Employment stickiness in small manufacturing firms*

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Abstract

Small firms often do not change their number of employees from year to year. This paper investigates the role of adjustment costs and indivisibility of labor in the employment stickiness of manufacturing firms with less than 75 employees. When small firms have to adjust employment in units of at least one employee, indivisibility becomes an important source of stickiness. A structural model of dynamic labor demand with adjustment costs and indivisibility is estimated using indirect inference on a panel of small French manufacturing firms. Adjustment cost are estimated to be very small. Indivisibility explains around 50% of the stickiness of employment, adjustment costs explain the other 50%.

Keywords: indivisibility, labor adjustment costs, employment, sticky employment, indirect inference

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1 Introduction

This paper analyses the causes of employment stickiness at small manufacturing firms. Employment at the firm level can be sticky under certain types of adjustment costs. It is well known that a fixed hiring or firing cost (or both) causes episodes of non-adjustment (see e.g. Hamermesh, 1989). In the presence of fixed costs, it is optimal to wait until large enough shocks occur before adjusting employment. There is empirical evidence that employment adjusts in a infrequent but lumpy fashion (e.g. Caballero, Engel and Haltiwanger (1997)). A fact not often emphasized in the literature on dynamic labor adjustment is the indivisibility of employment. Indivisibility is potentially important for small firms. Adding an extra employee for a firm with 10 employees adds 10% to the workforce whereas for a firm of 50 employees this is only a 2% addition. Even in the complete absence of hiring or firing costs one would expect the smaller firm with 10 employees to show higher employment stickiness as larger shocks are needed to get the same employment response of adding one extra employee. In the words of Hamermesh (1993) "*many firms are so small that these (=indivisibilities) become important...In a small firm experiencing a relatively small positive shock, hiring an extra employee may reduce profits even ignoring the adjustment costs that are incurred.* " In other words, non-adjustment might be optimal even in the complete abscence of adjustment costs.

In the empirical literature on dynamic labor demand at the firm or plant level[1], indivisibility has received a lot less attention than adjustment costs as a reason for stickiness of employment. Usually, in estimated models of dynamic labor demand, labor can adjust smoothly, i.e. in infinitesimal amounts so that production functions and adjustment cost functions are differentiable. This assumption is likely a good one when firms are large, however, can be far from the truth when firms are small. This paper takes indivisibility seriously and investigates when the differentiability assumption is dropped and replaced with the assumption that labor can only adjust in units (i.e. one, two, three, etc....). This allows to investigate the role of adjustment cost

[1] A large empirical literature estimate labor demand at the aggregate or industry level where indivisibility is likely less of an issue. However, labor demand estimates based on aggregate or industry level data are unlikely to lead to realistic estimates of adjustment costs at the firm or plant level due to aggregation. A summary of earlier dynamic labor demand studies using firm level data is given in Hamermesh and Pfann (1996).

and indivisibility simultaneously. Simply stated, imagine demand for the firms output goes up by 2% for both the firm with 10 employees and 50 employees. The firm of 50 employees is seen to hire 1 employee and the firm of ten employees does not hire. Does the firm with 10 employees face higher adjustment costs or does it simply face indivisibility (2% of 10 employees is 0.2 employees)?

The main aim of the paper is to infer the role of the "adjustment costs story" versus the "indivisibility- no-adjustment cost story" behind the stickiness of employment for small firms and to provide quantitative estimates on the relative importance of both of them. Without a theoretical model that combines adjustment costs, indivisibility and shocks to labor demand it is very difficult to disentangle the causes of stickiness. The paper therefore first develops a theoretical structural model incorporating all these elements. Using a large firm dataset of small manufacturing firms (all have less than 75 employees on average), the paper shows that the smaller the firm, the more likely its employment level will remain stable from one year to the next. The stickiness is quite pronounced for small firms and diminishes gradually as firms become larger. The estimation of the structural model shows that both adjustment costs and indivisibility explain this monotonic relationship between stickiness and size. As small firms employ a significant amount of the total labor force and produce a substantial amount of aggregate value added (especially in Europe), their employment stickiness is potentially important for the aggregate economy.

Being able to assess the relative importance between adjustment costs and indivisibility is quite important for both policymakers and macro modelers. For policy makers it is important to understand the extent to which adjustment costs explain the employment stickiness. It has often been argued that employment protection legislation and severance payments add to firing costs of firms. High firing costs would induce sticky employment behavior. If firing costs are at the center of the non-adjustment of small firms, a case could be made to policymakers to relax those cost as they create inefficiencies and output loss. Upon reduction of firing costs, firms should be seen both to hire and fire more often. However, if indivisibility causes non-adjustment of the employment level of small firms, hiring and firing will be little influenced upon a reduction of firing costs. If indivisibility is at the center of non-adjustment, it is likely that the firm will try to adjust along other margins, such as hours worked of its workforce. To the extent that overtime is expensive and reduction of time is regulated, a relaxation of overtime and reduction of time regulation might be more relevant for small firms.

Macro modelers should also be interested in employment stickiness and the reasons behind it. In most of the large macro-literature on inflation in a New -keynesian framework, employment adjustment costs are absent. Firms adjust employment fully flexibly without any adjustment costs. However recently there has been renewed interest in developing the implications of lumpy adjustment in employment in a general equilibrium setting. King and Thomas (2003) develop a model that incorporates fixed employment adjustment costs at the individual firm level and that when aggregated resembles partial adjustment for employment. In recent empirical work, Tilmann (2005) has argued that adding adjustment cost to labor can greatly improve the empirical fit of the forward looking Phillips curve in the Euro area. Understanding the magnitude and form of the adjustment costs and the possible other reasons such as magnitude of shocks or indivisibilities at the firm level is therefore also relevant for macro economics. Also if most of the stickiness stems from small firms, modelling heterogeneous firms might be important.

In this paper the "adjustment cost" story versus the "indivisibility-no adjustment cost" story for non-adjustment of employment are investigated for a profit maximizing firm. This is done in a number of steps. First, a theoretical model of optimal employment decision is developed under the presence of adjustment costs. The adjustment cost literature has convincingly argued that the traditional convex cost are not sufficient to explain employment changes. The model therefore allows a relatively broad set of possible adjustment costs, namely fixed, linear and convex and also allows for differences in the cost of increasing versus reducing employment. The firm has to hire employees in complete units and therefore the model is not differentiable in employment and has to be solved numerically. Second, the model is estimated by indirect inference (Gourieroux, Monfort and Renault, 1993) and crucially the shock process is estimated simultaneously with the adjustment cost parameters. The indirect inference methodology essentially estimates the structural parameters of the model by matching the moments of the data with the moments of the model. This paper therefore goes beyond most of this literature in estimating a fully structural model of employment adjustment[2]. The model parameters are estimated to fit the employment

[2]Another paper that estimates a fully structural model on US data is Cooper, Haltiwanger and Willis (2003), They however do not concentrate on the stickiness of employment as the plant data concerns large plants of generally more than 500 employees.

and output dynamics of a large set of French manufacturing firms. Third, once the structural parameter estimates are obtained it is analyzed how much of the stickiness of employment is caused by adjustment costs versus indivisibility.

The rest of the paper is structured as follows. In section two, a brief overview of the employment adjustment literature is given, in section three the data is described, in section four and five the theoretical model is developed and some model simulations are provided to give insight into the model. Sections six and seven provide the estimation method and results. Section 8 concludes.

