The R&D and Innovation Activities
and the Use of External Numerical Flexibility[*]

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Abstract

This paper studies the impact of R&D and innovation activities on the use of external numerical flexibility. The engagement in R&D and innovation is generally associated with both higher expected value and higher volatility of firm productivity and returns. These changes of firm productivity distribution are expected to influence the choice of using temporary labor contracts in opposite directions. Indeed, the comparative advantage of employing temporary workers, with respect to permanent workers, is positively affected by the probability of dismissals, because the latter implies higher firing costs. The probability of dismissals should fall when the expected productivity grows, but it could increase if the tails of the distribution function become thicker, because the probability of incurring in low levels of productivity goes up. The ambiguous effect on the probability of paying firing costs implies an ambiguous effect on the preference for using external numerical flexibility. We investigate which effect prevails using a dataset based on a survey of Italian Manufacturing firms. We run logit regressions to estimate the effect of firm engagement in R&D and innovation on the probability of employing at least a fixed-term or a temporary agency worker. We find a positive and always significant effect. In the last part of the paper, we estimate the effect of different types of R&D and innovation activities. Results show that both intra and extra muros R&D activities have a positive effect (suggesting that the relationship is not due to technological reasons), while the influence of the engagement in innovation changes according to the type of innovation activity.

JEL Classification : J41; O33.

Keywords: Flexible employment, Labor contracts, Research and Development, Innovation.

1 Introduction

In this paper we study the effect of undertaking R&D and innovation activities on the use of external numerical flexibility (ENF). R&D and innovation are considered risky activities, i.e. they are associated with higher but more volatile returns. By ENF we mean labor contracts with a termination date and no cost in case of non-renewal. Of course, both these features make them different from permanent contracts which are openended and entail firing costs in case of dismissal. Since firing costs are an adjustment cost and R&D and innovation imply higher uncertainty, one may expect a positive relationship between undertaking R&D and innovation activities and the use of flexible employment.[1] However, other considerations may suggest a negative relationship. First, R&D and innovation activities should improve firm performance, thus reducing the conditional expectation of future dismissals and the related firing costs. Second, these activities may perform better in the presence of a commitment to a long-lasting labor relationship, since it may induce the worker to enhance her firm-specific human capital.

We address this issue both theoretically and empirically. We begin with a model in which a firm has to choose between a permanent and temporary labor contract and study how the probability of choosing a labor contract changes with changes in the mean and variance of the distribution function of firm productivity (as a result of R&D and innovation activities). We show that, while mean increases drive the firm toward a permanent contract, it is not clear which contract should be chosen with mean-preserving shifts.

We then proceed empirically to estimate the probability of using ENF. Specifically, using a dataset of Italian manufacturing firms, we estimate the impact of undertaking R&D and innovation activities on the probability of using at least a non-permanent contract. Initially, we look at the aggregate of R&D and innovation activities and find that both increase the probability of using flexible employment. When we disaggregate among different types of R&D and innovation, we find some differences. R&D has always a positive impact on the probability of using ENF and the higher the impact is, the larger the amount of activity outsourced. An interpretation of this result is that the increase in uncertainty associated with R&D activity boosts the use of flexible employment in order to reduce the expected loss; however, there could be some positive complementarity between R&D activity and long-lasting labor contracts that mitigates this incentive. When we further distinguish between product innovation and process innovation, we get clear-cut results. While product innovation activity has always a positive impact on the probability of using ENF, process innovation activity has no (or negative) effects. This can be due to the fact that product innovation typically implies higher uncertainty, while

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[1] Hereafter, the terms flexibility and flexible will be used to refer to external numerical flexibility, thus excluding for instance internal numerical flexibility (like part-time contracts) and functional flexibility (changing workers' tasks).

process innovation is generally associated with cost rationalization, whose effects are not so uncertain.

The rest of the paper is organized as follows. Section 2 briefly reviews the literature concerning the firm's choice between permanent and temporary contracts and the literature concerning the effects of R&D and innovation activities. The theoretical model of section 3 investigates how R&D and innovation activities affect labor contract choice. Section 4 presents the empirical strategy: it describes the dataset and discusses the results of our regressions with different sets of explanatory variables. Section 5 concludes.

2 Review of the Literature

2.1 External Numerical Flexibility

The most common definition of external numerical flexibility refers to the possibility of changing the numbers of employed workers by using short-term labor contracts with no firing costs. Of these, the most frequently used are temporary contracts and temporary agency workers. Even if with some differences, these contracts were originally introduced to meet firm specific needs, e.g. substitution of permanent workers temporary out of work or adjustment of the production capacity to peaks of production. Subsequently, the use of flexible employment has gone beyond this original scope and nowadays it has become a way of selecting new employees or a buffer to reduce the costs of possible downsizing.

