Temporary Workers, Uncertainty and Productivity*

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Abstract

Hiring temporary workers can be viewed as a real option which allows firms to adjust labor input as economic conditions fluctuate and uncertainty about future demand increases. The "purchase price" of this real option may be, among other things, lower productivity. We develop a dynamic model of labor demand with uncertainty that allows us to draw some testable predictions on the level and on the composition of the labor force, according to the level of uncertainty. Using a panel of Italian firms, which collects also a measure of firm-specific uncertainty, we first present evidence that firms adjust the workforce size and composition according to uncertainty. Second, using a set of reforms of permanent and temporary employment, we estimate the relationship between TFP and permanent employment. We find that incentives to hire permanent workers positively affect TFP. This effect is stronger for firms facing higher uncertainty, as those belonging to high-tech sectors.

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1 Introduction

In the last two decades, aimed at reducing unemployment rates, many European countries have undertaken a series of reforms in the labor market in order to increase flexibility "at the margin". These reforms have deeply changed the European labor market and their effects have been studied from many different viewpoints.

One strand of the literature focuses on the employment effect of such reforms trying to assess empirically if labor markets are segmented and/or whether temporary employment arrangements are stepping stones to find a suitable and permanent job in the future (e.g. Ichino and Riphahan, 2005). More recently, increasing attention has been paid to the implications for the firms, often finding a negative relationship between the use of temporary work arrangements and productivity (e.g. Autor, Kerr and Kugler, 2007; Dolado, Ortigueira and Stucchi, 2012; Cappellari, Dell'Aringa and Leonardi, 2012).

These results, however, impose a simple question. Why do firms hire temporary workers then? Undoubtedly, for firms there is an evident trade off between the optimal labor input choice and productivity levels. In this spirit, the contribution of this paper is to show that there is an economic rationale behind hiring temporary workers, if they are viewed as a kind of real option for firms. Since hiring permanent workers implies irreversible costs due to employment protection legislation, when demand uncertainty increases, firms may find convenient to postpone the decision to hire workers permanently. This idea is not new: Dixit and Pindyck proposed it in their textbook "Investment under Uncertainty" edited in 1994. They argue that after the recession of early Nineties, permanent full-time hiring increased slowly because a high level of uncertainty about future demand, which forced US firms to wait before make the commitment involved in hiring permanent workers. In the meantime, they preferred to exploit the current profit opportunities using less irreversible and sometimes more costly (or less efficient) inputs of production, like temporary work, mainly in the form of employment-agency placement. Foote and Folta (2002) explicitly claim that the low productivity associated to hiring temporary workers is the cost of the real option of a lower degree of irreversibility.

The contribution of our paper is to derive a dynamic model of labor demand with uncertainty, where labor is treated as a quasi-irreversible input. Aimed at understanding the role of uncertainty on the level and on the composition (in terms of permanent and temporary workers) of the workforce, we calibrate the model in order to identify one regime with low and one with high uncertainty. Higher uncertainty enlarges the so called "inaction area", i.e. when firm postpones any decision on labor force adjustment; higher uncertainty reduces hirings, both of temporary and permanent workers, but less so for temporary; workers with a closed-end contract - an input completely reversible - are employed as a buffer. We then test these model predictions with an empirical analysis based on a panel of Italian firms for which we have a measure of perceived current output demand uncertainty, along with a measure of productivity for the period that goes from 1999 to 2010.

We carry out two types of empirical exercises. First, we analyze the relationship between firm uncertainty and labor demand growth and composition. Our identification strategy is based on the assumption that firm uncertainty is a firm-specific time-invariant characteristic. Thus, to each firm we assign a measure of uncertainty equal to the level of reported uncertainty about current output demand at the beginning of the period. We then model labor demand as a function of uncertainty and time, sector and region fixed effects. Our main identification assumption is that uncertainty in 1999 affects future labor demand, but the realization of labor demand in the year after 1999 does not affect firm's uncertainty in that year. We find that when uncertainty increases, total labor demand decreases, while the share of temporary workers in total workforce grows.

Second, we would like to verify that firms facing higher uncertainty face also lower TFP, not only because higher uncertainty has a direct effect on TFP, but also because uncertainty increases the incentives to hire temporary workers and temporary workers have a direct negative effect on TFP. To carry out this exercise we need an exogenous source of variation for the incentive to hire temporary workers. Following Cipollone and Guelfi (2002) and Cappellari, Dell'Aringa and Leonardi (2012), we rely on the fact that after 2001 the Italian government undertook several different reforms aimed at reducing the social contributions paid to hire young permanent workers and at the same time ease the use of temporary work arrangements (the so-called "Biagi

Law" of 2003). These interventions exhibits time, regional and sectoral variation. We then derive a variable which captures the disincentive to use closed-end contracts to isolate the effects of these workers on firms' TFP. Also, we control for our measure of uncertainty and for the interaction between uncertainty and the use of fixed term contracts. We find, in line with the previous literature, that TFP is negatively affected by the use of fixed term workers. As suggested by the theory, also uncertainty has a direct and negative effect on TFP. Moreover, the effect of temporary workers on TFP is not uniform across firms, but varies according to the firm-specific uncertainty. Going from the 10^{th} percentile to the 90^{th} percentile of the distribution of uncertainty (a difference equal to 0.17), TFP, on average, decreases by 11 per cent. The incentive to hire permanent workers contributes to the TFP increase for firms facing extremely high uncertainty by roughly 4 percentage points; on the contrary, it has virtually no effect for firms facing very low uncertainty.

Our framework differs from the one proposed by Boeri and Garibaldi (2007), who find a negative relationship between the share of closed-end contracts and firms' productivity growth. They interpret this result in terms of a transitory increase in labor demand induced by the higher flexibility of temporary jobs (the so-called "honeymoon effect"). They derive a model of labor demand with uncertainty, which encompasses a transition from a rigid to a two tier system. The introduction of the new regime, features a honeymoon effect that involves an increase in the share of firms able to adjust their employment levels, a temporary positive effect on average employment, and a temporary negative effect on average productivity because, under the decreasing marginal returns to labor hypothesis, firms hire increasingly less productive workers with closed-end contracts. Other papers investigate the relationship between TFP and temporary employment. Dolado, Ortigueira and Stucchi (2012) model a labor market where labor costs vary by type of job contract. They also present evidence based on Spanish data that higher shares of temporary workers decrease firms' total factor productivity. On a similar perspective, Bird and Knopf (2009) analyze the effects of wrongful-discharge protections on earnings, profitability and efficiency of the US banking sector, finding that a higher employment protection legislation raises wages, reduces profits and lowers productivity. Using time and geographical variation in employment protection legislation, Autor, Kerr and Kugler (2007) find that for the US, the introduction of employment protection legislation reduces productivity by distorting production choices. A higher employment protection legislation would trigger an excessively intensive capital deepening (with respect to optimal input choice of an hypothetical production function). However, they also find that that labor productivity rose substantially following adoption of new employment protection legislation. Similarly, Acharya, Baghai and Subramanian (2009) find that in the US strong dismissal laws appear to have a positive effect on the innovative pursuits of firms and their employees. Based on UK data, Michie and Sheenan (2003) find that the use of temporary workers along with little training (the so-called "low-road" practices to human resource management) is negatively correlated with productivity growth. A similar result is found by Kleinknecht et al. (2006) for the Netherlands: the employment growth in the Eighties and in the Nineties, occurred by means of temporary workers, is followed by a remarkable productivity slowdown. More recently for Italy, Cappellari, Dell'Aringa and Leonardi (2012) find not only that temporary work arrangements negatively affect TFP, but also that the effect differ across temporary job contracts: those associated to some training activity, like apprenticeship have instead a positive impact on TFP (confirming indirectly the "low-road" practice hypothesis).

