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Labor Contracts and Productivity Dynamics*

William Addessi†

Abstract

This paper studies the effect of labor-contract choice on firm productivity. We consider permanent and temporary contracts and investigate their impact on both labor-augmenting and TFP-augmenting technological factors. Our analysis suggests that labor-contract choice may affect the evolution of the firm productivity process and not (or not only) the level of labor productivity in a given productivity framework. We test our hypothesis using a panel data of Italian manufacturing firms. We assume that firm TFP follows a controlled Markov process that may be affected by the relative use of labor contracts, and that labor services are perfect substitutes for each other but may be characterized by different labor-augmenting factors. The empirical analysis is conducted by following the structural approach originally proposed by Olley and Pakes (1996) and by taking into account the multicollinearity issue highlighted by Ackerberg, Caves and Frazer (2006). Empirical results show that by endogenizing the TFP process: *i*) the difference between permanent and temporary contracts in the labor-augmenting productivity factor may be not significant; *ii*) the incidence of permanent contracts on total contracts has a positive effect on TFP dynamics. These results are consistent with the idea that the use of temporary contracts may permit an efficient allocation of labor services but dampen a source of TFP growth, as some empirical analyses based on aggregate data seem to highlight.

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1 Introduction

This paper studies the effect of labor-contract choice on firm productivity. We consider permanent and temporary contracts and investigate their impact on both labor-augmenting and TFP-augmenting technological factors. Generally, it is assumed that these types of labor services are perfect substitutes for each other and that permanent contracts imply higher productivity and higher expected costs than temporary contracts (see Caggese and Cuñat, 2008). We substantially agree with this view, but we question the source of the productivity gap. The literature has generally emphasized the difference in the labor-augmenting factor (see Caggese and Cuñat, 2008 and Aguirregabiria and Borrego, 2009) but we don't feel fully comfortable with this interpretation because it does not capture the intertemporal effect of labor-contract choice, while the temporal dimension is the element characterizing the type of contract. Our analysis suggests that labor-contract choice may affect the evolution of the firm productivity process and not (or not only) the level of labor productivity in a given productivity framework. We test our hypothesis using a panel data of Italian manufacturing firms. We assume that firm TFP follows a controlled Markov process that may be affected by the relative use of labor contracts, and that labor services are perfect substitutes for each other but may be characterized by different labor-augmenting factors. The empirical analysis is conducted by following the structural approach originally proposed by Olley and Pakes (1996) and by taking into account the multicollinearity issue highlighted by Ackerberg, Caves and Frazer (2006). Empirical results show that by endogenizing the TFP process: *i*) the difference between permanent and temporary contracts in the labor-augmenting productivity factor may be not significant; *ii*) the incidence of permanent contracts on total contracts has a positive effect on TFP dynamics. These results are consistent with the idea that the use of temporary contracts may permit an efficient allocation of labor services but dampen a source of TFP growth, as some empirical analyses based on aggregate data seem to highlight.

Our view is that workers determine the productivity process and not only the way they interact with it. Personal ability and attitude to work affect not only worker's productivity but also the way the productivity process works and evolves, because part of personal knowledge is not "kept

in secret" but is shared within the firm.[1] Labor conditions are a key element affecting workers' willingness to participate in the improvement of the productivity process and the perspective of a short-term relationship reduces such willingness. In this light, firms should benefit from the commitment to long-lasting labor relationships.[2] At the same time, temporary contracts may affect labor productivity positively because they ease the employment of "the right person at the right moment" and they incentivize workers to exert higher effort in order to get a contract renewal or the transformation to a permanent contract. The previous arguments suggest that labor-contract choice may have even contrasting effects on firm TFP productivity and labor productivity.

Starting from a Cobb–Douglas production function we try to disentangle the labor-augmenting and the TFP-augmenting effect of the labor-contract choice which, to the best of our knowledge, is an attempt that has not yet been made, and we find that the incidence of temporary contracts reduces TFP growth. This result suggests that a structural change in the labor-contract composition may induce not only a level effect on productivity (as in Boeri and Garibaldi, 2007, and Aguirregabiria and Borrego, 2009) but may also affect its evolution. In some way our contribution is related to Iranzo et al. (2008) and Parrotta et al. (2010). The former investigates the role of skill dispersion within and between status groups of workers, but they investigate how labor-specific elements affect labor-augmenting productivity with no dynamic effect. The latter investigates the effect of labor diversity (skill, education, demographics, and ethnicity) on firm TFP with no reference to the type of labor contract. The rest of the paper is organized as follows. Section 2 reviews the related literature, focusing mainly on the contributions concerning the relationship between labor contracts and productivity. Section 3 sketches the theoretical model supporting the empirical analysis. Section 4 presents the empirical strategy, describing the dataset and the estimation procedure, and it discusses the empirical results. Section 5 presents some robustness checks of our estimations. Section 6 draws conclusions.