Some authors assume that short-term and permanent workers are characterized by the same productivity. It follows that, because of the difference in the firing costs, firms should always prefer flexible employment. For example, Cahuc and Postel-Vinay (2002) describe an economy in which both types of employment coexist just because there is an institutional rule limit to the creation of flexible employment. Similarly, Boeri and Garibaldi (2007) describe a transitional economy that starts with a stock of permanent workers and introduce the possibility of hiring flexible employment, the new hired being all with temporary contracts. Others instead support the idea that, notwithstanding the firing costs, permanent contracts may be convenient because they have a higher level of productivity. Aguirregabiria and Borrego (2009) and Caggese and Cuñat (2008) characterize permanent workers with a higher labor-augmenting factor while Addessi (2011) argues that the most important difference is in the contribution to the firm productivity growth. In a similar vein, Albert et al. (2005) find a negative relationship between flexible employment and firm-provided training activities, with likely negative effects on workers' human capital accumulation. Finally, some studies that use cross-country industry-level data (Bassanini et al., 2008, Lisi, 2009, and Damiani and Pompei, 2010) find that the incidence

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of flexible employment may dampen TFP growth. While these studies focus on fixed-term contracts, Hirsch and Mueller (2010) investigate specifically the effect of temporary agency workers on firm productivity and find an hump-shaped relationship: the effect of employing temporary agency workers is initially positive but, for intensive levels of use, it becomes negative. In the light of the above, the assumption of our model that permanent contracts are associated with higher productivity than temporary contracts seems well supported. Notice that, even if this literature addresses the relationship between the type of labor contract and productivity, to the best of our knowledge there is no analysis of how R&D and innovation activities affect the firm's choice of the labor contract. That is, whether the choice of undertaking R&D and innovation activities shifts the preferences in favor of employment flexibility.

2.2 R&D and Innovation Activity

Broadly speaking, firm R&D and innovation activities aim at gaining market power by improving the quality of the product and/or at upgrading the efficiency of the production process. It is difficult to disentangle these effects empirically since dataset generally report firm revenues and not prices, quantities, and product quality, separately. When these activities are studied, they are generally considered a kind of investment characterized by higher mean returns and more uncertainty. A cornerstone in this strand of literature is Griliches (1979) where the R&D expenditure generates "knowledge capital" that increases firm productivity and is characterized by a depreciation rate just like physical capital. Recently, Doraszelski and Jaumandreu (2009) relax some assumptions concerning the relationship between R&D and productivity. They highlight that the accumulation of knowledge is not deterministic and may be non-linear as well as the depreciation process, and instead assume that firm TFP follows a stochastic process influenced by firm R&D expenditure. Their estimation results show that R&D expenditure is characterized by net returns significantly higher than net returns of physical capital. They also estimate that engaging in R&D roughly doubles the degree of uncertainty, i.e. the R&D activity introduces a further source of uncertainty in the production process. In terms of the effect of the R&D on the distribution function of firm productivity, they find that in some industries stochastic dominance emerges. This is because the distribution for performers is to the right of that of non performers, while in others sectors the probability of being in the lowest levels of productivity is higher for performers, even if the average value of productivity is still higher for performers.

The choice of engaging in R&D and innovation activities may be related to the type of institutions characterizing the economic system, particularly with labor market institutions. Saint-Paul (2002) distinguishes between "primary innovation" (characterized by the introduc-

tion of new products) and "secondary innovation" (characterized by the upgrading of the existing products). The former is considered a riskier activity because the demand facing a producer of new goods is more volatile; consequently, firms operating in labor markets characterized by high employment protection (as most of the European countries) should prefer the latter because it implies a lower probability of paying the firing costs associated with the reduction of the workforce. In countries like the U.S., where employment protection is low, firms are less scared of starting a riskier activity because in case of a non-performing outcome they can adjust the level of workforce without bearing firing costs. In Koeniger (2005) the relationship between firing costs and innovation is more ambiguous. Employment protection, on the one hand, deters the entry of new innovating firms because the presence of these costs increases the expected returns required to start a business, but, on the other, pushes incumbent firms to innovate in order to avoid dismissal costs.

Previous contributions assume that labor market institutions such as employment protection legialstion (EPL)[2] are given when the firm has to choose whether or not to undertake R&D and innovation activities. Alternatively, other contributions are more interested in how the performance of R&D and innovation activities is affected by different labor contracts. Zhou et al. (2011) resume some of the reasons that may induce a negative or a positive relationship between the R&D and innovation activities and the use of flexible employment. Permanent employees may be reluctant to adapt to new technologies, may hamper or make the reallocation of labor services very expensive, and may reduce the firm returns from innovation by asking higher wage claims in case of success. On the other hand, the use of ENF may impair the learning organizational process, may reduce employee loyalty and effort in acquiring firm-specific knowledge and firm incentive in providing training. Kleinknecht et al. (2006) estimate that the use of temporary agency workers has a positive effect on employment growth and sales among innovating firms, while the opposite effect emerges among non-innovating firms.[3]

Even if at aggregate level it is reasonable to assume labor market institutions as given, and to study the effect on R&D and innovation activities, when we look at the relationship at firm level it seems more appropriate to investigate the reverse causality. Indeed, the engagement in R&D and innovation is a firm strategic or long-run choice, hence taken before the choice of labor contracts.[4] This explains why we think that no endogeneity problem may arise from our estimations as it is quite hard to see how the presence of at least one flexible employee

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[2]On the interactions about EPL and labor market performance, see Saltari and Tilli (2009).