The paper is organized as follows. Section 2 describes the dynamic model of labor demand with uncertainty, for which we derive some testable implications, while Section 3 is devoted to a description of the data for the empirical testing. Section 4 deals with the effects of uncertainty on labor demand and workforce composition. In Section 5 the relationship between the share of temporary workers and productivity. Section 7 split the results by high and low tech sectors as these two sectors are characterized by different level of uncertainty. Section 7 further investigates possible differences across high and low tech sectors. Finally, Section 8 briefly concludes.

2 A Model of Labor Demand with Uncertainty

As in the standard models of investment under uncertainty, we consider a representative single product firm with homogeneous inputs (e.g. Bloom et al., 2007). Firm's decisions on investment are partially irreversible, and under uncertainty irreversibility generates real options on the investment decisions with a typical separation of the thresholds for investment and disinvestment, with no action undertaken between the thresholds.

Our model of labor demand is based on a very stylized Cobb-Douglas production function with two kinds of labor input, permanent and temporary workers, and is similar to the one developed by Chen and Funke (2009). Since we are interested in firms' behavior concerning labor adjustment, we assume that *i)* physical capital is fixed and firms do not invest, so that the real option term can be univocally attributed to permanent workers' hirings and *ii)* there is no entry/exit in the market, that would require more computational complexity in the model.

The production function of the representative firm is:

$$Y_t = A_t \cdot K_t^{\alpha_K} \cdot L_{P,t}^{\alpha_P} \cdot L_{T,t}^{\alpha_T} \tag{1}$$

where K is physical capital, L_T and L_P are temporary and permanent workers, respectively. The firm faces an isoelastic demand curve:

$$p_t = Y_t^{\frac{1-\rho}{\rho}} \times Z_t \tag{2}$$

where p is the price of the good, $\rho \geq 1$ and Z_t is the demand shock that follows a geometric Brownian motion of the following kind:

$$dZ_t = \eta Z_t dt + \sigma Z_t dW_t \tag{3}$$

where W_t is a Wiener process with independent, normally distributed increments, η is a deterministic drift parameter, and σ is the volatility parameter, so that the demand for the good produced is subject to uncertainty.

From the theory about investment under uncertainty it is well known that when an input is irreversible, a firm's optimal investment rule takes on a threshold form. Adjustment of the labor force when subject to hiring and firing costs will only occur when demand hits some thresholds. It has been well documented that because uncertainty raises the upper threshold for investment (the hiring threshold in this specific case), it reduces the rate of investment, with evident loss of efficiency.[1]

Firm's profits at time t are defined as:

$$\pi = A^{\frac{1}{\rho}} K^{\frac{\alpha_K}{\rho}} L_P^{\frac{\alpha_P}{\rho}} L_T^{\frac{\alpha_T}{\rho}} Z - w_P L_P - w_T L_T - C_P\left(\Delta L_P\right) - C_T\left(\Delta L_T\right) \tag{4}$$

where w_P and w_T are wages for permanent and temporary workers respectively and $C_P(\cdot)$ and $C_T(\cdot)$ are the labor adjustment cost functions (the subscript t is omitted to avoid cumbersome notation). Since the framework production function is a Cobb-Douglas, w_P and w_T also represent the marginal product of the two kind of workers.

Without loss of generality, we assume that, in case of temporary workers, there are no adjustment costs, so that we will set $C_T(\cdot) = 0$. For the sake of tractability, adjustment costs for permanent workers are symmetric and convex functions:

$$C_P\left(\Delta L_P\right) = \begin{cases} c_f + b_f \Delta L_P + \frac{1}{2}\lambda_f \left(\Delta L_P\right)^2 & \text{if} \quad \Delta L_P < 0 \quad (\textit{firings}) \\ c_h + b_h \Delta L_P + \frac{1}{2}\lambda_h \left(\Delta L_P\right)^2 & \text{if} \quad \Delta L_P > 0 \quad (\textit{hirings}) \\ 0 & \text{if} \quad \Delta L_P = 0 \quad (\textit{no change}) \end{cases} \tag{5}$$

where $c_{f/h}$ are fixed costs components for firing and hiring, respectively, $b_{f/h}$ are the unit costs of adjusting the size of the workforce and $\lambda_{f/h}$ are the adjustment speed parameters.

[1]The effect of uncertainty in raising the investment threshold is demonstrated, for example, by Pindyck (1988), Dixit (1989), Bentolila and Bertola (1990), Bertola and Caballero (1994), Dixit and Pindyck (1994) and Abel and Eberly (1996).

Given that r is the rate of return, firms maximize the present discounted value of their current and future stream of profits according to:

$$V = \max_{L_P} \int_0^\infty \left[A^{\frac{1}{\rho}} K^{\frac{\alpha_K}{\rho}} L_P^{\frac{\alpha_P}{\rho}} L_T^{\frac{\alpha_T}{\rho}} Z_t - w_P L_P - w_T L_T - C_P \left(\Delta L_P\right) \right] \exp^{-rs} ds \quad (6)$$

Applying Ito's Lemma, equation (6) becomes:

$$rV = A^{\frac{1}{\rho}} K^{\frac{\alpha_K}{\rho}} L_P^{\frac{\alpha_P}{\rho}} L_T^{\frac{\alpha_T}{\rho}} Z_t - w_P L_P - w_T L_T - C_P \left(\Delta L_P\right) + \eta Z V^Z + \frac{1}{2}\sigma^2 V^{ZZ} Z^2 \quad (7)$$

where V^Z is the derivative of V with respect to Z. The firm's optimal permanent and temporary levels of employment are obtained maximizing the expected discounted value of the future cash flow. Since temporary workers can be terminated at the end of the job contract at no cost, there is neither a real option term associated to hiring or firing them, nor a dynamic effect in firm's choice. Clearly, the model has no closed form; nevertheless it is possible to derive threshold levels for hiring/firing and by means of calibration it is possible to see how the firm's choice on the mix of temporary and permanent employment changes with demand uncertainty.

The first order condition for employment changes yields:

$$\pm b_{h/f} + \lambda_{h/f} \Delta L_P = \nu \quad (8)$$

where ν is the derivative of the value function (6) with respect to L_P. Substituting the cost function depicted in equation (5) into equation (7) and rearranging, we derive firing and hiring decisions for permanent workers.The hiring (firing) thresholds are derived finding the value of ν for which an additional worker (one worker less) would generate negative profits, leading to the following thresholds:

$$\nu = b_h + \sqrt{\left(\frac{2c_h}{\lambda_h}\right)} \text{ for hiring thresholds} \quad (9)$$

$$\nu = -b_f - \sqrt{\left(\frac{2c_f}{\lambda_f}\right)} \text{ for firing thresholds} \tag{10}$$

Given the structure of our model, the "inaction zone", i.e. the region where no hirings and firings occur because the demand shock is not large enough to compensate the costs of adjustment, is

$$-\sqrt{\left(\frac{2c_f}{\lambda_f}\right)} \leq \Delta L_P \leq \sqrt{\left(\frac{2c_h}{\lambda_h}\right)} \tag{11}$$

The larger the fixed costs, the wider the inaction area is: the firm does not hire/fire until the number of hirings/firings covers the fixed costs. Also the adjustment speed parameter affect the inaction area: smaller values of $\lambda_{h/f}$ would imply a smaller inaction area.