[1] The same argument is present in Kleinknecht et al. (2006) who find that externally flexible labor is associated with lower labor productivity growth.

[2] It is surely important the reference to the role of reciprocity (Gächter and Falk, 2002) and mutual dependency (Lorenz, 1992) in labor relationships, where a permanent labor contract, in the presence of relevant employment protection rules, represents a commitment device and a sign of trust.

2 Related Literature

The effects of the choice between permanent and temporary contracts have been studied from both macro and micro perspectives and it often overlaps with the study of the influence of employment protection legislation on market performances. Since this literature is too vast to be summarized here, we limit citation to the contributions that mostly add to the understanding of the impact of labor-contract choice on productivity.[3] A first way to approach the issue is to take as given the labor demand function and assume labor services to be characterized by the same productivity independently of the type of labor contract. Under these conditions, Boeri and Garibaldi (2007) suggest that an increase in the margin of employing temporary labor contracts should induce an increase in employment (due to reduced expected costs) and a fall of labor productivity (due to the decreasing marginal return of labor).[4] An implication of their analysis is that a two-tier labor market reform shifts the equilibrium point of the economy but it does not affect its dynamics, and in the "long run" there is no use of permanent contracts.

On the contrary, the hiring with both types of labor contracts, characterized by different (expected) costs, can be rationalized by introducing a source of productivity gap. Labor contracts may imply a labor-augmenting factor, that is specific to each type of contract. Indeed, permanent contracts are generally considered more expensive because they imply lower flexibility (the labor hoarding phenomenon) and higher firing costs but they are supposed to imply higher productivity in some way. Consistently with this view, Aguirregabiria and Borrego (2009), who analyze the impact of the two-tier labor-market reform implemented in the '80s in Spain, estimate that temporary contracts are characterized by a lower labor-augmenting factor.[5] Similarly to Aguirregabiria and Borrego (2009) we permit the labor contracts to be characterized by different labor-augmenting factors but we also investigate the effect on firm TFP dynamics.

[3] Other contributions investigated the opposite relationship, i.e. the effect of productivity on the labor-contract choice. Casquel and Cunyat (2008) state that productivity contributes to determining whether the temporary contracts represent a way to access permanent contracts or they represent a trap. Caggese and Cuñat (2008) provide evidence of pro-cyclical behavior of the incidence of permanent contracts analyzing firm labor demand under positive and negative TFP shocks.

[4] The authors measure labor productivity as value added per worker.

[5] Dolado and Stucchi (2008), focusing on Spanish manufacturing firms, find that the effect of temporary contracts on productivity depends on the convertions rates in permanent contracts. When the convertion rate is high the effect is positive, while the opposite occurs in case of high shares of temporary contracts.

Another recent field of literature that is strictly related to our investigation use cross-country industry-level data to analyze the effect of either the use of, or the regulation concerning the use of, temporary contracts on TFP and labor productivity dynamics. Some examples are Bassanini et al. (2008), Lisi (2009), Damiani and Pompei (2010), and Iona and Vallanti (2011). Bassanini et al. (2008) analyze the effect of labor market regulation on TFP dynamics using annual cross-country aggregate data referring to the OECD area. They find that high constraints on permanent workers' dismissal have a negative impact on TFP growth, especially in industries with greater layoff propensity. But another result of their analysis is particularly interesting to our purposes. The authors find that stricter regulation for temporary contracts has no impact or positive impact on TFP growth. Even stronger results emerge in Lisi (2009), Damiani and Pompei (2010), and Iona and Vallanti (2011) supporting the hypothesis of an inverse relationship between temporary contracts and productivity growth. Similar conclusions characterize Ortega and Marchante (2010) who find that the use of temporary contracts reduced productivity growth in Spain but not in all sectors. The results of the cited literature are fully consistent with our investigation concerning the dynamic effect of labor-contract choice on firm productivity.