[3]The opposite occurs referring to temporary workers, but the estimated coefficients are not singnificantly different from zero.

[4]For example, Aw et al. (2009) investigate the effect of R&D and export activities on firm productivity. In their model firms choose whether to engage in R&D and/or export activities assuming that labor services will be chosen optimally

should affect the choice concerning the engagement in R&D and innovation. Thus, our aim is to investigate whether the decision of engaging in R&D and innovation activities affects the use of flexible employment.

3   The Model

In this section, we describe the labor demand for permanent and temporary contracts when firms are subjected to revenue shocks.

Every firm can produce by employing a permanent or a temporary worker which yields a flow of profits $\pi_P(y)$ and $\pi_T(y)$, respectively, where y is a stochastic variable, that we interpret as firm productivity.[5] For each y, the flow of profits deriving from a permanent worker is assumed to be higher than from the temporary worker $(\pi_P(y) > \pi_T(y))$. However, while closing a temporary job is costless, laying-off a permanent worker involves a firing cost F. Firms draw their productivity from a general distribution $G(y)$ with support in the range $y \in [y_{\min}, y_{\max}]$. An idiosyncratic shock to firm productivity occurs at a Poisson constant rate λ.

The equations below are the standard valuation equations, deriving from the no-arbitrage principle and assuming perfect capital markets and a constant interest rate r. The expected present value of profit from a position filled as a permanent job $rV_P(y)$ is given by:

$$rV_P(y) = \pi_P(y) + \lambda \left(\int_{y_P^*}^{y_{\max}} V_P(s)\, dG(s) + \int_{y_{\min}}^{y_P^*} -F\, dG(s) - V_P(y) \right) \tag{1}$$

The left hand side of equation (1) represents the return required by the market for a permanent job, $rV_P(y)$. The job yields a profit flow equal to $\pi_P(y)$. y_P^* indicates the productivity threshold below which the firm lays off permanent workers. Consequently, if the productivity is in the range $y_P^* \leq y \leq y_{\max}$, the firm keeps the permanent worker at the new level of productivity, otherwise it closes the job and pays the firing cost F.

Consider now the asset value of a temporary job. The expected present value of profit $rV_T(y)$ is:

$$rV_T(y) = \pi_T(y) + \lambda \left(\int_{y_{TP}}^{y_{\max}} V_P(s)\, dG(s) + \int_{y_T^*}^{y_{TP}} V_T(s)\, dG(s) - V_P(y) \right) \tag{2}$$

Equation (2) states that the return required by the market $rV_T(y)$ must be equal to the flow

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of profit $\pi_T(y)$ plus the change in value caused by three events: if the new level of productivity is between y_{TP} and y_{max}, the worker is switched from a temporary to a permanent position, where y_{TP} is defined as the level of productivity in which $V_P(y_{TP}) = V_T(y_{TP})$. If instead the new level of productivity is between y_T^* and y_{TP}, the firm keeps the flexible contract (at the new level of productivity), where y_T^* is the threshold value of productivity below which the firm dismisses a temporary worker. Finally, if the new level of productivity is below y_T^*, the temporary worker is fired and the job is closed with no costs.

When a permanent job is closed, the firm gives up $V_P(y)$ and pays the firing cost F. Hence, a permanent job with productivity y will be closed if $V_P(y) < -F$. Similarly, since laying off a temporary job is costless, it will be destroyed if $V_T(y) < 0$. This implies that at the respective productivity thresholds $V_P(y_P^*) = -F$ and $V_T(y_T^*) = 0$.

The firm prefers a permanent job to a temporary job if:

$$V_P(y) \geq V_T(y) \tag{3}$$

Making use of the Bellman equations (1) and (2) and simplifying, eq. (3) is satisfied if:

$$\pi_P(y) - \pi_T(y) + \lambda \left(-G(y_P^*) F + \int_{y_P^*}^{y_{TP}} V_P(s) \, dG(s) - \int_{y_T^*}^{y_{TP}} V_T(s) \, dG(s) \right) \geq 0 \tag{4}$$

Integrating by parts, we obtain:

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\begin{aligned}
\pi_P(y) - \pi_T(y) \quad \geq \quad & \lambda(G(y_P^*) F - V_P(y_{TP}) G(y_{TP}) + V_P(y_P^*) G(y_P^*) + \int_{y_P^*}^{y_{TP}} V_P'(s) G(s) \, ds \\
& + V_T(y_{TP}) G(y_{TP}) - V_T(y_T^*) G(y_T^*) - \int_{y_T^*}^{y_{TP}} V_T'(s) G(s) \, ds)
\end{aligned} \tag{5}
$$