The first order condition for temporary employment L_T is the derivative of equation (4) with respect to L_T: it reduces to a simple function of the demand shock Z and the level of permanent employment L_P.

$$\begin{aligned} \frac{\alpha_T}{\rho} A^{\frac{1}{\rho}} K^{\frac{\alpha_K}{\rho}} L_P^{\frac{\alpha_P}{\rho}} L_T^{\frac{\alpha_T}{\rho}-1} Z - w_T = 0 \\ L_T = \left(\frac{w_T}{\frac{\alpha_T}{\rho} A^{\frac{1}{\rho}} K^{\frac{\alpha_K}{\rho}} L_P^{\frac{\alpha_P}{\rho}} Z} \right)^{\frac{\rho}{\alpha_T+\rho}} \end{aligned} \tag{12}$$

When the demand shock is positive and large enough to approach the hiring threshold, the firm will hire temporary workers first, and permanent employees after. Symmetrically, as the demand shock is as negative as to hit firing thresholds, the firm will adjust workers with a closed-end contract first and permanent employees subsequently. In summary, the availability of temporary workers widens the inaction area and serves as a buffer to adjust labor force - quickly and cheaply - to unexpected demand fluctuations, as reported on Figure 1 .

As mentioned above, we are mainly interested to understand how uncertainty, proxied by the volatility parameter σ in equation (3), affects the number of hirings and their composition, in terms of open and closed-end contracts. To do so, we calibrate the model as indicated on Table (1), with σ that takes two possible values, one for a low uncertainty regime ($\sigma = 0.15$) and one for a high uncertainty regime ($\sigma = 0.25$). Moreover, we assume that wages are the same for permanent and temporary workers.[2] Hiring and firing thresholds are depicted on Figure (2). Consistently with the rigidity of the Italian labor market, the model has been calibrated in such a way that hiring and firing thresholds are never symmetric, with the firing threshold being more flat the the hiring threshold. High levels of uncertainty make the firing threshold even more flatter, while hiring thresholds become steeper with higher uncertainty.

Based on the aforementioned calibrations, the stylized model allows us to draw some testable implications, based on the graphical evidence depicted on Figure (3):

Hypothesis 1: when uncertainty increases, the number of total hirings decreases;

Hypothesis 2: when uncertainty increases, the number of temporary hirings decreases, but seemingly less so with respect to permanent hirings. Consequently, the share of temporary workers in total workforce increases;

Hypothesis 3: when uncertainty increases, the number of permanent hirings decreases;

Hypothesis 4: when uncertainty increases and the "inaction area" becomes larger, preventing firms to adjust labor force to demand conditions, therefore undermining their efficiency (hence productivity).

The next section is devoted to test empirically these hypotheses on a sample of Italian manufacturing firms for the 1999-2010 period.

[2] We also calibrated the model with different wages, in particular we set $w_T = 0.8 w_P$, but the results are confirmed.

3 The Data

The data used in the empirical analysis come from two sources. The first is the Bank of Italy yearly survey on industrial and non financial service firms with more than 20 employees (INVIND, hereinafter). The survey collects data on the most relevant variables on company activities, like investment, sales, ICT expenditure, price changes, firm's strategies, and, more importantly, detailed information on employment, such as yearly average job flows and their composition, i.e. permanent vs. temporary workers.[3]. The sample is stratified according to firms' branch of activity, size class and geographical areas. Along with information on the reference year, which is the one prior to the interview, firms are also required to report their expectations on turnover and prices for the current year, which allow us to get estimates of the expected real demand change and to estimate ex post also the size of the unexpected demand shock. Firms are also asked to report an upper and a lower bound for their expected real demand change: these bounds can be used to proxy the volatility of the expected demand, which is bounded from above by the squared of the difference between the upper and the lower bounds. This measure of uncertainty have been used, for instance, to show how capital investments respond to firm-specific uncertainty (e.g. Guiso and Parigi, 1999). For the purpose of this paper, we select only manufacturing firms which started participating in the survey between 1999 and 2001, until 2010 (or until the time of leaving the sample).

The second dataset that we use is the Company Accounts Data Service (CADS) that collects balance sheet information on a large sample of firms, with a very good coverage of large firms (see also Pistaferri, Guiso and Schivardi, forthcoming, for further details). Using balance sheet information, it is possible to build a measure of capital stock, by means of the perpetual inventory method, and to estimate firm level total factor productivity (TFP) with the methodology proposed by Levinsohn and Petrin (2003) that, using intermediate input purchases as a control function, allows us to obtain TFP estimates that do not suffer from the common selectivity and simultaneity problems.

[3]In Italy there are many different types of closed-end job contracts, but our data do not allow us to distinguish them by type, as done by Cappellari, Dell'Aringa and Leonardi, 2012.

Table 2 reports the characteristics of the sample used in the empirical analysis and some statistics on selected variables: total net hires (i.e. minus fires) normalized by total workforce, net percentage growth of permanent workers (equal to the differences between hires and fires/separations of permanent workers), the share of temporary workers in total workforce, the growth rate of temporary workers and the log of TFP. The sample size coming from the merge of the two datasets ranges from about 1,100 firms in 1999 to roughly 700 in 2010 (Table 3).

4 Uncertainty and firms' workforce

4.1 Empirical strategy

In this section we present evidence to support the hypothesis that uncertainty affects labor demand and its composition, by discouraging firms to hire permanent workers. This is a direct test of the validity of the hypotheses 1-3 discussed in Section 2. Therefore, we look at the relationship between uncertainty and: (1) total workforce change, defined as the ratio between the difference of total hires and separations between time t and $t+1$ and total workforce at time t; (2) the percentage change of permanent workers, defined as above, but only on the flows and the stock of permanent workers; and (3) the share of temporary workers in total workforce.

For the empirical analysis we need then to define uncertainty. As already mentioned in section 3 INVIND collects data on firms' expected demand volatility for each year that a firm participates to the survey. In some sense, our survey suggests that each year firms observe their market and, given current and past information, they update their belief about the parameters η and σ of equation 3. However, a regression of labor demand on firm's contemporaneous uncertainty may be problematic, because this can be interpreted as causal only if one assumes that product markets are fully competitive and output demand is fully exogenous to firms' control. Under less restrictive assumptions, for instance monopolistic competition, firms can influence product demand and, consequently, uncertainty and labor demand.

To partially overcome this problem we estimate the following model:

$$l_{i,t,r,s} = \alpha\sigma_{i,r,s,0} + \beta_t + \gamma_s + \delta_r + u_{i,t,r,s} \tag{13}$$

where i denotes the $i-th$ firm, t ($t = 0, 1, ...T$) is time, s is the 3-digit NACE sector and r is region. $l_{i,t,r,s}$ is the outcome we are interested in. The term $\sigma_{i,0}$ (other indexes are dropped to ease notation) is equal to the level of uncertainty registered by firms at the beginning of the period. This is equal to 1999 for those which participated to the survey in that year and 2000 or 2001[4] for those entering the sample at that time (firms entering the sample in subsequent years are excluded). The term $\sigma_{i,0}$ is time invariant.

The basic assumption of our specification is that, after controlling for time, sector and regional trends, labor demand at time t is explained by the firm-specific level of uncertainty $\sigma_{i,0}$. We assume that even if $\sigma_{i,0}$ is potentially endogenous with respect to contemporaneous labor demand $l_{i,0}$, it is not endogenous to future realized turnover as t grows. In other words, we assume that current uncertainty $\sigma_{i,t}$ at time t (which, accordingly to the theoretical model presented in section 2, should affect labor demand at the time t) depends on firm-specific uncertainty at time zero, plus other factors partially captured by time, sector and region fixed effects. The variable $\sigma_{i,0}$ is then a proxy for current uncertainty and, as long as it is measured before $\sigma_{i,t}$ is determined, it can be viewed as a good proxy-control, according to the definition used also by Angrist and Pischke (2008).

It is important to stress that the validity of our assumption is based on the hypothesis that firms at time zero are not able to set long-term strategies which affect both uncertainty and labor turnover and workforce composition in the future. Our identification strategy allows to easily exclude reverse causality, i.e. the case in which realized labor demand at time t determines uncertainty at time zero. However, it does not allow us to exclude that labor turnover at time t has been determined by other factors determining also uncertainty at time zero.