2 Employment adjustment: the literature

A large empirical and theoretical literature has investigated the dynamics of employment at the firm or plant level.[3] The dynamics of employment at the firm level are usually explained by positing certain structures of adjustment costs. If adjustment costs are convex, employment will adjust frequently in small amounts but not in large amounts. The convex (and symmetric in hiring and firing) adjustment costs are the standard assumption of the early literature on dynamic labor demand (Sargent, 1978, Shapiro, 1986).

On the contrary, if adjustment costs are fixed or linear, employment adjusts infrequently and in large amounts. Bertola and Saint-Paul (1994) provide a theoretical model of linear adjustment costs. They show that both hiring and firing are less frequent when e.g. firing costs are increased. Hamermesh (1989) using monthly data on 7 manufacturing plants finds that adjustment costs in labor are best described by fixed costs. He finds further that plants production workers remain fairly constant over time, except for large changes when also output changes in large amounts. Davis and Haltiwanger (1990) show that in the LRD 25% of the employment growth rates ly in the

[3] In contrast to the paper here, a lot of the earlier empirical work on employment dynamics at the firm level using panel data does not provide direct estimates of adjustment costs. Rather in the early work the emphasis is on the dynamics of employments where in the estimates of the dynamic employment regressions it is impossible to retrieve the structural adjustment cost parameters. Early examples are e.g. Arellano and Bond (1991) and Nickell and Wadhwani (1991) for UK firms and Bresson, Kramarz and Sevestre (1992) for French firms.

interval [-.05,0.05] They unfortunately don't specify how high the percentage on zero adjustment is, so the 25% is an upper bound of the stickiness considered in this paper. Caballero, Engel and Haltiwanger (1997) find that a large number of plants in the US (in the LRD data) choose not to adjust their employment, even when shortages are large. Varejao and Portugal (2003) report that in a large sample of Portugese plants 75% of the plants do not adjust employment from one quarter to the next. In a study on labor adjustment in Norwegian plants Nilsen et al. (2003) allow for fixed costs and fixed cost as function of size. They find fixed cost unrelated to plant size, so that inaction is larger for small firms.

Overall, the consensus of the literature thus far seems to be that adjustment of employment can not be explained by convex cost alone, one also needs fixed or linear costs. Second, adjustment costs are generally asymmetric (e.g. Pfann and Palm, 1993); where depending on the country, time period and sample sometimes hiring is more expensive than firing or the other way around. A summary of the literature up to the early nineties is given by Hamermesh and Pfann (1996).

In this paper the dynamics of labor adjustment on a set of French firms is investigated. A number of earlier papers have estimated the adjustment costs for French firms. Goux et al. (2001) use a panel of 915 French manufacturing firms for which they can measure the number of hirings and firings for indefinite and fixed term contract workers sepearately. They estimate the costs of employment adjustment for these two types of workers using a dynamic labor demand model with quadratic convex adjustment costs. For indefinite contract workers they find firing cost to be much higher than hiring costs (around 40 times higher) . Their estimates unfortunately only allow to make these comparative statements. They do not allow to measure the absolute amount of adjustment costs.They also find that it is practically costless to adjust workers on fixed time contracts. Using survey data on actual severance payments and actual costs (such as training hours, expenses on job advertising, etc.) upon hiring, Abowd and Kramarz (2003) provide an analysis of hiring and firing costs for French firms. They conclude that for permanent contracts, the cost of hiring are much lower than the cost of firing. However the highest cost of firing are associated with collective terminations, which are reductions in employment of 10 employees or more. These are mostly relevant for larger firms not for the firms in the dataset used here, where reductions in employment of 10 persons are very rare. Based on two cross-sections Kramarz and Michaud (2004) revisit the findings of Abowd and Kramarz (2003). Again they find that collective terminations have the highest costs. They also find hiring cost to be small, for instance they mention that in two surveys of French firms that hire workers respectively 49% (for 1992) and 62% (for 1996) of the firms declare a zero hiring cost . It is hard to tell in advance the size of hiring or firing cost as most of these costs are hard to observe directly. In principle, in the case of hiring they include job advertising, interview cost and training cost of the employee and the cost of reorganising work. Likewise, the cost of reducing employment includes besides legal severance payments, the cost of helping employee finding new job, and other costs. According to the OECD (OECD,2005), employment protection legislation is relatively strict in France. For permanent contracts (the standard contract in the law) dismissal procedures are highly restrictive in the sense that it is difficult to fire someone for economic reasons only. However, although it might be difficult to fire someone, legal severance payments are relatively low. For instance they amount only to less than 3 months of wage in case of a dissmissal for economic reasons for someone with 15 years of seniority in a firm. Temporary contracts are much less restrictive, but however are restricted in their use. However Abowd and Kramarz (2003) argue that temporary contracts are the more common method of hiring, e.g. up to 80% of all hirings in 1992 according to their data, exactly to avoid the costs associated with terminating permanent contracts. Overall, the findings of the French literature suggest that hiring costs are likely low and firing cost are mostly high for collective terminations and for employees on indefinite term contracts. However they are low for fixed term contracts. The literature also suggests that fixed term contracts are therefore the preferred choice for hiring new employees. Recent estimates for the US suggest very low adjustment cost for labor (Hall, 2004 on industry level data) (Cooper, Haltiwanger and Willis, 2003 on firm level data).

An alternative explanation for the stickness of employment is provided by indivisibility. However, the empirical literature on dynamic labor demand has not given much attention to this issue. This has naturally been the case as the data used in most of the literature have considered plants or firms larger than those considered here. E.g. in the work by Caballero, Engel and Haltiwanger (1997) and Cooper, Haltiwanger and Willis (2003) plants are mostly larger than 500 employees. Others have argued for a minimum role of indivisibilities. Nilsen et al. (2003) mention indivisibilities as a potential explanation of non-adjustment, however dismiss the idea as "less plausible for plants of more than 25 workers".

3 Data

This paper exploits the annual accounts of 1902 small French manufacturing firms. The employment, sales and profit data is obtained from the AMADEUS database. The yearly employment level of these firms (in number of employees) are observed over the period 1995-2003, i.e. 9 years. As is the case with many databases used in the adjustment literature, the gross hiring and firing within the year are unknown so only the net change in the number of employees from year to year can be observed. All manufacturing firms have more than 10 and less than 75 employees on average over the period. The data are trimmed to remove outliers (see the appendix for the details about trimming.)

A limitation of the study (in which it is similar to most dynamic labor adjustment studies) is the absence of hours worked data. To the extent that a fixed employment level can produce different labor inputs by working more or less hours over the year, the stickiness measured by employment level might be overstating the stickiness of labor input. However aggregate yearly manufacturing data suggests that adjustment, over a year, takes place in terms of number of people working rather than hours. Over the period 1995-2003, the simple correlation of aggregate value added growth in manufacturing with employment growth is 0.32, while the correlation with total hours worked is only 0.16. Abraham and Houseman (1994) provide evidence that in Germany, France and Belgium first hours are adjusted rather than employment, at least in the short run. They ascribe this to costly employment adjustment. Aggregate measures of the number of hours worked per employed person show a trend decline in France by 8.5% over the period 1995-2003 (i.e. from 1558 hours to 1431 hours) (OECD, 2005). Hours declined every year except 1996.

Although one can not observe how many plants these firms have, considering they all have less than 75 employees, it is likely that most have just 1 plant. Despite what one might think, small firms are quite important in terms of total value added in the French economy. According to the French statistical office, in manufacturing, firms below 20 employees produce around 10 percent of manufacturing output and firms between 20 and 250 employees produce another 25%. The numbers for services are much higher 30.4% and 22.2 % respectively.[4]Employment stickiness for these firms is therefore

[4]See table NATTEF09204.xls from INSEE website. By comparison, for the US , plants

also likely of importance for the aggregate economy.