Notice that $V_i'(s) = \frac{\pi_i'(s)}{r+\lambda}$ with $i = P, T$, i.e. the marginal effect of a productivity change on the value of a job is equal to the present value of the marginal effect on the flow of profits. To get an analytical solution, we assume that profits are linear in y and that $\pi_i'(s) = 1$ with $i = P, T$. This implies that the gap between the flow of profits associated with the two types of labor contracts does not depend on the level of productivity, i.e. $\pi_P(y) - \pi_T(y) = k$ (constant) $\forall \ y$. Introducing these assumptions and applying the conditions $V_P(y_P^*) = -F$, $V_T(y_T^*) = 0$, and $V_P(y_{TP}) = V_T(y_{TP})$, then eq. (5) simplifies to:

$$k \geq \frac{\lambda}{r + \lambda} \int_{y_P^*}^{y_T^*} G(s)\, ds \qquad (6)$$

The RHS measures the expected present value of the difference in the revenues between keeping a temporary or a permanent worker in the range between the respective productivity thresholds and y_{TP}. In eq. (6) emerges only the range between y_T^* and y_P^* because it assumed $V_P'(s) = V_T'(s)$ and, consequently, in the range of productivity common to both types of opened job position the gap is null.

Let us assume that the form of the productivity distribution is uniform with support $\left[m - \frac{1}{2f}; m + \frac{1}{2f}\right]$, where m is the mean and f is a parameter that controls for the variance. In this case eq. (6) becomes

$$k \geq \frac{\lambda}{\lambda + r} (y_T^* - y_P^*) \left[\frac{1}{2} - \left(m - \frac{y_T^* + y_P^*}{2}\right) f\right] = \Phi \qquad (7)$$

Given that the LHS of condition (7) is constant, we focus only on the RHS, denoted by Φ for convenience. Our hypothesis is that firm investment in R&D and innovation increases both mean (higher m) and variance (lower f) of the productivity distribution. We evaluate these effects by taking the differentiation of Φ with respect to m and f, it gives:

$$\frac{d\Phi}{dm} = -\frac{\lambda}{\lambda + r} (y_T^* - y_P^*) f < 0 \qquad (8)$$

$$\frac{d\Phi}{df} = -\frac{\lambda}{\lambda + r} \left(m - \frac{y_T^* + y_P^*}{2}\right) \qquad (9)$$

Eq. (8) confirms that an increase in the mean of the productivity distribution shifts the preference towards permanent contracts. On the contrary, a change in the variance has an ambiguous effect. Eq. (9) shows that the effect depends on the position of the productivity thresholds with respect to the average productivity along the support of the productivity distribution. Indeed, under the assumption of uniform distribution it is easy to see that if the average productivity is greater (less) than the mean of the threshold values, the derivative is negative (positive), i.e. an increase in the variance shifts the preference towards temporary (permanent) contracts.

TABLE 1 SAMPLE DESCRIPTIVE STATISTICS*

% firms with flex	64.6	% firms with in	63.4
% firms with tm	36.9	corr(flex, rd)	0.186
% firms with ag	50.7	corr(flex, in)	0.182
% firms with rd	45.6	corr(rd, in)	0.435
* All the correlations are significant at 1 percent.			

4 The Empirical Analysis

4.1 Dataset

We estimate the relationship between firm engagement in R&D and innovation activities and the use of ENF using a sample of Italian Manufacturing firms. Specifically, we use the survey conducted by the MedioCredito Centrale – Capitalia – Unicredit Research Centre, which covers the period 2001-2003. This dataset includes information about firms' structural characteristics and workforce composition, the R&D and innovation activities undertaken and the sources of financing.[6] The dataset provides annual information for many variables while for others the answers refer to the entire period. For this reason we choose to perform a cross-section analysis.

Table 1 reports some descriptive statistics characterizing our sample. The definition of ENF is strictly related to the type of labour contract. We consider flexible (*flex*) both the temporary contracts (*tm*) and the temporary agency worker (*ag*). Even if Italian aggregate data show that the number of temporary agency workers is lower than the number of workers with fixed-term contract, Table 1 shows that the use of temporary agency workers is more spread across firms. As to firms' activities, in our sample less than half of the firms are engaged in R&D (*rd*) while more than 63 per cent are engaged in innovation (*in*). Finally, Table 1 shows that the selected variables are positively correlated among each other thus providing a first evidence of the linkage between these firm choices.

4.2 Benchmark empirical models

We run logit regressions that differ in the number of explanatory variables, where the dependent variable, *flex*, is equal to 1 if the firm employed at least a worker with a fixed-term contract or from a temporary worker agency, and equal to zero otherwise. The main purpose is to evaluate whether undertaking R&D and innovation activities affect the probability of using ENF. Table 2 (regression *R1*) reports the estimation results when only R&D and innovation are used as

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[6]More details on the implementation of the survey can be found in the report of the Research Centre of the Unicredit Corporate Banking and at the website http://www.unicreditcorporate.it/media/rapporto_corporate.htm. This dataset has been used in other studies (see Caggese and Cuñat, 2008 and Hall et al., 2006).