Here, we argue that our main hypothesis is not so strong if one first considers that turnover depends also on job separations and, especially for permanent positions,

[4]During these years the cross-section distribution of uncertainty remained fairly stable

separations are not under firms' control, but depend on workers' decisions to change job or to retire. During the period that we consider retirement decisions were affected by many reforms, which could not be anticipated in 1999-2000. Second, we also look at realized workforce composition, which depends on the possibility to hire temporary workers, subject to numerous reforms occurred after year 2001, as we will discuss more extensively in the section **??**. Therefore, we argue that both realized turnover and composition of workforce are at least in part exogenous to firms'decisions at time zero.

Finally, endogenity of uncertainty at time zero with respect to realized turnover at time t, would imply a high ability of firms to set long term strategies. This ability in turn depends on market power, i.e. the capability to control product demand. Market power of firms in our sample is indeed likely to be very low. The plausibility of this hypothesis can be appreciated if one considers firms' market shares (a proxy for market power). For each firm in the sample we have computed the share of its value added in total national sector value added, by using a rather detailed definition of sectors (NACE 3-digit). In 1999, the average market share was indeed very low (equal to 0.009). It is important also to mention that on average the firms of our sample export roughly 20% of their output, facing also high international competition.

Nevertheless, even if our exogenity assumption is likely to be not very strong in Section 6 we present also some additional estimates to further support out identification strategy.

4.2 Results

Table 4 reports the estimates of equation (13) and the 3 outcomes that we consider. In all estimates standard errors are robust.

In all the specifications the measure of uncertainty is related to the outcome variable in a way which is consistent with the real option theory. Uncertainty reduces the growth of total workforce and of its permanent component. It positively affects the share of temporary workers in total workforce. Going from the 10^{th} to the 90^{th} percentile of the distribution of uncertainty, total labor demand decreases by -0.006, the sample average being equal to -0.003. The effect on permanent workers is -0.005

(the average is equal to -0.01), while the share of temporary workers in total workforce increases by 1 percentage point (over 8 percentage points on average).

5 Total factor productivity

5.1 Empirical strategy

Modeling the relationship between TFP, worker composition and uncertainty is further complicated by the fact that, not only current uncertainty, but also workforce composition and TFP are surely jointly determined. Therefore, we need an exogenous source of variation of workforce composition.

To solve this problem, we construct a variable which is based on some legislative changes occurred in Italy during the period that we consider as an external source of variation for workforce composition. At the beginning of the last decade, the national government drastically reduced social contributions paid by firms for newly hired permanent workers aged no less than 25 years old and not working with an open-end contract in the 24 months prior her/his hiring. This tax credit was aimed at supporting firms hiring permanently and applied to all new hires that took place since October 2000. A firm was eligible for the tax benefit if the newly hired worker increased the overall number of permanent employees over the average recorded the previous year. It is widely believed that the tax rebate paid by the government was very generous, especially for firms located in Southern Italy, where the benefit was 50% higher than in other regions.[5] Because of severe budget constraints, in 2003, the Italian government reduced the benefit and its automatism. In 2007, this benefit was completely turned off. However, after 2007, some Italian regions, at different times, introduced similar incentives, even if the amount of the tax rebate was in many cases

[5] Cipollone and Guelfi (2003) show that firms used this subsidy to hire under open-end contracts primarily those workers who would have been hired under such a contract regardless the subsidy, even though after a short transition into temporary employment. Also their findings are consistent with real option theory. Under uncertainty on workers' skills, temporary work arrangements can be viewed as a call option which give to firms the right to hire a worker with an open-ended contract only after having observed their productivity. If the cost of irreversibility decreases substantially because of the fiscal incentives, firms might prefer to do not buy this option and hire workers with an open-end contract.

less generous.[6] Therefore this fiscal incentive varied by intensity, time and region. We then define a variable equal to 0 in the years and regions when the fiscal incentive was not in place and to the tax rebate (normalized by the maximum value paid) for the years and regions of adoption.

Thus, we first run the following regression, aimed at showing that indeed fiscal incentives affects the demand for permanent and temporary workers in our sample:

$$l_{i,t} = \lambda_1 F_{r,s,t} + \beta_t + \gamma_s + \delta_r + u_{i,t,r,s} \tag{14}$$

where $l_{i,t}$ are the growth rates of temporary and permanent workers in the firm, β_t, γ_s, and δ_r are time, sector and region fixed effects respectively, and $F_{r,s,t}$ represents fiscal incentive to hire permanent workers in region r and sector s at time t, and $u_{i,t,r,s}$ is the error term.[7]

Then, following the notation of section 4, we define (log) TFP as $y_{i,r,s,t}$ and we estimate the following regression:

$$y_{i,t,r,s} = \alpha\sigma_{i,r,s,0} + \lambda_1 F_{i,r,s,t} + \lambda_2 F_{i,r,s,t} * \sigma_{i,r,s,0} + \beta_t + \gamma_s + \delta_r + u_{i,t,r,s} \tag{15}$$

where the interaction term $F_{i,r,s,t} * \sigma_{i,r,s,0}$ is aimed at capturing the effect of the incentive to hire permanently as uncertainty increases. A positive sign for λ_1 is a signal that incentive to hire permanently has a positive effect on TFP (as indirectly confirmed also by Cappellari, Dell'Aringa and Leonardi, 2012). A positive sign for λ_2 suggests that the effect is differentiated by uncertainty, being higher for those firms that face more volatile markets and, because of uncertainty, hire more temporary workers.

5.2 Results

Other things equal, the variable F should negatively affect the growth rate of temporary workers (Columns (1) and (2)) and positively affect the growth rate of permanent

[6]The regions paying this tax rebate were Umbria, Liguria and Friuli-Venezia Giulia from 2007, Piedmont for 2007 and 2008, Emilia-Romagna in 2008 and 2009, Sardinia and Marche from 2008, Lazio in 2010

[7]We do not include firms' fixed effects as the variables are expressed in percentage change.

ones (Columns (3) and (4)). This is exactly what we find in the regressions presented in Table 5.[8] Standard errors are robust. According to our the introduction of the highest fiscal incentive to hire permanently (paid in the Southern regions between 2001 and 2003) increases the growth rate of permanent workers by around 3 percentage points.[9]

We now consider TFP. Table 6 reports the estimates based on equation (15). The first column includes only the reform variable F and confirms the strong effect on TFP of incentives to hire permanent workers. The effect is similar in sign and size to what found by Cappellari, Dell'Aringa and Leonardi (2012). The second column includes firm-specific uncertainty and the sign is negative, as suggested by the theory. Column (3) includes both terms, while column (4) includes also the interaction between $\sigma_{i,r,s,0}$ and $F_{i,r,s,t}$. The coefficient λ_2 is positive. When the interaction term is included, the effect of F decreases considerably and it is not statistically significant from zero. This evidence confirms that the effect of incentives to hire permanently affects TFP only when firms' willingness to hire temporary workers increases, i.e. when uncertainty about output market increases. In other words, in case of very low uncertainty, the effect of permanent workers on TFP is negligible. The effect of the incentive to hire permanent workers on TFP is instead stronger for firms who use temporary workers as substitute for permanent positions as uncertainty increases. Going from the 10^{th} percentile to the 90^{th} percentile of the distribution of uncertainty (a difference equal to 0.17) TFP, on average, decreases by 11 per cent. The incentive to hire permanent workers contribute to increase TFP for firms facing extremely high uncertainty by roughly 4 percentage points.

In all, our estimates suggest that on average the negative relationship between temporary workers and TFP typically found in the literature might be due not to lower productivity of temporary workers, but to uncertainty, which both affects TFP and lead firms to hire more temporary workers to increase flexibility.