For the purpose of analysis the firms are split into five size groups according to the average number of employees over the period. The five size groups are defined using the following intervals ([10,15[, [15,25[,[25,35[,[35,50[,[50,75[ ). Although the intervals are chosen somewhat arbitrary they are large enough so that there are enough firms in each group and small enough so that the firms in each group can be considered to be of similar size. The number of firms in each group are respectively: 353, 532, 302, 448 and 267. For the purpose of the analysis in this paper all statistics are calculated as across firm averages. [5]

Figure 1 depicts the frequency distribution of the absolute (i.e. number of people) yearly employment changes for each firm group. A number of stylized facts can be seen looking at the distributions. One of the more striking features of the employment changes distribution is the frequent absence of adjustment, the mode of the distribution is always at zero for every group. Otherwise said, there are many periods in which employment does not adjust from one year to the other, i.e. stays fixed. The frequency of non-adjustment is 40% for firms in the first size group of 10 to 15 employees, implying that an average firm keeps employment fixed from one year to next in 40% of the years. This frequency of non-adjustment gradually declines and is 16% for the largest size group (50 to 75 employees). These numbers are similar to those found by Nilsen et al. (2003) on yearly Norwegian data. They find, for instance, that for plants of 25 workers or less the frequency on non-adjustment is 25%. So the first stylized fact is that the frequency of inaction is high for all groups but gradually declines for larger firms. Second, firms do not adjust employment in large absolute amounts when they adjust. On the contrary, beside non-adjustment, adjusting employment upward or downward by just 1 employee is the most frequent, adjusting 2 employees is second most frequent, and so on. This seems initial evidence against large

with less than 100 employees represent about 25% of employment in the manufacturing sector (Table IV, Davis and Haltiwanger, 1992)

[5] Each statistic is first calculated for each individual firm over the period 1995-2003 after which the average (accross firms) of these statistics is calculated. For example, suppose the dataset consists of 3 firms, where firm 1 has a frequency of nonadjustment of 1/8, firm 2 of 2/8 and firm 3 of 4/8. The sample frequency would be 1/3*(3/8+2/8+4/8)=3/8.

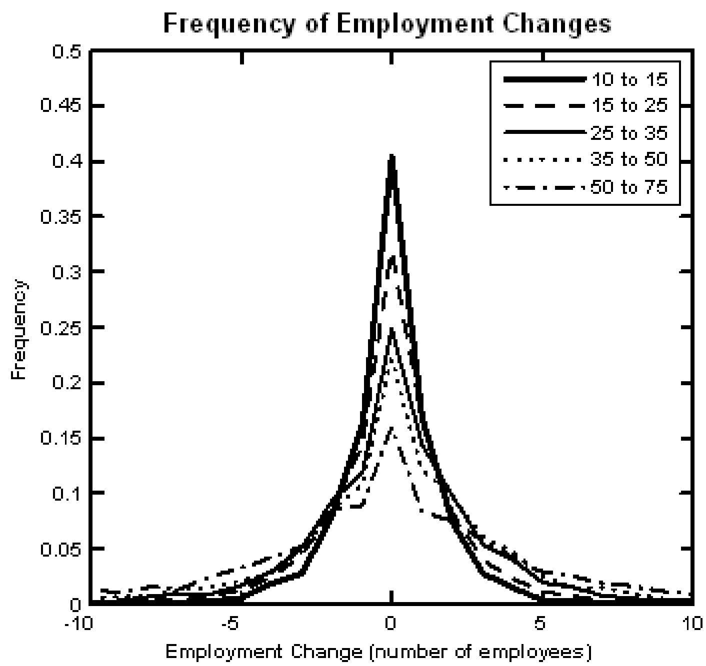

Figure 1: Frequency of employment changes

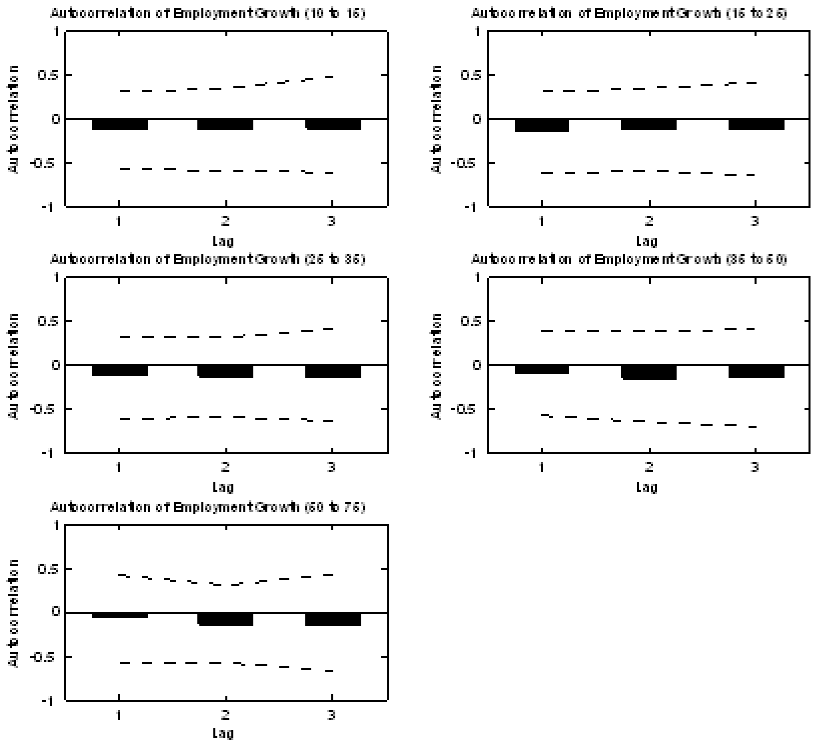

Figure 2: Autocorrelation of employment growth

fixed costs, as such fixed cost would favour adjustment of employment in large amounts. Third, firms adjust approximately as frequently downward as they do upward.

Figure 2 shows the average autocorrelation of employment growth at lags one, two and three with 90% confidence bands (i.e. 90% of the firm level autocorrelations are within that band). In all size groups this autocorrelation is negative at all lags. High employment growth periods are followed by low periods of growth. The frequency of non-adjustment and the negative autocorrelation of employment are a first is indication that a model of partial adjustment with only quadratic adjustment cost is unlikely to fit the data. Negative autocorrelation is expected when large adjustments are followed

