on the 31^{st} of December 2011 and 0 otherwise. ♦ The sector x *département* employment growth rate is defined as the average at the sector x *département* level of the employment growth rate, defined as the difference in the number of employees between the 31^{st} of December 2010 and the 31^{st} of December 2009, divided by the number of employees on the 31^{st} of December 2009. ♦ The sector x *département* revenue growth rate is defined as the average at the sector x *département* level of the revenue growth rate, defined as the difference in the revenue between 2010 and 2009, divided by the absolute value of the revenue in 2009. ♦ The 2010 short-time work take-up is equal to 1 if the establishment uses short-time work in 2010 and to 0 otherwise.

Notes: ♦ This table displays the estimation of equation (9) with instrumental variable. ♦ The regressions are run by quintile of revenue growth rate of firms in 2009 predicted by equation (13). ♦ The endogeneous variables are the short-time work take-up and the revenue growth rate. ♦ The instruments are the share of response time longer than 14 days, the distance to the past short-time work user, and the sector x commuting zone revenue growth rate. ♦ Previous (year 2008) leverage, hourly gross wage, number of hours worked per worker, turnover rate, share of temporary jobs, firm size (10-50-250-1000 employees), age, are included in the regressors. The sector-specific fixed effects, the 2010 and 2011 short-time work take-up, the sector x *département* leave-one-out 2009, 2010 and 2011 mean revenue growth rate are also included in the regressors. ♦ Robust standard errors clustered at the sector x *département* level are reported in parentheses: * p<0.10, ** p<0.05, *** p<0.01.

Table 16: Short-time work take-up, survival and employment growth of firms in 2009-2011 by tercile of their predicted revenue growth rate in 2009

Tercile	1	2	3
Death rate	−.163	−.216	−.232
	(.120)	(.265)	(.302)
Employment growth rate	.307*	.480	−.451
	(.166)	(.366)	(.461)
Observations	256,058	256,059	256,059

Sources: *DADS*, *FICUS* and *FARE* (*INSEE*) and *Sinapse* (*DGEFP*).

Scope: ♦ Mainland France excluding Corsica. ♦ Market sectors excluding agriculture.

Definitions: ♦ The death indicator is equal to 1 if the firm has zero employee on the 31^{st} of December 2011 and 0 otherwise. ♦ The employment growth rate is defined as the difference in the number of employees between the 31^{st} of December 2011 and the 31^{st} of December 2008, divided by the number of employees on the 31^{st} of December 2008. ♦ See Table 5. ♦ The sector x *département* death rate is defined as the average at the sector x *département* level of the death rate, equal to 1 if the firm has zero employee on the 31^{st} of December 2011 and 0 otherwise. ♦ The sector x *département* employment growth rate is defined as the average at the sector x *département* level of the employment growth rate, defined as the difference in the number of employees between the 31^{st} of December 2010 and the 31^{st} of December 2009, divided by the number of employees on the 31^{st} of December 2009. ♦ The sector x *département* revenue growth rate is defined as the average at the sector x *département* level of the revenue growth rate, defined as the difference in the revenue between 2010 and 2009, divided by the absolute value of the revenue in 2009. ♦ The 2010 short-time work take-up is equal to 1 if the establishment uses short-time work in 2010 and to 0 otherwise.

Notes: ♦ This table displays the estimation of equation (9) with instrumental variable. ♦ The regressions are run by quintile of revenue growth rate of firms in 2009 predicted by equation (13). ♦ The endogeneous variables are the short-time work take-up and the revenue growth rate. ♦ The instruments are the share of response time longer than 14 days, the distance to the past short-time work user, and the sector x commuting zone revenue growth rate. ♦ Previous (year 2008) leverage, hourly gross wage, number of hours worked per worker, turnover rate, share of temporary jobs, firm size (10-50-250-1000 employees), age, are included in the regressors. The sector-specific fixed effects, the 2010 and 2011 short-time work take-up, the sector x *département* leave-one-out 2009, 2010 and 2011 mean revenue growth rate are also included in the regressors. ♦ Robust standard errors clustered at the sector x *département* level are reported between parentheses: * p<0.10, ** p<0.05, *** p<0.01.

Table 17: Profitability and financial situation over 2008-2011 of firms using short-time work in 2009 and belonging to the lowest quintile of the predicted revenue growth in 2009

Quintile	2008	2009	2010	2011
Return on assets	$-.024^{***}$	$-.065^{***}$	$-.037^{***}$	$-.020^{***}$
	(.002)	(.003)	(.003)	(.002)
Return on equity	$-.033^{***}$	$-.125^{***}$	$-.061^{***}$	$-.026^{***}$
	(.004)	(.006)	(.006)	(.005)
Interest coverage	-10.658^{***}	-29.261^{***}	-20.092^{***}	-10.462^{***}
	(1.415)	(1.847)	(2.118)	(2.249)
Leverage	$.004^{*}$	$.011^{***}$	$.005^{***}$	.001
	(.002)	(.002)	(.002)	(.002)
Nb of observations	153,594	153,594	153,594	153,594

Sources: *DADS*, *FICUS* and *FARE* (*INSEE*) and *Sinapse* (*DGEFP*).

Scope: ♦ Mainland France excluding Corsica. ♦ Market sectors excluding agriculture.

Definitions: ♦ Return on equity is equal to EBITDA/Total Equity ♦ Return on assets is equal to EBITDA/Total Assets ♦ Coverage is equal to EBTIDA/Interest expense. ♦ Leverage is equal to Total debt / Total Assets;

Notes: ♦ The table reports the difference in the value of the corresponding index between firms using short-time work in 2009 and other firms, conditional on sector and firm age ♦ Standard errors clustered at the sector x *département* level are reported between parentheses: * p<0.10, ** p<0.05, *** p<0.01.