[8]To test the robustness of our results to a different specification of the variable F, in additional estimates, instead of using a normalized version of F we set it equal to 1 if case of positive incentive and zero otherwise. Results are similar to those presented in Table 5.

[9]These figures are compatible with aggregate data on permanent employment growth in Italian private sector during the same period. See e.g. Bank of Italy, 2002, Annual Report.

6 Robustness checks and IV

In Section 4 we argue that we cannot exclude that firms at time zero set a long-term strategy which contemporaneously determines their uncertainty and future labor demand. This possibility is more likely as t, i.e. the time in which we measure employment growth and workforce composition is close enough to time zero, the time in which we observe uncertainty. This potential source of bias should be instead smaller as t is far from the beginning of the period that we consider.

To support our identification assumption in Table 7 we split the sample in two parts and we carry out the same estimates presented in Tables 4 and 6 for the sub-sample of firms in years 2006-2010. All the results have the same sign of the estimates based on the full period 1999-2010 and are statistically significant.

To further support our identification strategy we also carry out IV estimates. Using survey data, we use a measure of the exogenous shock to product demand suffered by firms at time zero. As mentioned in Section 3 INVIND collects each year the realized sales at time t, at time $t-1$ and the expected change between t and $t+1$ (in real terms, as it collects also realized and expected price changes). It is then possible to calculate the (squared) difference between the expectations formulated at time $t-1$ about time t and the realized change at time t.[10] As before, we consider employment growth (total and permanent), workforce composition and TFP in the period 2006-2010. We argue that the unexpected demand shock at time zero can affect firm's belief about the shape of the distribution of shocks. It is reasonable to assume, however, that it cannot exert a direct effect on the main outcome variables after 7 years.

Column (1) of Table 8 reports the first stage. According to the results, the large is the unexpected demand shock occurred at time zero, the higher is firm's perceived uncertainty. IV estimates of total and permanent employment growth and workforce compositions have the expected sign and, with the exception of workforce composition (column 4) are significant and larger than those reported in Table 7. Also TFP is

[10] We calculate the unexpected demand change at time zero, equal to the change between 1998 and 1999 if the firm was already present in our panel and to the next two changes for firms entering the sample in 2000 or 2001 (as for $\sigma_{i,0}$).

negatively affected by an increase in uncertainty. The IV estimated effect is 5 times larger than the one obtained by OLS and this lead to conclude that OLS estimates are likely to be a lower bound for the true effect of uncertainty on TFP.

Finally, let us mention that as additional robustness checks, in some unreported estimates we have added the average and the standard deviation of the real value added growth of firms included in CADS (NACE 3-digit sector), for each year between 1999 and 2010. These additional controls are aimed at capturing time-varying sectoral trends. The results closely resemble those presented in Table 4. We also carried out estimates using alternative specifications. We used a time-varying measure of uncertainty $\sigma_{i,t}$ and a dynamic model specification, estimated by a standard Arellano-Bond GMM estimator. These estimates are aimed to test for bias due to possible autocorrelation of residuals. Also in this case, the results are very similar to those reported in Table 4.

7 High and low tech sectors

One of the most relevant determinants of sectoral uncertainty is technology (Krishnan and Bhattacharya, 2002). If we look at the distribution of firm-specific uncertainty at the beginning of the period by low and high tech sectors, identified according to the standard OECD classification, we find that in Italy at the beginning of the past decade the distribution of the firm-specific uncertainty is more skewed to the left for high-tech sectors.[11]

Accordingly, we expect the effect of uncertainty on labor demand to be stronger in high-tech sector; similarly, the effect of uncertainty and of the use temporary workers on TFP should be even stronger. Table 9 reports the results of the regressions (13)-(15) separately for high and low tech sectors. This exercise is not only interesting *per se* but can also be viewed as a further robustness check.

The first 3 columns of Table 9 refer to labor demand equations. All the coefficients have the same sign and magnitude than those reported on Table 4. However, the two

[11]For the purposes of this paper, we label hight (low) tech those firms belonging to the high (low) and medium-high (-low) OECD classification. High tech manufacturing sectors include NACE 2-digit 24, 29, 30, 31, 32, 33, 34, and 35.

sectors differ because of the impact of temporary employment of TFP. While the effect of uncertainty in both sectors is negative and of similar magnitude, the impact of the incentive to hire permanent workers is positive for high-tech sectors and nil for low-tech sectors. The possibility to invest in permanent employment is more fruitful in the first sector. Interestingly, in high-tech sector the coefficient of the interaction term $F_{i,r,s,t} * \sigma_{i,r,s,0}$ is not significant. Thus, even in the presence of very low uncertainty the impact of permanent workers in TFP is positive in high tech sectors. This result is in line with the hypothesis that permanent workers are more productive because of higher (firm-specific) human capital. Instead, in the low tech sector, on average there is no evidence of a positive effect of permanent workers on TFP. However, the effect of permanent workers on TFP is positive only for firms facing high specific uncertainty.

In all, this evidence suggests that the positive effect of permanent workers found in high tech sector might be due to their higher rates of human capital accumulation, as a consequence their more stable labor relationship. Our data on hires do not allow us to control for characteristics of the labor force and to test directly this hypothesis. However, some indirect confirmation of this assumption may be derived by looking at the effects on TFP of another reform occurred in the period that we consider, analyzed also by Cappellari, dell'Aringa and Leonardi (2012, see their paper for further details on this contract)).

The reform of apprenticeship was included in the Law no. 30/2003, the so called "Biagi Law", and it was a temporary job contract characterized by lower labor costs. Low labor costs were intended to compensate the training costs paid by firms for workers and the time spent by workers in attending specific training external courses organized by local authorities. Because of this training purpose, these contracts where characterized by duration longer than standard temporary contracts and were typically associated to higher attachment of workers to firms. Legislation to regulate apprenticeship was reformed many times during the past two decades. The "Biagi Law" of 2003, in particular, made apprenticeship more suitable for the firms. However, the new law was not implemented immediately and uniformly, because the regional governments (involved in workers' external training programs) had the power of regulating additional aspects of apprenticeship. Some regions adopted regulations before others generating variation over space and time.[12] Moreover the law no. 80/2005 stated that in the absence of regional regulations, the introduction of the "Biagi Law" should be regulated by sector-specific collective agreements, introducing an additional source of variation.[13]

Cappellari, Dell'Aringa and Leonardi (2012) show that the reform of apprenticeship contracts induced the substitution of temporary workers with apprentices, with positive effects on firms' TFP. They argue that it follows from the training content of the contract and from the longer duration which allow workers to accumulate human capital. When discussing the results of Table 9 we argued that the direct positive effect of permanent workers on TFP in the high-tech sector is probably due to the possibility for permanent workers to invest in firm-specific human capital. If this story holds true, we should find that also the introduction of apprenticeship, which was directly aimed at increasing human capital, should have the same effect on TFP of high-tech firms, regardless any indirect effect of uncertainty. Similarly, we should find no effect of apprenticeship in low-tech industries, where the process of specific human capital accumulation is likely to be less intensive.