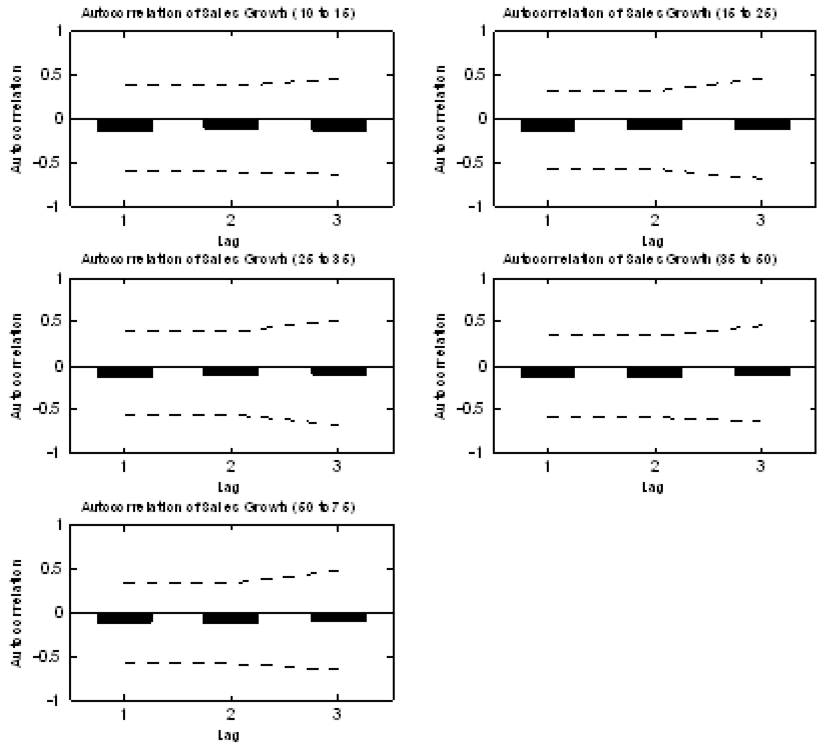

Figure 3: Autocorrelation of sales growth

by non-adjustment. The average negative autocorrelation of employment growth at the firm level coincides with negative autocorrelation of output growth as depicted in Figure 3.

In the next section a theoretical model is developed of a profit maximizing firm. The aim is to estimate the parameters of the model such that they match as closely as possible the features described above, the distribution of employment changes and the dynamics of employment and output.

4 The model

Consider an imperfectly competitive firm with costly employment adjustment. The firm's real output is given by the constant returns to scale Cobb-Douglas production function:

$$Y_{it} \equiv Y(A_{it}, K_{it}, L_{it}) = A_i e^{a_{it}} K_{it}^{\alpha} {L_{it}}^{1-\alpha} \tag{1}$$

where A_i is the productivity level of firm i and a_{it} a productivity shock. The productivity shock is exogenous and follows an AR(1) process

$$a_{it} = \rho_a a_{it-1} + \epsilon_{it}, \tag{2}$$

where ϵ_{it} is distributed normal with mean zero and variance σ_{ϵ}^2.

The firm can adjust its number of employees L_{it} with a cost of adjustment given by the following function:

$$\begin{aligned} C(L_{it-1}, L_{it}) &= I^h(\Delta L_{it})[H^f + H^l \Delta L_{it} + H^c I^h(\Delta L_{it})^2] &(3)\\ &\quad + I^r(\Delta L_{it})[F^f + F^l |\Delta L_{it}| + F^c (\Delta L_{it})^2] &(4) \end{aligned}$$

with $I^h(\Delta L_{it}) = 1$ if $\Delta L_{it} > 0$ and $I^h(\Delta L_{it}) = 0$ otherwise, and $I^r(\Delta L_{it}) = 1$ if $\Delta L_{it} < 0$ and $I^r(\Delta L_{it}) = 1$ otherwise. The function nests different cases of adjustment costs considered in the literature. First, costs are allowed to depend on the direction of change of employment , i.e. increase or reduction of employment matters so that cost asymmetries are allowed. Second, the cost of change in employment is a function of a fixed part, a linear part and a convex (quadratic) part. [6] The production factor K_{it} has no adjustment costs and can be adjusted within the period. K_{it} should be considered here broadly as all other factors of production that can be adjusted within the period.

Demand for the firms output is given by the isoelastic demand function.

$$p_{it} = Y_{it}^{\xi-1} p_{i0} \tag{5}$$

with $0 < \xi < 1$. The price elasticity of demand is equal to $\frac{1}{\xi-1}$.

[6] In the literature, there are also other types of adjustment costs considered. E.g. Cooper et al . (2003) consider a disruption costs, where output is lower when employment adjusts

So output times price is given by $p_{it}Y_{it} = Y_{it}^{\xi-1}p_{i0}Y_{it} = p_{i0}Y_{it}^{\xi}$. Real profits[7] at time t are given by

$$\Pi_{it} = p_{i0}(A_i e^{a_{it}} K_{it}^{\alpha} {L_{it}}^{1-\alpha})^{\xi} - WL_{it} - rK_{it} - C(L_{it-1}, L_{it}) \quad (6)$$

The firm maximizes the present value of the future flow of real profits discounted at a rate β. Profits can be normalized by the wage and after maximizing out the flexible production factor K_{it} the value function of the firm can be written as function of employment and the productivity shock only.[8]

$$\begin{aligned} V(a_{it}, L_{it-1}) &= \max_{\{L_{it}\}} A_i^*(e^{a_{it}})^{\frac{-\xi}{\alpha\xi-1}} {L_{it}}^{\frac{-(1-\alpha)\xi}{\alpha\xi-1}} - L_{it} - C^*(L_{it-1}, L_{it}) &(7)\\ &\quad + \beta E_{a_{it+1}|a_{it}} V(a_{it+1}, L_{it}) &(8) \end{aligned}$$

where A_i^* is just equal to A_i multiplied by a constant [9] ,$C^*(L_{it-1}, L_{it})$ is equal to $C(L_{it-1}, L_{it})$ up to a normalization by W. Adjustment costs can therefore be measured in terms of yearly real wages which are normalized to 1.

The value function has two state variables, current period productivity shock a_{it} and last periods employment L_{it-1} . Employment this period is the only control variable. The value function depends on twelve structural parameters:$\Theta = \{\alpha, \beta, A_i^*\xi, \rho_a, \sigma_\epsilon, H^f, H^l, H^c, F^f, F^l, F^c\}$. The 6 parameters $H^f, H^l, H^c, F^f, F^l, F^c$[10] determine the form and level of adjustment costs. The productivity shock process is governed by the two parameters $\{\rho_a, \sigma_\epsilon\}$.

The effect of indivisibility

The indivisibility in the model is implied by L_{it} taking only values in the set of natural numbers $\{1, 2, 3, ..\}$. When employment is indivisible, i.e.

[7] Instead of productivity schocks one could alternatively model demand schocks leading to an identical profit function.

[8] The model assumes a constant real wage effectively assuming real wage rigidity. This implies that all fluctuations in employment are subscribed to productivity (or demand) shocks At the firm level it is likely that employment fluctuations indeed stem mostly from productivity or demand shocks.

[9] The constant is a function of A_i, r, W, α, ξ.

[10] One should write $H^{f*}, H^{l*}, H^{*c}, R^{*f}, R^{l*}, R^{c*}$ as they are the original parameter normalized by W. However from now on the * is removed from the notation for convenience

when it can only change in multiples of 1, firms will optimally not adjust employment in the face of small shocks *even in the complete absence of adjustment cost*. To see this, consider the static employment problem with indivisibility of labor. Indivisibility in employment creates 'jumps' in the marginal product of labor. Without indivisibility, firms will employ labor up to point where the marginal product of the last employee is equal to that employees wage. However, with indivisibility, the marginal product of the last employee will be larger (or at best equal) than his/her wage. The marginal product of the next (not hired employee) lies below its wage. If the gap between the two marginal products is large enough, small shocks to the marginal product (e.g. productivity or demand shocks) will not lead to extra hiring or firing. The indivisibility can be seen as a real rigidity. It is optimal for the firm not to react (with hiring or firing) to small shocks to the marginal product.