TABLE **2** BASELINE LOGIT REGRESSION

	R1
rd	.58
	(.07)
in	.52
	(.07)
LR χ^2	194
n. obs	4,103

explanatory variables. These variables are binary, equal to 1 if the firm carried out these activities and equal to 0 otherwise. The values reported in each cell of Table 2, indicate the estimated values of the regression coefficients, while the standard deviations are inside brackets. Both R&D and innovation have a positive and significant impact on the probability of using flexible employment.[7]

Since the coefficients are significantly different from zero, it is interesting to evaluate how much the choice of engaging in R&D and innovation activities would affect the probability of employing at least one flexible worker. We start observing that Table 1 shows that 64.6 per cent of firms in the sample used ENF, while regression *R1* predicts that the probability of opting for this choice is 65.3 per cent. We next calculate how much the predicted probability changes when the value of one independent variable changes, while the other one is at its average value (as shown in Table 1). We also calculate the 95 per cent confidence interval for these marginal effects.

Let's start from the choice of engaging in R&D activity. Without R&D activity, the predicted probability of using flexible employment is 59 per cent and 72.1 per cent otherwise. This implies a change of 13.1 per cent whose confidence interval ranges between 9.9 and 16.3.

Similarly, without innovation activity the predicted probability of observing ENF is 57.4 per cent and 69.5 per cent otherwise. This implies a change equal to 12.1 per cent with a confidence interval from 8.7 to 15.5.

At this point, we introduce some variables in order to control for firm and employee characteristics. Table 3 reports for each control variable three types of information: *i*) the incidence among firms in the case of binary variables, and the mean value, otherwise; *ii*) the correlation with the use of ENF; and *iii*) the number of available observations in our sample. The list of control variables is the following one. The Pavitt classification indicates that a firm's activity

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[7]There is weak evidence of a higher impact of R&D activity, but the difference between the coefficients is not significant.

pertains to a sector that is supplier dominated, scale intensive, specialized supplier, and science based ($pv1$, $pv2$, $pv3$, and $pv4$, respectively). The average (along the three years of the survey) level of employment (em) and the average ratio of sales over employment (se) that should control for firm size and labor productivity. The incidence of employees with secondary high school (hs) and a graduate degree (gd) to control for employee education, and the average number of employees used in R&D activity (er). The source of investment financing, distinguishing among: risk capital ($c0$), self-financing ($c1$), short-term bank loans ($c2$), medium/long-term bank loans ($c3$), medium/long-term bank loans at subsidized rates ($c4$), government grants ($c5$), fiscal benefits ($c6$), leasing ($c7$), group firms' loans ($c8$), other firms' loans ($c9$). The dataset reports the incidence of each financing source on the total amount. In the following regressions we use these variables as binary variables (equal to 1 if the financing source has been used and equal to zero otherwise) but we ran the same regressions maintaining the incidence share and the results do not change significantly.[8] Finally, two other elements reported in the dataset are considered. The first is still related to the financial side. Firms are asked to answer whether they would have desired further credit (cr), where a positive answer may be interpreted as a signal of credit rationing.[9] The last control we include is related to export activity, *exp*, equal to 1 if the firm exported and to zero otherwise. This kind of activity introduces another source of uncertainty related to the behavior of foreign markets.

The first column of Table 4 reports the results concerning the logit regression ($R2$) which includes all the control variables listed in Table 3. Only the variables whose coefficients are significant at 10 per cent or less are reported. All the reported coefficients, except one, are positive. This implies that the selected variables increase the probability of using flexible employment. The firm size is relevant while the sales per employee are not. Even if Table 3 suggests a significant correlation between Pavitt classification and the use of flexible employment, no significant relationship emerges in our regressions. Similarly, the average number of workers employed in R&D activity has not a significant impact and the same is true for employees' education levels. Just two sources of firm investment financing, short-term bank loans and leasing, have

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[8]In more than a case we could have treated regressors as continuous variables but we generally preferred treating them as dummy variables. The choice is due to the fact that we are studying the discrete choice of using or not using ENF and not the intensity in the use of ENF. Then, we should refer to the marginal condition for the use of at least one flexible employee. Since the weight of an employee in firm structure is low, it should be sufficient to detect the presence of the different elements among the firm characteristics, independently of their relative relevance, without incurring in higher measurement errors implied by more detailed data.

[9]The presence of financial constraints is expected to shift the labor demand towards flexible types of labor contract in order to avoid the coexistence of binding financial constraints and firing costs (see Caggese and Cunat, 2008).