We then define a dummy, labeled A equal to 1 for the years and sectors when the apprenticeship reform took place. First, if we consider the full sample and we do not split it by high and low tech sectors, we find that the overall average effect of apprenticeship on TFP is around 3%. The size of this effect is fully comparable with the finding of Cappellari, dell'Aringa and Leonardi (2012), who run a similar regression. The results of the estimates by high and low tech firms are reported in Table 10. Unfortunately, INVIND does not collect information about firms' apprentices, and we cannot replicate the estimates presented in columns (1)-(4) of Table 9. Thus, Table 10 refers then to TFP only. The effect of apprenticeship on TFP is very high in high-tech firms (around 10 percentage points) and nil in low tech firms. In the first sector, when controlling for uncertainty and for the interaction term $A^*\sigma_{i,0}$, the effect of apprenticeship survives and does not change its size, confirming that the

[12]These were Emilia-Romagna, Tuscany, Friuli-Venezia Giulia, Marche, Sardinia and the Autonomous province of Bolzano

[13]Between 2004 and 2007, collective agreements round involved Textile, Wood Products, Chemicals, Food Products and Metal Manufacturing. Between 2008 and 2010 all the other manufacturing sectors were involved.

positive effect on TFP is not due to the interaction between uncertainty and standard temporary positions, but is likely to be entirely due to this type of job contract, which is associated with training activities. In low tech sectors the direct effect of apprenticeship is not significantly different from zero while both the direct and the indirect effects of uncertainty are statistically significant and have the expected sign.

8 Conclusions

The negative relationship between temporary work arrangements and labor productivity has been largely documented in the literature. However, a simple question arises. Why do firms hire temporary workers then? Firms face is a clear trade off between the optimal labor input choice and productivity levels. In this paper we tried to show that there is an economic rationale behind hiring temporary workers, if they are viewed as a of real option for firms: hiring permanent workers implies irreversible costs mostly due to employment protection legislation, and when demand uncertainty increases, firms may find convenient to postpone the decision to hire workers permanently and exploit the current profit opportunities using less irreversible and sometimes more costly (or less efficient) inputs of production, like temporary work.
We develop a dynamic model of labor demand with uncertainty that allows us to draw some testable predictions on the level and on the composition of the labor force, according to the level of uncertainty. The model suggests that when uncertainty increases i) the number of permanent hirings decreases; ii) the number of temporary hirings decreases, but seemingly less so with respect to permanent hirings; iii) the number of total hirings decreases and iv) firms are prevented to adjust labor force to demand conditions, therefore undermining their productivity level. An empirical test of the aforementioned implications was performed based on data from the INVIND survey, matched with balance sheet information from CADS. Our results indicate that when uncertainty increases, total labor demand decreases, while the share of temporary workers in total workforce grows. Therefore, uncertainty has in impact both on the levels and on the composition of the workforce. Moreover, exploiting an exogenous source of variation of workforce composition, we find that uncertainty

has a negative effect on productivity: the effect of the incentives to hire permanent workers on TFP is stronger for firms who use temporary workers as substitute for permanent positions as uncertainty increases.

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Table 1: Model's parameters and their values for calibration.

Parameter	**Value**
σ_{low}	0.15
σ_{high}	0.25
η	0.00
ρ	0.50
w_P	1.00
w_T	1.00
c_h	0.05
c_f	0.05
b_h	0.02
b_f	0.05
λ_h	0.01
λ_f	0.50
A	1.00
K	6.00

Table 2: Sample size, mean and standard deviation of the main variables.

	Observations	Mean	St. dev.
Firm uncertainty (σ)	10,804	0.081	0.077
Total workforce percentage change	10,796	-0.003	0.096
Permanent workers percentage change	10,740	-0.011	0.135
Share temporary workers	10,804	0.094	0.245
Temporary workers percentage change	10,402	-0.034	0.695
Total factor productivity (log)	10,660	3.066	0.640

Notes: INVIND-CADS data. Firm uncertainty is equal to the squared of the difference between the upper and the lower bound of the real expected demand change in percentage terms, as stated by firms in 1999-2001. Total workforce percentage change is equal to the difference between hires and separations between time t and $t+1$ and total workforce at t. Permanent workers percentage change is defined as above but it refers only to flows of permanent workers. The share of temporary workers is calculated with respect to total workforce. TFP (in logs) is estimated according to the semi-parametric estimator developed by Levinsohn and Petrin (2003, see Section 3 for details).

Table 3: Sample size by year.

Year	**Observations**
1999	1,106
2000	1,081
2001	1,044
2002	988
2003	935
2004	873
2005	859
2006	826
2007	789
2008	764
2009	708
2010	687
Total	10,660

Notes: INVIND-CADS data by year. The sample includes only firms participating to INVIND in 1999 or entering the sample in 2000-2001, for which a merge with CADS was possible.

Table 4: Worker composition and uncertainty.

	(1) Δ total workforce (%)	(2) Δ permanent workers (%)	(3) Hires temporary w. over total work.
$\sigma_{i,0}$	-0.041***	-0.043***	0.057*
	[0.017]	[0.017]	[0.030]
Sector dummies	yes	yes	yes
Time dummies	yes	yes	yes
Region dummies	yes	yes	yes
Observations	10,772	10,744	10,804
R-squared	0.05	0.04	0.32

Notes: In column (1) the dependent variable is the annual percentage change of total workforce. In column (2) the dependent variable is the annual percentage change of permanent workers. In column (3) the dependent variable is the number of yearly hires of temporary workers in total workforce. The fixed effect $\sigma_{i,0}$ is equal to the squared of the difference between the upper and the lower bound for the real expected demand change in percentage terms, declared by firms in 1999-2001. Robust standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 5: Reforms and the growth rate of temporary and permanent employment.

	(1) Δ temporary workers (%)	(2) Δ permanent workers (%)
F	-0.045*	0.022**
	[0.026]	[0.010]
Time fixed effect	yes	yes
Sector fixed effects	yes	yes
Region fixed effects	yes	yes
Observations	9,845	10,241
R-squared	0.036	0.078

Notes: In column (1) the dependent variable is the annual growth rate of temporary workers. In columns (2) it is the annual growth rate of permanent workers. The variable F is a measure of fiscal incentives to hire permanent workers. It is equal to 0 for the years of no fiscal incentive to the hires of permanent workers and equal to the fiscal incentive paid in the region of the main branch of firm, normalized by the maximum incentive paid over the period 2001-2010. The estimates include also time*region dummies. Robust standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 6: TFP, uncertainty and permanent employment. Standard errors in brackets.

	(1)	(2)	(3)	(4)
		TFP (log)		
F	0.034*		0.034*	0.001
	[0.020]		[0.020]	[0.023]
$\sigma_{i,0}$		-0.499***	-0.500***	-0.652***
		[0.069]	[0.069]	[0.092]
$\sigma_{i,0}$*F				0.390**
				[0.150]
Sector dummies	yes	yes	yes	yes
Time dummies	yes	yes	yes	yes
Region dummies	yes	yes	yes	yes
Observations	10,397	10,397	10,397	10,397
R-squared	0.50	0.51	0.51	0.51

Notes: In all columns the dependent variable is the log of TFP, which is estimated according to the semi-parametric estimator developed by Levinsohn and Petrin (2003, see Section 3 for details). The fixed effect $\sigma_{i,0}$ is equal to the squared of the difference between the upper and the lower bound for the real expected demand change in percentage terms, declared by firms in the period 1999-2001. The variable F is equal to 0 for the years of no fiscal incentive to the hires of permanent workers and equal to the fiscal incentive paid in the region of the main branch of firm, normalized by the maximum incentive paid for the period 2001-2010. Robust standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 7: Robustness checks: estimates for the sub-period 2006-2010.

	(1) Δ total workforce (%)	(2) Δ permanent workers (%)	(3) Hires temporary w. over total work.	(4) TFP (log)
$\sigma_{i,0}$	-0.032*	-0.050**	0.079**	-0.572***
	[0.019]	[0.023]	[0.040]	[0.143]
Sector dummies	yes	yes	yes	yes
Time dummies	yes	yes	yes	yes
Region dummies	yes	yes	yes	yes
Observations	3,754	3,749	3,763	3,612
R-squared	0.03	0.02	0.12	0.51

Notes: In column (1) the dependent variable is the annual percentage change of total workforce. In column (2) the dependent variable is the annual percentage change of permanent workers. In column (3) the dependent variable is the number of yearly hires of temporary workers in total workforce. In column (4) the dependent variable is the log of TFP, which is estimated according to the semi-parametric estimator developed by Levinsohn and Petrin (2003, see Section 3 for details). The fixed effect $\sigma_{i,0}$ is equal to the squared of the difference between the upper and the lower bound for the real expected demand change in percentage terms, declared by firms in the period 1999-2001. Robust standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 8: Unexpected demand change. IV estimates for the sub-period 2006-2010. Standard errors in brackets.