The model makes the implicit assumption that the employment level also determines the level of employment input. Otherwise said yearly hours are fixed in this model. To a certain extent this will provide a maximal potential effect of indivisibility. Outside of the model are two possible ways of adjustment. First, firms could adjust by adding part-time workers. Say a firm with 10 full time employees could hire 0.2 workers if it could find a worker for 1 day per week. To the extent that this worker also has hiring or firing cost this might be too costly. Alternatively, workers could do overtime. However, overtime generally pays a premium in France of about 25% (10% for firms with less than 20 employees) making overtime quickly prohibitively expensive as a solution to increase yearly hours. Including those two margins in the model and investigating them would entail a much more detailed dataset that includes hours worked, hours payed (overtime and regular time) and employment levels in part-time versus full-time employees.

5 Some model simulations

To understand the employment dynamics of the above model the results of a few simple parameterizations is presented in this section. By setting all six adjustment cost parameters $H^f, H^l, H^c, F^f, F^l, F^c$ equal to zero except one parameter, one can distinguish 6 baseline adjustment cost models: the fixed hiring cost model, the linear hiring cost model, the convex hiring cost model, the fixed firing cost model, the linear firing cost model and the convex firing cost model. The model without any adjustment costs is compared with these six basic adjustment cost models to illustrate the effect different adjustment cost have on the dynamics of employment.

Figure 4 shows how the policy function of the six adjustment cost models look like at the steady state employment. On each graph in figure 4 the policy function of the adjustment cost model is shown (in bold) together with the policy function in the absence of adjustment costs. The policy function describes the employment change as a function of the shock a_{it} (at the steady state employment level of the non-adjustment cost model).The parameterization for this figure is $A_i^* =$1.7764, $\sigma_\epsilon =$0.0218 ,$\rho_a =$0.1578 ,ξ=0.8876 and the adjustment cost parameters $H^f, H^l, H^c, F^f, F^l, F^c$ are set consecutively equal to 0.05. Steady state employment of the non-adjustment model is 11 employees.

A number of facts can be seen. First the staircase pattern of the no-adjustment cost policy function is due to indivisibility, employment has to change in natural numbers $\{1, 2, 3, ..\}$. Second, fixed hiring costs cause the firm to not react to small positive shocks (i.e. the employment change is zero) and react once shocks become large enough. Linear hiring costs have a similar no reaction to small shocks effect. However in addition when adjustment takes place it occurs in smaller amounts than the non adjustment model for a given shock. Convex hiring cost also firms don't react to small shocks and react also less than the fixed and linear cost models to larger shocks. It is notable that the convex cost model also small shocks firms do not change employment. The convex hiring schedule is actually identical to the linear hiring cost schedule up to a certain level of the shock. After that react with smaller adjustments towards large shocks than linear hiring cost model

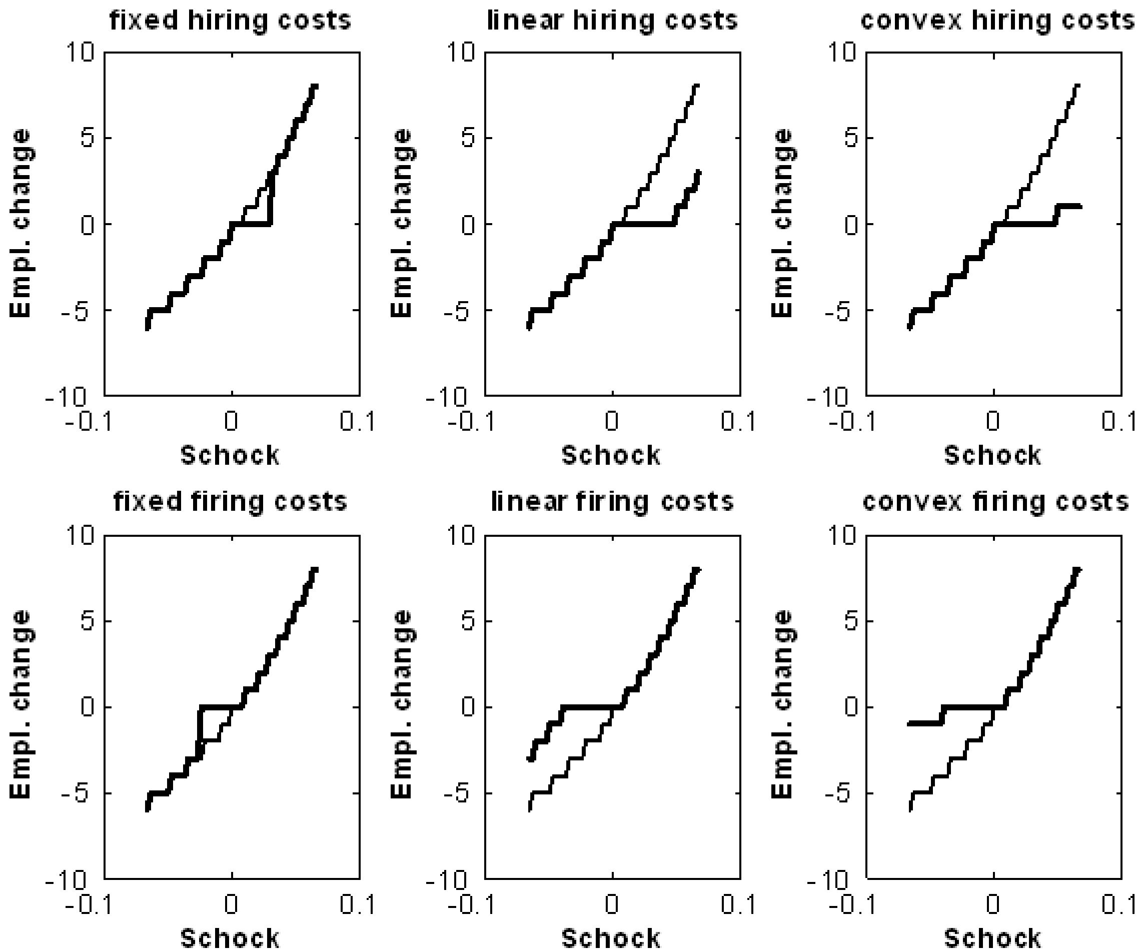

Figure 4: Comparison policy function no-adjustment cost model with 6 adjustment cost models

Table 1: Moments of employment changes for different adjustment cost models

	Frequency non adjust.	+1 empl.	-1 empl.	+5 empl.	-5 empl.	std. dev. empl. growth	autocorr. empl. growth
Data*	0.40	0.17	0.16	0.0035	0.0057	0.13	-0.13
no adj. costs	0.27	0.20	0.19	0.0039	0.0071	0.13	-0.16
H^f= 0.01	0.43	0.05	0.17	0.0057	0.0053	0.13	-0.14
H^l= 0.01	0.44	0.17	0.16	0.0032	0.0032	0.11	-0.08
H^c= 0.01	0.42	0.32	0.15	0	0.0025	0.09	-0.01
F^f= 0.01	0.43	0.19	0.04	0.0039	0.0085	0.13	-0.13
F^l= 0.01	0.43	0.17	0.16	0.0039	0.0028	0.10	-0.05
F^c= 0.01	0.40	0.15	0.31	0.0032	0	0.08	0.02

The data are for comparison from group 1 , [10,15[employees

The policy functions shown above tell what happens after a shock, however do not provide insight into how the distribution of employment changes will look like if one simulates the model for a large set of firms. Table 1 contains the outcome of a set of simulations of the model (353 firms for 9 years) again under different scenarios for the adjustment cost parameters. I.e. the 6 basic models are simulated. Each time the adjustment cost parameter is set equal to 0.01.(The parameterization for table 1 is A_i^* =1.7399, σ_ϵ =0.0147 ,ρ_a =0.8999 ,ξ=0.8912, which are equal to the estimated parameters for group 1) It is noteworthy to see what this implies. For instance consider hiring costs. For all three hiring cost models (fixed, linear, convex) changing employment by 1 employee will costs 1% of a yearly wage. However the hiring of two employees will still cost 1% for the fixed cost model whereas it will cost 2% for the linear and 4% for the convex cost model.