TABLE **3** DESCRIPTIVE STATISTICS OF CONTROL VARIABLES

	pv1	pv2	pv3	pv4	em	se	exp	gd	hs	er	
% firms	51.5	17.1	26.8	4.5	107.5**	240.5**	74.1	5.3***	37.3***	3.7**	
corr(flex,.)	-.04*	0.00	0.05*	0.02	0.12*	-0.02	-.13*	0.06*	0.00	0.08*	
n. obs	4,103	4,103	4,103	4,103	4,103	3,942	4,076	3,778	3,778	4,066	
	cr	c0	c1	c2	c3	c4	c5	c6	c7	c8	c9
% firms	14.6	2.4	60.9	12.2	18.5	12.7	14.0	15.7	26.7	0.02	0.00
corr(flex,.)	-.02	0.04	0.12*	0.07*	0.08*	-.02	0.03	0.05*	0.08	0.04	0.01
n. obs.	4,041	3,452	3,452	3,452	3,452	3,452	3,452	3,452	3,452	3,452	3,452

*The correlation is significant at 1 per cent. ** Average value. *** Average share

coefficients significantly different from zero. Furthermore, export activity has a positive effect while the self declaration to be financially constrained is the only variable which reduces the probability of using ENF. The introduction of these control variables has reduced the estimate of the coefficients of the independent variables we are interested in. The decrease is higher for the role of innovation and the impact on the confidence interval of its coefficient is quite relevant, even if it is still statistically significant at 5 per cent.

In the middle of Table 4 ($R3$), we report the estimates obtained by regressing over only the variables emerged significant at 10 per cent or less in regression $R2$. Again, the coefficients of both R&D and innovation are positive and strongly significant. Also the other variables have a significant impact, except for the indicator of credit rationing. In particular, the estimated value for the coefficient of export activity increases while the estimated standard deviation remains stable.

Regression $R4$, in the last column of Table 4, does not include the indicator of credit rationing and the source of investment financing. The results highlight that the selected variables have a significant influence on the dependent variable. The coefficient of innovation activity emerges as particularly high. The choice of excluding variables whose coefficients are statistically significant is due to the fall of observations that they imply, and it is supported by the application of the Bayesian Information Criterion (BIC). The number of observations in regression $R4$ is equal to 4,076 but it falls to 3,429 if we include the variables related to the source of financing, and to 3,387 when we include also the indicator of credit rationing (whose coefficient is not always significant). Furthermore, even if we nullify the effect of the number of observations, i.e. referring to the smallest sample size when we compare different regressions with a different

TABLE **4** LOGIT REGRESSIONS WITH CONTROL VARIABLES

	R2	R3	R4
rd	.39	.38	.41
	(.10)	(.09)	(.08)
in	.20	.25	.46
	(.09)	(.09)	(.08)
exp	.20	.30	.29
	(.10)	(.09)	(.08)
em	.004	.002	.002
	(.0006)	(.0003)	(.0004)
cr*	-.19	-.14	
	(.11)	(.11)	
c2	.22	.24	
	(.12)	(.11)	
c7	.23	.25	
	(.09)	(.08)	
LR χ^2	203	187	280
n. obs	2,981	3,387	4,076
*Significant at 10 per cent in R2, not significant in R3.			
All other coefficients significant at 5 per cent or less.			

number of observations, the BIC suggests excluding *cr*, *c3* and *c7*. Indeed, comparing regression *R4* and regression *R3* the difference in the BIC is equal to 8.241, providing strong support for logit *R4*. If we consider a regression that excludes just *cr*, the difference in the BIC is equal to 1.715, still providing weak support for logit *R4*.

Focusing on regression *R4*, the empirical model predicts that the probability of opting for ENF is 66.6 per cent. Without R&D activity this probability is 62.4 and 71.4 otherwise. This implies a change equal to 9 per cent points whose 95 per cent confidence interval is between 5.7 and 12.4. Without innovation activity the predicted probability of using flexible employment is 59.8 and 70.3 otherwise. This implies a change equal to 10.4 per cent points whose confidence interval is between 7 and 13.8.

Furthermore, it is worth noting that if we run the previous regressions also as probit, we obtain very similar results in terms of statistical significance of the regression coefficients and marginal effect on the probability of using ENF. In each case, comparing the regression performance, the BIC always provides support for logit regression (weak in *R1*, positive in *R2*, strong in *R3*, and very strong in *R4*).[10]

Before extending our analysis to include the different types of R&D and innovation activities,

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[10]We thank Ronald Oaxaca for suggesting a clearer way of presenting our estimation results.

we provide some further information concerning logit *R4* of Table 4.

4.2.1   Goodness of fit

The goodness of fit of the model is generally quite poor. However, these types of empirical models can hardly explain the adoption of flexible employment; rather, they can verify whether there is a statistically significant relationship between the dependent and independent variables. The *McFadden's R^2* is given by the ratio of the difference of deviance between the model with only the constant term and the model with the independent variables, over the deviance of the model with only the constant term, where the deviance is defined as -2 times the log of the likelihood. This statistic is equal to 0.053. The *McFadden's Adjusted R^2*, that takes into account the number of parameters, is equal to 0.051. Another statistic is the *Efron's R^2*, that is given by 1 minus the ratio of the sum of square difference between observed and predicted values over the sum of the square difference between the observed data and their mean. The *Efron's R^2* is equal to 0.069. The Maximum Likelihood R^2 that measures the geometric mean square improvement per observation is equal to 0.066. The number of correctly classified observations over the total number of observations is 64.7 per cent.