	First-Stage	**Second stage**			
	(1)	(2)	(3)	(4)	(5)
	Uncertainty $\sigma_{i,0}$	Δ total work. (%)	Δ perm. work. (%)	Hires temp. over tot.	TFP (log)
Demand shock at t_0	0.383 [0.027]***				
$\sigma_{i,0}$		-0.187*** [0.089]	-0.304*** [0.116]	0.116 [0.203]	-2.747*** [0.589]
Sector d.	yes	yes	yes	yes	yes
Time d.	yes	yes	yes	yes	yes
Region d.	yes	yes	yes	yes	yes
Observations	2,722	2,708	2,710	2,710	2,655
R-squared	0.24	0.04	0.01	0.11	0.50

Notes: The first column reports the first-stage. The $\sigma_{i,0}$ is equal to the squared of the difference between the upper and the lower bound for the real expected demand change in percentage terms, declared by firms in the period 1999-2001. The instrumental variable is the unexpected demand percentage change equal to the difference between realized change observed in 1999 (or 2000, or 2001, according to the time of entry into the panel) and the change that the firms stated to expect for that year during the previous year interview. Columns (2)-(5) reports second-stage regressions. In column (2) the dependent variable is the difference between hires and fires between time t and $t+1$ and total workforce at t. In column (3) the dependent variable id defined as in (2), but it refers only to flows of permanent workers. In column (4) the dependent variable is the share of temporary workers in total workforce. In column (5) the dependent variable (TFP) is estimated according to the semi-parametric estimator developed by Levinsohn and Petrin (2003, see Section 3 for details). Robust standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 9: Uncertainty, fiscal incentives and the effects on workforce composition and TFP by high and low tech sectors.

	High tech sectors				
	Δ total workforce (%)	Δ permanent workers (%)	Hires temp. over total work.	TFP (log)	
	(1)	(2)	(3)	(4)	(5)
$\sigma_{i,0}$	-0.034**	-0.029	0.028*	-0.547***	-0.655***
	[0.017]	[0.018]	[0.016]	[0.095]	[0.126]
F				0.092***	0.067*
				[0.033]	[0.039]
$F^{*}\sigma_{i,0}$					0.263
					[0.205]
Sector d.	yes	yes	yes	yes	yes
Time d.	yes	yes	yes	yes	yes
Reg. d.	yes	yes	yes	yes	yes
Observations	3,245	3,244	3,249	3,472	3,472
R2	0.015	0.012	0.033	0.362	0.362
	Low tech sectors				
$\sigma_{i,0}$	-0.051***	-0.053***	0.152***	-0.448***	-0.626***
	[0.015]	[0.016]	[0.043]	[0.101]	[0.127]
F				0.010	-0.025
				[0.025]	[0.028]
$F^{*}\sigma_{i,0}$					0.463**
					[0.219]
Sector d.	yes	yes	yes	yes	yes
Time d.	yes	yes	yes	yes	yes
Reg. d.	yes	yes	yes	yes	yes
Observations	7,522	7,515	7,550	6,925	6,925
R2	0.032	0.022	0.121	0.525	0.525

Notes: The dependent variables of the first 3 columns are defined as in Table **??**, in column (4) and (5) the dependent variable is the log of TFP. Similarly, the fixed effect $\sigma_{i,0}$ and the variable F are defined as in the previous tables. High and low tech sectors are identified according to the standard OECD definition based of Ateco 2-digit classification. Robust standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 10: Apprenticeship reform and TFP by high and low tech sectors. Standard errors in brackets.

		High tech sectors	
		TFP (log)	
	(1)	(2)	(3)
A	0.103***	0.106***	0.106***
	[0.031]	[0.031]	[0.036]
$\sigma i, 0$		-0.548***	-0.731***
		[0.095]	[0.128]
A*$\sigma i, 0$			0.443**
			[0.172]
Sector dummies	yes	yes	yes
Time dummies	yes	yes	yes
Region dummies	yes	yes	yes
Observations	3,472	3,472	3,472
R2	0.363	0.363	0.363
		Low tech sectors	
A	0.001	0.001	0.001
	[0.024]	[0.024]	[0.024]
$\sigma i, 0$		-0.447***	-0.589***
		[0.101]	[0.127]
A*$\sigma i, 0$			0.367*
			[0.190]
Sector dummies	yes	yes	yes
Time dummies	yes	yes	yes
Region dummies	yes	yes	yes
Observations	6,925	6,925	6,925
R2	0.525	0.525	0.525

Notes: The dependent variable is the log of TFP. The independent variable A is a dummy equal to 1 for those sectors, year and regions where apprenticeship where introduced, and zero otherwise. The fixed effect $\sigma_{i,0}$ is defined as in the previous tables, as well as additional time-sector control variables. High and low tech sectors are identified according to the standard OECD definition based of Ateco 2-digit classification. Robust standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.

Figure 1: Inaction zone, with and without temporary employment.

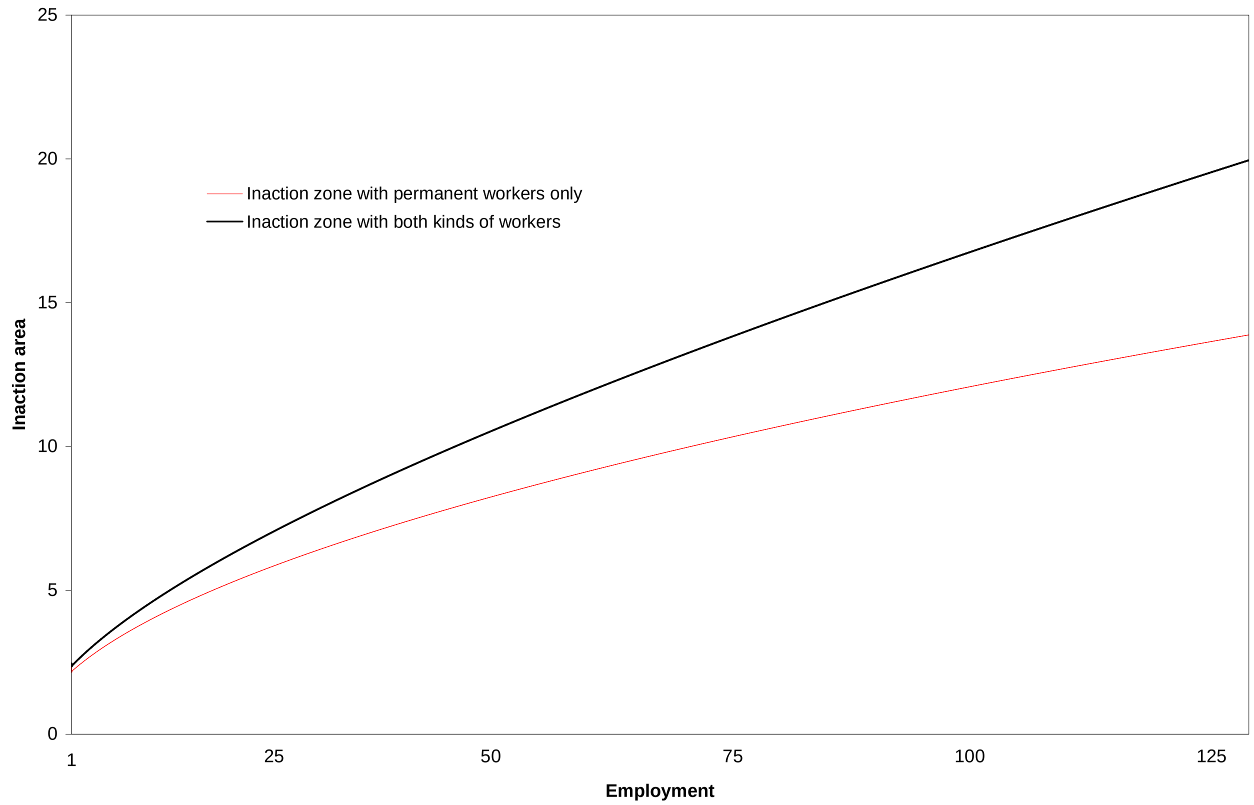

Figure 2: Hiring and firing thresholds with different uncertainty regimes (low and high).