Table 1 compares the frequency of non-adjustment, the frequency of adding (reducing) by 1 or 5 employees, the standard deviation of employment growth and the autocorrelation of employment.

The first finding that can be derived from the simulation exercise is that all adjustment costs increase the frequency of non adjustment compared to the non-adjustment case. The frequency of non-adjustment is lowest in the absence of adjustment costs. However, importantly, even in the no-adjustment cost model the frequency of non-adjustment is not zero. It is still 27%. This is entirely due to indivisibility of employment. Non surprisingly, the frequency of hiring 1 employee is lowest in the case of fixed cost, while it is highest in the case of convex hiring adjustment costs. Symmetrically, reducing one employee is lowest in the case of fixed firing costs and highest in the case of convex firing cost. The table also illustrates the well known effect of convex costs to reduce the frequency of large adjustments. Interestingly, one-sided convex costs reduce the frequency of both large hiring and large firing. The intuition for this result is that since shocks are temporary, firms will have to reverse hiring or firing decisions. Fixed costs increase the frequency of large adjustments however only one-sidedly, i.e. fixed hiring costs induce more frequent large increases in employment but not more frequent large reductions in employment. Employment growth is most volatile in the absence of adjustment costs and least volatile in the presence of convex costs. Also, the autocorrelation of employment is lowest (i.e. most negative) in the absence of adjustment costs. The effect of linear adjustment costs are usually somewhat between fixed and convex costs.

6 Estimation method

The structural parameters of the model are estimated using the indirect inference method as explained in Gourieroux, Monfort and Renault (1993). Essentially the above model can written be succinctly as:

$$Y_{it}, = f^y(L_{it-1}, a_{it}, \Theta) \quad (9)$$

$$\Pi_{it}, = f^\pi(L_{it-1}, a_{it}, \Theta). \quad (10)$$

$$L_{it} = f(L_{it-1}, a_{it}, \Theta) \quad (11)$$

$$a_{it} = \rho_a a_{it-1} + \epsilon_{it} \quad (12)$$

where $\Theta = \{\alpha, \beta, A_i^* \xi, \rho_a, \sigma_\epsilon, H^f, H^l, H^c, F^f, F^l, F^c\}$.

The estimation of Θ consist of a number of steps. In a first step, for a given set of parameter values Θ the value function above is solved using value function iteration. (see e.g. Judd 1998, page 412). The state space of employment is discrete and consists of a subset of the natural numbers[11] The AR(1) productivity shock process is transformed into a discrete Markov process on a very fine grid of 51 points using Tauchen (1986). The solution gives the policy function, i.e. the function $f(L_{it-1}, a_{it}, \Theta)$ (and immediately also f^y, f^π). Given the solution of the model and initial condition $L_{it} = L_0$,

[11] The upper bounds on the employment state space should be wide enough so that the solution is not influenced by them.

it is possible to simulate values of $\widehat{S} = \{\widehat{L}_{it}, \widehat{Y}_{it}, \widehat{\Pi}_{it}, ...\widehat{L}_{it+9}, \widehat{Y}_{it+9}, \widehat{\Pi}_{it+9}\}_{i=1}^{N}$, i.e. to simulate an artificial dataset, where N is the number of firms in the dataset.[12] This simulation is done drawing simulated values of a standard normal distribution which are then multiplied by σ_ϵ to obtain $\{\widehat{\epsilon}_{it}, ...\widehat{\epsilon}_{it+9}\}_{i=1}^{N}$. On both the actual data and the simulated data a set of moments (in the case here there are 21 moments) $\{M_{jN}\}_{j=1}^{21}$ and $\{\widehat{M}_{jN}(\Theta)\}_{j=1}^{21}$respectively is calculated.

The indirect estimator of Θ is defined as $\widehat{\Theta}$, the solution of the quadratic loss function:

$$\min_{\Theta} [M_{1N} - \widehat{M}_{1N}(\Theta)\ M_{2N} - \widehat{M}_{2N}(\Theta) ... M_{21N} - \widehat{M}_{21N}(\Theta)]\Omega \tag{13}$$

$$[M_{1N} - \widehat{M}_{1N}(\Theta)\ M_{2N} - \widehat{M}_{2N}(\Theta) ... M_{21N} - \widehat{M}_{21N}(\Theta)]' \tag{14}$$

where Ω is a positive definite matrix. For the estimation the identity matrix is used. The moments taken cover both the the distribution of the employment adjustments as the dynamics of employment and output. First, one would want the estimated model to match the distribution of employment adjustment as depicted in Figure 1, i.e. the frequency distribution over the range [-5,+5]. This gives 11 moments (i.e. the frequency of an adjustment of -5 employees, -4 etc. up to +5 employees). The distribution of employment changes however does not reveal the dynamics of employment adjustment across time. To that extent 3 additional moments are calculated, the autocorrelation of employment growth (in logs) at lags 1, 2 and 3. To also match the dynamics of output, autocorrelation of output growth (in logs) at lag 1, 2 , 3 are calculated as well. Finally, 3 other moments are added: the average level of employment, the average level of profits (divided by total wages) and the standard deviation of employment growth.

To avoid estimating too many parameters, the discount rate β is set equal to 0.93 throughout the whole exercise. Likewise α is not estimated but is set equal to 0.33 throughout. This leaves 10 parameters to estimate.

7 Results

For each of the size groups the model above is estimated. The five estimated models (one for each group of firms) fit the data very closely. The

[12] In pratice the first 100 years of the simulation are dropped so that the initial condition becomes immaterial.

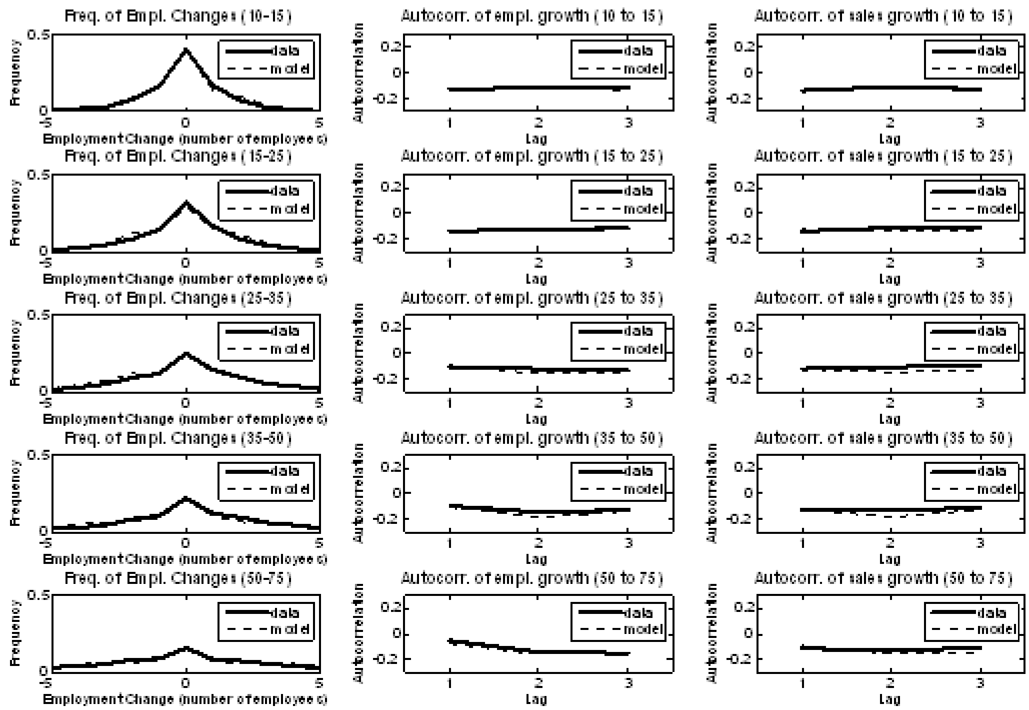

Figure 5: Moments of the data versus the estimated model

estimated moments are very close to the data moments for each of the five stimated models. Figure 5 compares the frequency distribution of employment changes, the autocorrelation of employment growth and of sales between the estimated models and the data. Table 2 compares the data moments with the moments of the estimated model for the average employment level (in logs), the standard deviation of employment growth, the standard deviation of output growth and the profit margin.