4.2.2   Tests of significance

We start testing the hypothesis that all the coefficients of the independent variables are null versus the alternative hypothesis that at least one coefficient is different from zero. In logistic regression the *likelihood ratio chi-square test* is generally used. The deviance of our model is equal to $5,016.923$ while the deviance of the model with only the constant term is equal to $5,296.796$. This implies that the reduction in the deviance induced by introducing our selected variables is equal to 279.873. This difference has a chi-square distribution with four degrees of freedom since the constraints are equal to the number of independent variables. The test clearly induces to reject the hypothesis that all the parameters are null.

We also tested the relevance of each variable and in different ways. The *Wald tests* and *log likelihood tests* confirm the relevance of each selected variable. Just one aspect is worth noting. Generally, the BIC provides strong support for preserving each variable, except for export. The difference in the BIC with and without *exp* is 1.8 providing weak support for the model that includes it.

We also checked if there is some multicollinearity between independent variables. No suspicious correlation emerges. The tolerance indexes, given by 1 minus the R^2 between each variable and the other variables, are always next to the unit. The lowest value belongs to *rd* equal to 0.76.

TABLE **5** DIFFERENT TYPES OF R& D AND INNOVATION ACTIVITIES

	rdi	rde	in1	in2	in3	in4
% firms	41.6	20.6	41.7	42.8	20.4	27.2
corr(flex,.)*	.179	.164	.172	.122	.121	.138
*All the correlations are significant at 1 per cent or less.						

4.3 Extensions

Our dataset allows us to disentangle different types of R&D and innovation activities. R&D activity can be run inside the firm (*rdi*) and outside (*rde*). The innovation activity can concern product innovation (*in1*), process innovation (*in2*), management and organizational innovations related to product innovation (*in3*), and management and organizational innovations related to process innovation (*in4*). Since they are all binary variables, Table 5 reports the incidence among firms.[11] Furthermore, it reports the correlations with the use of flexible employment which are all positive and significant.

Table 6 reports the estimates of logit models which take into account the previous classification of R&D and innovation activities, but differ in the number of independent variables included, just as in Table 4. *R5*, *R6*, and *R7* include the same variable of *R2*, *R3*, and *R4*, respectively. The main results are as follow.

Both ways of running R&D activity (inside and outside) have always a positive effect on the probability of using ENF and the interaction with external structures seems to produce a higher impact. These results provide support for the idea that the positive relationship between R&D activity and use of flexible employment is not due to some technological reasons. Even when the firm delegates the R&D activity to an external entity the probability of using ENF increases. Consequently, it seems reasonable to interpret the empirical results in favor of our theoretical model that keeps constant the revenue gap between permanent and temporary contracts after a change in the productivity distribution. Perhaps, a complementarity between R&D and permanent contracts could be introduced (since the coefficient of *rdi* is always lower than that of *rde*).

More complex is the interpretation of the results about the role played by the different types of innovation, even if some clear evidence still emerges. First of all, product innovation has always a positive and significant effect on the probability of using ENF while the impact

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[11]For internal and external R&D activity we have also the share of incidence. Regressions with shares, instead of binary variables, have been run with no qualitatively significant change in the results. Furthermore, BIC provides very strong support for logit with dummy variables.

TABLE **6** LOGIT REGRESSIONS WITH DIFFERENT TYPES OF R&D AND INNOVATION

	R5	R6	R7
rdi	.23	.19	.21
	(.10)	(.09)	(.09)
rde	.43	.40	.47
	(.12)	(.11)	(.11)
in1	.32	.39	.38
	(.10)	(.10)	(.09)
in2	-.19	-.15	.02
	(.10)	(.09)	(.08)
in3	-.01	-.07	-.02
	(.13)	(.12)	(.11)
in4	.38	.40	.43
	(.12)	(.11)	(.10)
exp	.17	.27	.26
	(.10)	(.09)	(.08)
em	.004	.002	.002
	(.0006)	(.0004)	(.0004)
cr	-.21	-.17*	
	(.11)	(.11)	
c2	.21*	.23	
	(.12)	(.11)	
c7	.23	.25	
	(.09)	(.08)	
LR χ^2	238	229	323
n. obs	2,981	3,387	4,076
*Significant at 10 per cent. All others		
significant at 5 per cent or less.		

of process innovation is not significant or negative. This difference can be explained in the light of our interpretation of the linkage between these firm strategic choices and the labor contract choice. Indeed, product innovation can be considered a risky activity while process innovation is more related to the rationalization of costs, which can be hardly associated with an increase in uncertainty. More puzzling is the interpretation of the difference between the effect of management and organizational innovations related to product innovation, and the effect of management and organizational innovations related to process innovation. Further qualitative information may be helpful for a better understanding.

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Focusing on regression *R7*, the predicted probability of opting for ENF is 66.9 per cent. Firms not running inside R&D activity have a probability equal to 64.9 that rises to 69.6 otherwise. This implies a change equal to 4.7 per cent points whose 95 per cent confidence interval is between 1.1 and 8.4. Firms not running outside R&D activity have a probability equal to 64.7 that rises to 74.7 otherwise. This implies a change equal to 9.9 per cent points whose 95 per cent confidence interval is between 5.9 and 14. Without product innovation activity the predicted probability of using ENF is 63.4 and 71.6 otherwise. This implies a change equal to 8.3 per cent points whose confidence interval is between 4.5 and 12.