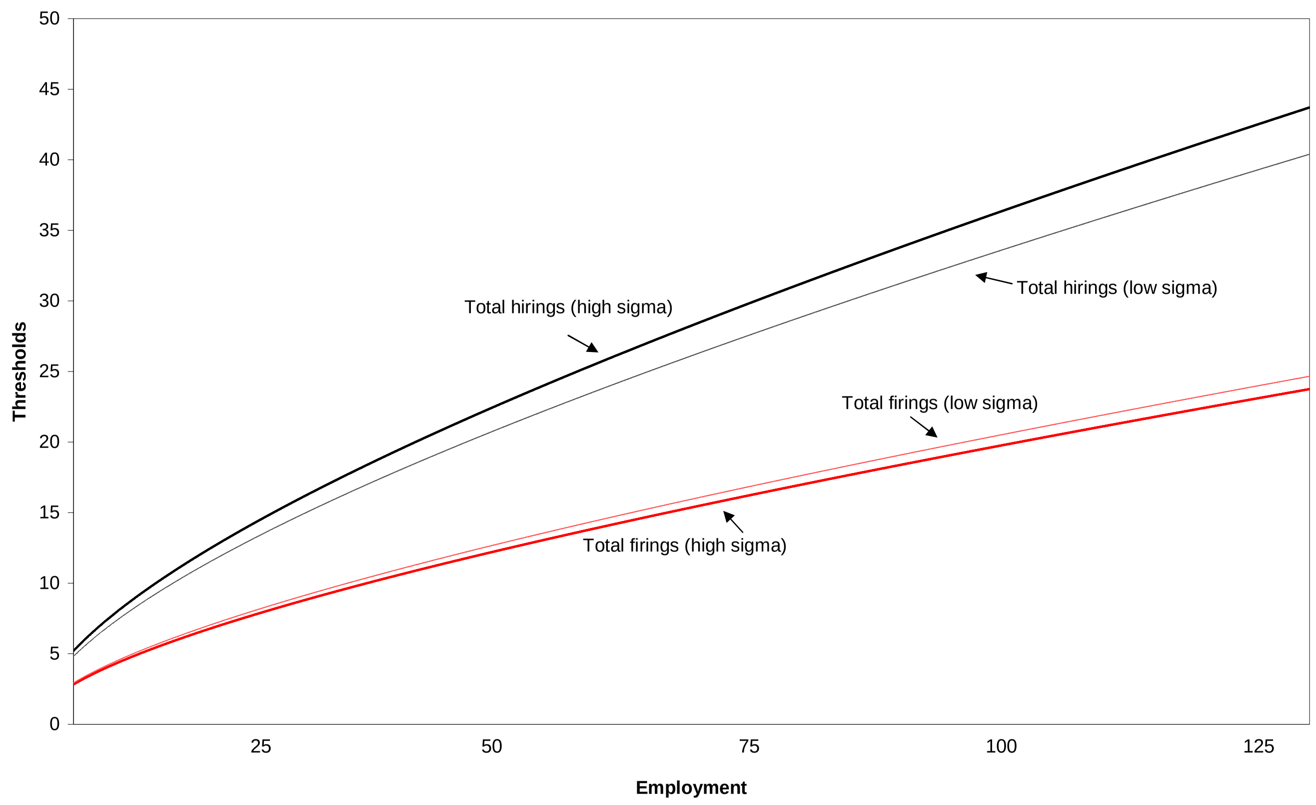

Figure 3: Hiring thresholds with different uncertainty regimes (low and high), for total, temporary and permanent employment.

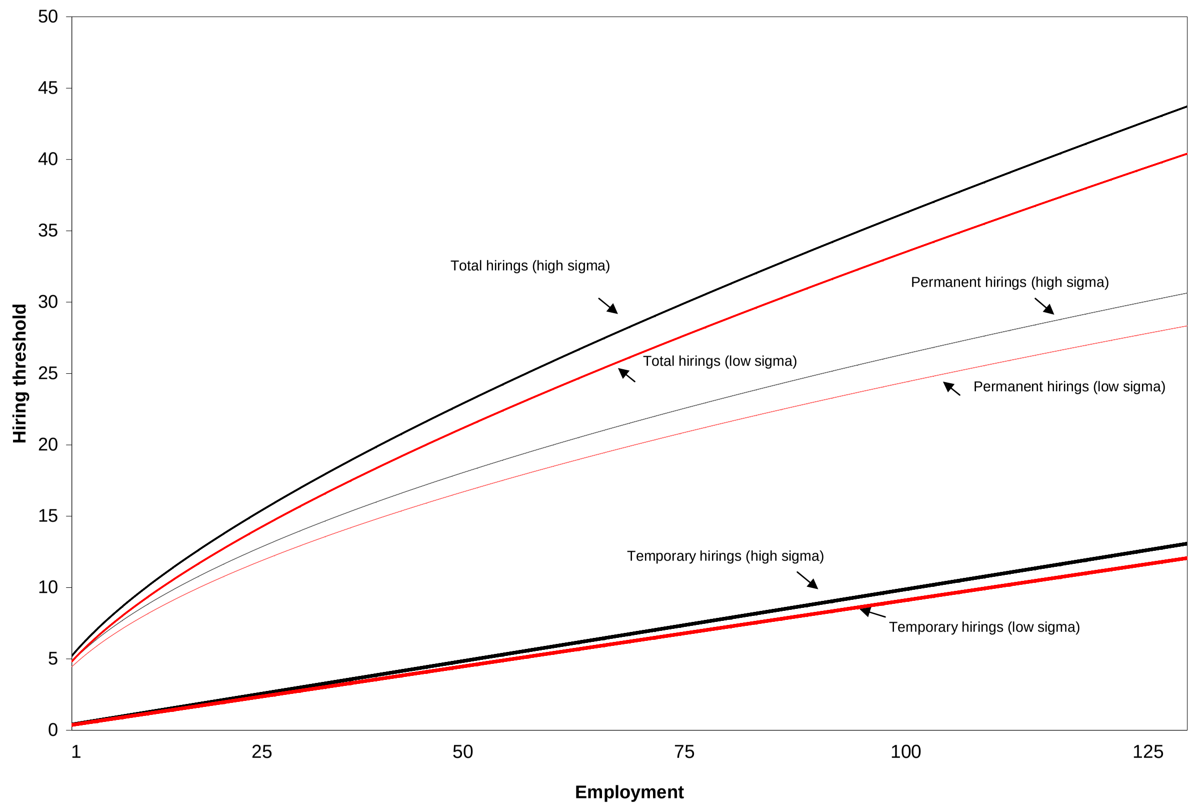

Figure 4: Distribution of firm-specific uncertainty by high and low tech sectors.