Table 2: Data moments versus moments of estimated model

	[10,15[	[15,25[	[25,35[	[35,50[	[50,75[
av. empl (logs) model	2.50	2.93	3.38	3.76	4.11
av. empl (logs) data	2.49	2.95	3.38	3.73	4.11
st. dev. empl growth model	0.12	0.10	0.09	0.09	0.08
st. dev. empl growth data	0.13	0.12	0.10	0.09	0.09
st. dev. outp. growth model	0.14	0.11	0.10	0.10	0.09
st. dev. outp. growth data	0.16	0.14	0.14	0.14	0.14
profit margin model	0.18	0.22	0.20	0.22	0.19
profit margin data	0.18	0.22	0.21	0.22	0.19

The structural parameters of the model can essentially be divided into two subgroups. The first group are the production and demand parameters $\{A^*, \xi, \rho, \sigma_\epsilon\}$. The second group are the adjustment cost parameters $\{H^f, H^l, H^c, F^f, F^l, F^c\}$. The production and demand parameter estimates are presented in Table 3a . They have all very small standard errors (not reported).

Table 3a Structural Parameters Estimates

	Production and demand			
Size classes	A^*	ξ	ρ	σ_ϵ
Class 1 [10,15[	1.74	0.89	0.90	0.01
Class 2 [15,25[	2.09	0.87	0.88	0.01
Class 3 [25,35[	2.12	0.88	0.55	0.01
Class 4 [35,50[	2.43	0.87	0.56	0.01
Class 5 [50,75[	2.30	0.89	0.77	0.01

All parameters are significant at the 99% level

In the theoretical model, holding the other parameters constant, an increase in the parameter A^* (which is a function of the productivity level) will increase the steady state size of the firm. It is therefore not surprising that it is generaly estimated to be larger for the larger firm groups than the smaller firm groups. The estimates of the demand curve parameter ξ are very similar across firm groups (in the range 0.86 to 0.89). They imply an elasticity of demand, between 7 and 9. This is quite close to other estimates in the literature. Estimating a full general equilibrium model using US data, Rotemberg and Woodford (1997) find an elasticity of 7.88 and argue that this estimate is quite plausible. The autocorrelation of the productivity shocks is determined by ρ. For all size groups productivity shocks are highly positively autocorrelated with an estimate of ρ ranging from 0.55 to 0.90. The standard deviation of productivity shocks ϵ_{it} are also similar in size across groups. The standard deviation is around 0.01.

The estimates of the adjustment cost parameters are presented in Table 3b. The adjustment cost parameters estimates imply small adjustment costs in absolute terms. Contrary to what the non-adjustment frequencies might have suggested, the point estimates of the fixed hiring costs are very small (and sometimes even negative). The smallest firm group (10,15 employees) has the largest (and significant) fixed cost parameter estimate at 0.0045, implying a fixed cost of 0.45% of a yearly wage. Otherwise said, imagine a yearly wage of 50000 euro, this would imply a fixed hiring cost of 225 euro. The point estimates of the linear and quadratic hiring costs are also very small. Group 5 has the largest (and significant) estimate of linear hiring costs at 0.2% of a yearly wage per hired worker. Group 3 has the largest convex cost parameter estimate at 0.0003 implying a convex cost of 0.03% per worker hired (squared). Also, the firing cost parameter estimates are generally not large, they are of the same order of magnitude as the hiring cost parameter estimates. For each given firm group, not all cost parameters are significantly different from zero. This implies that the model seemingly does not need 6 parameters to fit the data well. Looking at the individual parameters however is misleading as the total cost of hiring or firing consists of the sum of a fixed, a linear and a convex part. What matters to the firm is to the total cost of hiring or firing. E.g. it is not because point estimates of some fixed costs parameters are sometimes negative that total costs are negative as total costs are the sum of fixed, linear and convex costs! To understand what the individual coefficients imply in terms of the total cost curve, Table 4 presents the costs of increasing or decreasing (in terms of 1 yearly wage) employment by 1 or 5 employees. The numbers in table 4 reaffirm the message of the individual point estimates namely that hiring and firing cost are not large. Hiring or firing 1 employee is not very costly and is between -0.2% and 0.5 % of a yearly wage for hiring and 0.1% and 0.8% for firing. Firing 5 employees costs between 0.4 and 4.2% of a yearly wage bill. Hiring 5 employees costs between -0.6% and 1.2% of a yearly wage bill.

Why are estimated hiring and firing costs so low? With respect to hiring cost the evidence of Kramarz and Michaud (2004) also mentioned above suggest that around 50% of the firms declare a complete absence of hiring costs. Interestingly, Kramarz and Michaud (2004) in their estimations also find that fixed hiring costs are very small and even negative on average. This is consistent with the finding of very low hiring costs in this paper. With respect to firing costs, a possible explanation is the use of temporary contracts. Although the type of contract is not observed in the dataset used here, Abowd, Corbel and Kramarz (1997) state that for France two-thirds of all hiring is on short-term contracts and more than half of separations are due to the ending of these short-term contracts. Goux et al. (2001) note that in 1992, about 80% of all hirings in private firms were made through fixed-term contracts. Despite legal restrictions on short time contracts, the numbers above suggest that they are used quite often in France. The findings of Goux (2001), Kramarz and Michaud (2004) and Abowd and Kramarz (2003) suggest that hiring and firing on fixed term contract has low adjustment costs. Goux et al (2001) argue that European employers can now bypass the regulations of dismissals by offering fixed-term instead of indefinite-term contract. Also, small firms might be less likely to give severance payments above those required by law (which are low) than large firms. The low levels of hiring and firing cost might therefore not be so surprising after all. Evidence from other countries also suggests that labor adjustment costs might be low. Cooper,et al. also find evidence of very small quadratic adjustment costs for the US.

The finding that absolute adjustment costs are low does not imply they are unimportant for the dynamics of employment. Even small adjustment cost can have large implications for the dynamics of employment (In the same vain that small menu costs can have large effects on pricing and output (Mankiw, 1985)).The high elasticity of demand implies that the marginal profits are sensitive to small changes in costs. This implies that small adjustment costs can have large effects. Especially the effect on the frequency of non-adjustment might be quite large. A (seemingly) small adjustment cost can make the difference between hiring or not hiring (or firing and not firing).