Finally, it is worth a brief reference to the literature that investigates the effect of labor-contract choice on other indicators of workers' performance, such as training and effort, which could affect productivity. For example Albert et al. (2005), using Spanish firm data, find that temporary contracts are less likely to be used in firms providing training and that they have a lower probability of being chosen to participate in firm-provided training activities. These results are consistent with a lower productivity of temporary contracts. Concerning the effect on the effort choice, the basic assumption is that temporary contracts are screening tools for employers and temporary workers are incentivized to provide high effort in order to increase the probability of moving on to a permanent contract, but there is no evidence that the higher effort is associated with higher productivity. Engellandt and Riphahn (2005) analyze data from Swiss Labor Force Survey and find that temporary workers are significantly more likely to work unpaid overtime hours than permanent workers. The same intuition characterizes Beccarini (2009) and Ghignoni (2009) who find, referring to the Italian labor market, that temporary workers provide higher

effort than permanent workers but "if, and only if," they expect to transform their labor contract into a permanent one. Both authors cast some doubts on the existence of a positive relationship between effort indicators and productivity.[6] Finally, Battisti and Vallanti (2011) estimate on a sample of Italian firms that the presence of temporary contracts reduces permanent workers' effort.

3 The Model

We assume that the firm production function is a Cobb–Douglas where output Y depends on physical capital K, labor L, and a technology factor e^{ω}; thus $Y_t = e^{\omega_t} K_t^{\alpha} L_t^{\beta}$, where the subscript t indicates the time period. Workers are employed with permanent P or temporary T contracts. The use of one or the other kind of contract affects production function through two channels. First of all, as largely highlighted in the literature, labor contracts may imply a *static* difference in labor productivity. This implies that L can be substituted with $P + sT$ with $s > 0$. The other effect is *dynamic* and affects TFP growth. In fact, it is assumed that firm TFP evolves over time as a first order Markov process and may depend on the composition of the labor contracts with a time period lag. Let $x_t = P_t / (P_t + T_t)$, $\mu_t \sim N\left(0, \sigma_{\mu}^2\right)$, and $g(\cdot)$ be a function relating firm TFP to its previous value, then the production function can be rewritten as $Y_t = e^{g(\omega_{t-1}) + \gamma x_{t-1} + \mu_t} K_t^{\alpha} L_t^{\beta}$.[7] Let W_P and W_T indicate, respectively, permanent and temporary workers' wages. Furthermore, firms may pay firing costs if they lay off permanent workers. Let us define the function $q_t = (1 - \delta_p) P_{t-1} - P_t$, where δ_p is the natural separation rate of permanent workers that does not imply firing-cost payment. Let us define the indicator function $S_t = 1$ if $q_t > 0$ and $S_t = 0$ otherwise, and indicate with F the value of the firing cost per worker.

Under the previous assumptions firm j solves the following maximization problem.

[6] Similarly, Olsson (2009) find that a reduction of employment protection reduces sickness absence (as a measure of effort) but the effect on labor productivity remains ambiguous.

[7] When we will present the estimation procedure, the stochastic component μ will be disentangled in two components, not correlated each other, in order to distinguish between the part of shock not observed by both econometrician and entrepreneur, and the part not observed only by econometrician.

$$V_j\left(\chi_{j,t}\right) = \max_{\{P_{j,t},T_{j,t},I_{j,t}\}} \left\{ Y_{j,t} - W_{P,t}P_{j,t} - W_{T,t}T_{j,t} - Fq_{j,t}S_{j,t} - I_{j,t} + \frac{1}{1+\zeta} E\left[V_j\left(\chi_{j,t+1}\right)\right] \right\},$$

where $\chi_{j,t} = (K_{j,t}, P_{j,t-1}, \omega_{j,t})$ is the vector of the state variables characterizing firm j, ζ is the time discount factor, and the investment is defined as follows: $I_{j,t} = K_{j,t+1} - (1-\delta_k) K_{j,t}$, with δ_k measuring the depreciation rate of capital. Each firm chooses the amount and the type of labor contracts and the capital accumulation. Hereafter, for simplicity, we drop the j firm indicator.

After some simple algebra, the optimal choice of labor with temporary contracts can be expressed as follows:

$$\frac{\partial Y_t}{\partial T_t} \equiv \frac{\partial Y_t}{\partial L_t}\frac{\partial L_t}{\partial T_t} = W_{T,t} - \frac{1}{1+\zeta} E\left[\frac{\partial Y_{t+1}}{\partial x_t}\frac{\partial x_t}{\partial T_t}\right]. \tag{1}$$

Equation (1) states that firms hire temporary workers until their current marginal productivity is equal to the real wage less their intertemporal effect on future revenues. Under our assumptions, temporary contracts may produce a dynamic effect since they affect future productivity by modifying the labor-contract composition in the workplace.