Finally, some statistics concerning logit *R7* are reported. The *McFadden's R^2* is equal to 0.061 while the *McFadden's Adjusted R^2* is equal to 0.058. The *Efron's R^2* is equal to 0.077 and the Maximum Likelihood R^2 is equal to 0.076. The number of correctly classified observations over the total number of observations is 64.9 per cent. The deviance of our model is equal to 4,973.61 which implies a reduction in the deviance induced by introducing our selected variables equal to 323.019. Consequently, we can reject the hypothesis that all the parameters are null.

Furthermore, it is worth noting that using the BIC to compare *R7* and *R4* the difference is equal to 10.062 providing very strong support for the former model that takes into account the different types of R&D and innovation activities.

5 Conclusions

In this paper we have studied the impact of R&D and innovation activities on the probability of using external numerical flexibility. We have presented a theoretical model to analyze how firm demand for permanent and temporary labor contracts are affected by an increase in the mean and variance of the distribution function of firm productivity. We interpreted such changes as induced by the firm's engagement in R&D and innovation activities, and showed that while an increase in the mean productivity should reduce the use of flexible employment, an increase in the variance has ambiguous effects. We next estimated the impact of firm engagement in R&D and innovation activities on the probability of employing at least a fixed-term or a temporary agency worker using a sample of Italian Manufacturing firms. We found that R&D activity, performed both inside and outside the firm, has always a positive impact, that is particularly high in the latter case. On the contrary, innovation activity has a significant and positive effect in the case of product innovation, while it has no, or negative, impact in the case of process innovation. Both results are consistent with our theoretical model.

References

Addessi W. (2011): "Labor Contracts and Productivity Dynamics", mimeo.

Aguirregabiria V. and C. Alonso-Borrego (2009): "Labor contracts and flexibility: Evidence from a labor market reform in Spain", mimeo.

Albert C., García-Serrano C., and V. Hernanz (2005): "Firm-provided training and temporary contracts", Spanish Economic Review, 7, 67-88.

Aw B. Y., Roberts M. J., and D. Y. Xu (2009): "R&D investment, exporting, and productivity dynamics", NBER working paper n.14670.

Bassanini A., Nunziata L., and D. Venn (2008): "Job protection legislation and productivity growth in OECD countries", IZA discussion paper n.3555.

Blanchard O. and A. Landier (2002): "The Perverse Effects of Partial Labour Market Reform: Fixed-Term Contracts in France", Economic Journal, 112, 480, 214-244.

Boeri T. and P. Garibaldi (2007): "Two Tier Reforms of Employment Protection: A Honeymoon Effect?", Economic Journal, 117, 521, 357-385.

Caggese A. and V. Cuñat (2008): "Financing constraints and fixed-term employment contracts", Economic Journal, 118, 2013-2046.

Cahuc P. and F. Postel-Vinay (2002): "Temporary jobs, employment protection and labor market performance", Labour Economics, 9, 63-91.

Damiani M. and F. Pompei (2010): "Labour protection and productivity in EU economies:1995-2005", European Journal of Comparative Economics, 7 (2), 373-411.

Doraszelski U. and J. Jaumandreu (2009): "R&D and productivity: Estimating endogenous productivity", Harvard working paper.

Griliches Z. (1979): "Issues in assessing the contribution of R&D to productivity growth", Bell Journal of Economics, 10, 1, 92-116.

Hirsch B. and S. Muller (2010): "Temporary Agency Work and the User Firm's Productivity: First Evidence from German Panel Data", Nuremberg discussion paper n. 68.

Kleinknecht A., Oostendorp R. M., Pradhan M. P., and C. W. M Naastepad (2006): "Flexible Labour, Firm Performance and the Dutch Job Creation Miracle", International Review of Applied Economics, 20 (2), 171-187.

Koeniger W. (2005): "Dismissal costs and innovation", Economics Letters, 88, 79-84.

Lisi D. (2009): "The Impact of Temporary Employment on Labour Productivity: Evidence from an Industry-Level Panel of EU Countries", MPRA Paper n. 26076.

Mortensen, D.T. and G.R. Neumann (1988): "Estimating Structural Models of Unemployment and Job Duration", in W.A. Barnett, E.R. Bernt, and H. White (eds.), Dynamic Econometric Modelling, Proceedings of the Third International Symposium in Economic theory and

Econometrica, Cambridge: Cambridge University Press.

Saint-Paul G. (2002): "Employment protection, international specialization, and innovation", European Economic Review, 46, 375-395.

Saltari E. and R. Tilli (2009): "The role and significance of endogenous firing costs in a matching model with endogenous job destruction", The Journal of Socio-Economics, 38, 799-808.

Zhou H., Dekker R., and A. Kleinknecht (2011): "Flexible labor and innovation performance: evidence from longitudinal firm-level data", Industrial and Corporate Change, 20(3), 941-968.