Table 3b Structural Parameters: Adjustment Costs

Size classes	H^f	H^l	H^c	F^f	F^l	F^c
Class 1 [10,15[	**0.0045**	0.0000	0.0000	**0.0030**	0.0007	−0.0001
Class 2 [15,25[	0.0016	-0.0011	−0.0001	0.0028	0.0002	0.0001
Class 3 [25,35[	−0.0016	**0.0012**	**0.0003**	0.0024	**0.0025**	**0.0011**
Class 4 [35,50[	**−0.0006**	**−0.0015**	0.0001	0.0002	**0.0077**	0.0001
Class 5 [50,75[	0.0001	**0.0020**	0.0001	−0.0007	**0.0019**	0.0001

Parameter estimates significantly different from zero at the 99% level are in bold

Table 4 The costs of changing employment *

Size classes	−5	−1	+1	+5
Class 1 [10,15[	0.4	0.4	0.5	0.5
Class 2 [15,25[	0.6	0.3	0.0	−0.6
Class 3 [25,35[	4.2	0.6	0.0	1.2
Class 4 [35,50[	4.1	0.8	−0.2	−0.6
Class 5 [50,75[	1.1	0.1	0.2	1.0

*The cost are in % terms of 1 yearly wage

One of the main aims of the paper is to provide a test whether the "shocks-adjustment costs story" versus the "indivisibility- no-adjustment cost story" is behind the stickiness of employment for small firms and in addition to provide quantitative estimates on the relative importance of both of them. The estimated model contains both the effect of indivisibility and adjustment costs. A key question is: What if adjustment cost would not just be very small but effectively zero? What would happen to the frequency of non-adjustment? The way to disentangle the effect of indivisibility from the effect of adjustment costs on the frequency of non-adjustment is to calculate the frequency of non-adjustment under different parameter assumptions. By altering the estimated model parameters, especially the adjustment cost parameters, one can see what happens with the frequency of non-adjustment.

This results of this exercise is shown in Table 5. Table 5 shows what happens with the frequency of non-adjustment in the estimated model when certain structural cost parameters are set to zero instead of their estimated value and all other estimated parameters are left unchanged. Given, the estimation of a structural model, the Lucas critique does not apply. When all adjustment costs are set to zero, one is left with the pure effect of indivisibility (conditional though on the variance of the shock process). Table 5 also shows the frequency of non-adjustment in the data versus the fully estimated model. The estimated model (including the adjustment costs) matches quite closely the frequency of non-adjustment in the data for all firm groups. The last three columns of table 5 show the frequency of non-adjustment upon setting respectively firing cost, hiring cost and all hiring and firing cost to zero in the estimated model. It has often been argued that the high levels of protection of workers against firing in Europe would perversely cause firms also to hire less and therefore cause more sticky employment. Essentially, are the firing costs causing non-adjustment? The difference in the non-adjustment of the estimated model and the model with firing cost equal to zero gives an estimate of the magnitude purely caused by firing costs. Firing cost are indeed causing employment to become more sticky than it otherwise would be in the absence of firing costs. For instance, the smallest firm group would adjust 6.1% more often (39.6%-33.5%) in the absence of firing costs. Nevertheless still a substantial amount of non-adjustment remain even in the absence of adjustment costs. This non-adjustment is entirely due to indivisibility. Table 5 shows clearly that indivisibility becomes less and less important as firms get larger. Where firms of the first group (10-15 employees) would not adjust employment in 27% of the years in the absence of adjustment costs, this would only be 6.7% for firms of the 5th group (50-75 employees). Indivisibility clearly explains more than 50% of the frequency of non-adjustment for firms below 25 employees.

Table 5 Frequency of non-adjustment: estimated model versus data

Size classes	Data	Est. Model	Est. Model $F^f, F^l, F^c = 0$*	Est. Model $H^f, H^l, H^c = 0$*	Est. model $F^f, F^l, F^c, H^f, H^l, H^c = 0$
Class 1 [10,15[	40.4	39.6	33.5	32.9	27.2
Class 2 [15,25[	32.0	29.3	22.3	29.2	22.0
Class 3 [25,35[	24.9	24.1	11.5	24.3	12.0
Class 4 [35,50[	22.2	21.4	4.7	26.3	9.9
Class 5 [50,75[	16.0	15.5	11.7	10.9	6.7

* The Model (adj. cost=0) has the same parameters as the estimated model except all cost parameters

The policy implications are that even seemingly small hiring or firing costs can have large effects. They induce firms to not adjust employment as often as they would otherwise. However, in addition, for firms of the size in this paper, i.e. below 75 employees, other margins of employment adjustment are necessary to be able to fully react to demand or productivity shocks. Simply due to indivisibility small firms will often not hire or fire. The existence of fixed term contracts does not alter this result. Flexibility in working hours (even over periods as long as 1 year) are therefore necessary for those firms to fully exploit profit opportunities that small shocks give them. However, overtime is generally expensive so that at current juncture it is unlikely to be a margin that can be used to the full extent. It is possible that many small firms have (unreported) usage of 'unpaid overtime' or 'extra effort' as an answer to the indivisibility problem they face. The results in the paper clearly show that small firms have a reduced adjustment at the margin of the number of employees compared to larger firms due to indivisibility. Adjustment costs do not even seem to be the most important factor for the smallest firms. The results in this paper also have macro implications. In France, 10% of manufacturing value added is produced in firms with less than 20 employees, for services this is even 30% (in construction even 53%). If demand growth is low (say 1%) these firms will optimally not hire any new people so that indivisibility is potentially an explanation of periods of jobless growth. Jobless growth should be more prevalent in countries where small firms are more important in terms of value added. The results in this paper do beg the question of how small firms do adjust. Much more research is needed in this respect. Does the indivisibility imply small firms adjust more on hours or do they adjust more by hiring part-time or temporary workers? This research however will require much more detailed information on hours worked, temporary workers hired and so on.

8 CONCLUSION

Small firms frequently do not adjust their employment level from year to year. Adjustment costs in terms of hiring and firing costs are only part of the reason. This paper has shown that hiring and firing costs are relatively small. However small cost do reduce the frequency of adjustment substantially. The smaller firms are, the less often they adjust their employment level. A substantial fraction of the non-adjustment stems from indivisibility. It does not pay for small firms to react to small shocks to hire or fire individual workers even in the absence of adjustment costs. To what extent adjustment on other margins such as the hours worked or effort, given overtime legislation, provide a profitable alternative adjustment mechanism for small firms remains an open question. Two lessons for policymakers can be derived. Even the reduction of small adjustment costs (legal severance payments, e.g.) will induce more flexible hiring and firing in small firms. Second, such a reduction can not overcome the indivisibility problem small firms face. A flexible adjustment of hours worked is a necessity for small firms to react to productivity or demand shocks.

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9 Appendix

Construction of the dataset

The dataset was constructed using the AMADEUS database. This database contains balance sheet statement and profit and loss accounts of European firms. First all French manufacturing firms were selected. From this selection, firms with complete data on employment, profit, sales and capital stock for 9 years were kept. To make sure that the selected firms were truly plants and not headquarters without a physical plant, firms that had more than 50% of fixed assets under a different form as tangible assets (i.e financial fixed assets, which are equity in other firms) were dropped. Firms were also dropped if they had a large outlier observation in the 9 year period. The outliers were defined as a growth rate of more than 200% in employment in a given year, a growth rate of sales more than 200% in a given year. Further, firms which employment grew more than 60% over the whole period were removed. This last criterion is done as the model in the paper has a long run stationary employment level of the firm as it solution. This paper is therefore not able to say anything on the relationship between long run firm growth and adjustment costs. This would imply a different type of analysis.