The optimal choice of workers with permanent contracts is described by the following condition:

$$\frac{\partial Y_t}{\partial P_t} \equiv \frac{\partial Y_t}{\partial L_t}\frac{\partial L_t}{\partial P_t} = W_{P,t} - FS_t + \frac{1}{1+\zeta}\left(1-\delta_p\right) FE\left[S_{t+1}\right] - \frac{1}{1+\zeta} E\left[\frac{\partial Y_{t+1}}{\partial x_t}\frac{\partial x_t}{\partial P_t}\right]. \tag{2}$$

Most of the elements of equation (2) are quite standard in the reference literature. Current firing costs disincentivize the dismissals of permanent workers while new permanent contracts are negatively affected by wages and expected firing costs. Instead, the last element on the right-hand side is specific to our model and takes into account the role of labor-contract composition in the TFP dynamics.

Under the previous conditions, it is possible to define the criteria ruling the labor-contract choice. For this purpose, let us subtract equation (1) from equation (2) and analyze when the use

of permanent contracts implies a revenue advantage so high as to exceed the higher costs.

$$\frac{\partial Y_t}{\partial L_t}(1-s)+\frac{1}{1+\zeta}\left(\frac{\partial x_t}{\partial P_t}-\frac{\partial x_t}{\partial T_t}\right)E\left[\frac{\partial Y_{t+1}}{\partial x_t}\right]\geq -FS_t+\frac{1}{1+\zeta}(1-\delta_p)FE\left[S_{t+1}\right]+(W_{P,t}-W_{T,t}) \tag{3}$$

Caggese and Cuñat (2008) study the implications of the condition ruling the labor-contract choice according to the business phase that firms are going through.[8] We limit ourselves to focusing on the choice of recruitment. Permanent contracts imply higher expected costs due to the probability of paying firing costs.[9] This requires that new permanent contracts are signed only if they provide a comparative advantage in terms of revenues, i.e. higher productivity.[10] This view is largely accepted in the literature and the way this can be formalized is by imposing $s<1$. We introduce the intertemporal effect of the labor-contract choice by the second element on the left side of equation (3), whose sign is given by the sign of $E\left[\partial Y_{t+1}/\partial x_t\right]$ since $\left(\partial x_t/\partial P_t-\partial x_t/\partial T_t\right)/\left(1+\zeta\right)>0$. Our guess is that TFP is significantly affected by the incidence of permanent contracts. The introduction of this element permits us to not impose an upper bound on the value of s. It follows that it cannot be excluded *a priori* that the labor-contract choice implies, for example, a trade-off between a short-run and a long-run productivity advantage (i.e. $s>1$ and $\gamma>0$), which is what we will investigate empirically in the next section.

Finally, it is important the optimal condition for capital accumulation. In fact, notwithstanding this condition is quite standard, it provides useful insights concerning the polynomial function that has to be used in the empirical strategy to control for the unobserved productivity,

$$K_{t+1}=\left(\frac{\alpha}{\zeta+\delta_k}E\left[e^{\omega_{t+1}}\left(P_{t+1}+sT_{t+1}\right)^{\beta}\right]\right)^{\frac{1}{1-\alpha}}. \tag{4}$$

Eq. (4) indicates that capital accumulation increases in the elasticity of output to capital (α) and decreases in the time discount factor (ζ) and depreciation rate (δ_k). It is more important,

[8]The authors analyze how the choice changes when firms are in upturn or in downturn and when they are financially constrained or unconstrained.

[9]Furthermore, it is widely recognized that temporary workers receive lower salaries. Some evidence can be found in Brown and Sessions (2005) and Picchio (2006).

[10]Alternatively, an institutional rule limiting the use of temporary contracts could be introduced (see Cahuc and Postel-Vinay, 2002).

to our purposes, to highlight that investment increases in the expected TFP and labor services. The strictly increasing relationship between investment and TFP is the theoretical implication used in our estimation procedure to control for TFP. Furthermore, the relevance of the expected labor services requires to include also the current level of permanent contracts in the function describing the investment choice, since permanent contracts may affect, through the firing costs, both the total amount of future labor services and their composition.

4 Empirical strategy

4.1 Dataset

We use the MedioCredito Centrale – Capitalia – Unicredit dataset that consists of quantitative and qualitative information about a representative sample of Italian manufacturing firms. In particular, it includes information about the types of labor contract. This survey is published every three years and we use a three-year balanced panel from 2001 to 2003 that represents the minimum time period to implement our estimation procedure.[11] Firm balance sheet data are provided by AIDA database. We measure the starting capital stock taking the value reported in the 2001 firm balance sheet and the capital stocks for 2002 and 2003 are obtained by adding firm investment and applying a depreciation rate equal to 0.1.[12] We drop outliers and firms with missing data, and, as required by our estimation procedure, firms with null investment.[13]

Table 1 reports some descriptive statistics characterizing our sample and the samples of Italian firms used in other articles. In particular, capital per worker is in line with that estimated by Iranzo et al. (2008). The last six rows of the table report the correlations between value added per worker, permanent workers, temporary workers and incidence of permanent workers (with one period lag). To our purposes, it is worth noting that the lagged value of the incidence

[11] More details concerning 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, among others: Caggese and Cuñat (2008) and Hall et al. (2006).

[12] The same value is applied, for example, by Aguirregabiria and Borrego (2009).

[13] To be precise, we drop firms with the ratio between value added and capital stock, investment and capital stock, value added and employment, and capital stock and employment, higher than 5.5, 1, 0.2, and 0.3, respectively (where all the monetary values are reported in millions of 2001 euros).

of permanent workers is positively correlated with the value added per worker (often used as a measure of productivity) and negatively correlated with current levels of temporary workers. This implies that excluding x, in a regression where it should be included, may induce a serious bias in the estimation of the temporary contract coefficient.

Table 1: Descriptive Statistics

	sample	references
No. of firms	1,914	
% firms with no temp. workers	60	67***
No. of workers (L)	149	198* -142**
st. dev. of L	438	949*
share of perm. workers (x)	0.96	0.96***
st. dev. of x	0.11	
capital per worker (KL)	0.061	0.07*
st. dev. of KL	0.047	
value added per worker (YL)	0.049	0.041*
st. dev. of YL	0.021	
correlation (YL,P)	0.08*°	
correlation (YL,T)	-0.04	
correlation (P,T)	0.32*°	
correlation (YL,x(-1))	0.09*°	
correlation (P,x(-1))	0.05	
correlation (T,x(-1))	-0.59*°	

* Source Iranzo et al. (2008). ** Source Hall et al. (2006). *** Source Caggese and Cuñat (2008). *° The correlation is significant at 1 per cent. All monetary values are reported in millions of 2001 euros.

4.2 Estimation Procedure

The estimation technique of the firm production function represents an interesting and open issue in the microeconometric literature. The major difficulty is related to the presence of unobservable variables that strongly affect the choice of the inputs of production. In particular, it has been emphasized that the econometrician does not observe firm productivity, while firm productivity (at least partially) enters the entrepreneur's information set before the decision on the use of easily adjustable inputs. This implies that the OLS procedure generates biased estimates of the output

elasticity to the input factors, especially for labor. The standard techniques used to deal with this kind of issue (i.e. fixed effects and instrumental variables) have not provided satisfactory results (see Ackerberg et al., 2007, for a discussion). Consequently, part of the literature has relied on the implications of some theoretical models to improve the estimation procedure. In particular, we refer to the structural approach that started with the seminal contribution of Olley and Pakes (1996) (OP). This approach is characterized by the use of theoretical-model predictions to define the unobserved firm productivity as a function of some observed firm characteristics. This method requires that at least one firm-specific observable variable is a strictly monotonic function of firm productivity (*strict monotonicity condition*) and that the relationship between this variable and firm productivity is affected only by the firm variables that the econometrician can control for (*scalar unobservable assumption*). As in the original OP contribution we use investment expenditure to control for productivity.[14]

This approach requires a two-step regression. In the first step, we run a non-parametric regression including labor services in the polynomial form, aimed at removing the idiosyncratic shock that does not enter the entrepreneur's information set (the untransmitted shock).[15]

In the second step, we estimate all the parameters of the production function by a nonlinear least square regression. We prefer a nonlinear least square regression to a GMM because, as discussed later, many firms do not employ temporary contracts, and thus it is not possible to identify uniquely the conditions that should be imposed in the GMM procedure. Since labor demand is affected by current productivity while current capital is given, labor services are instrumented with their lagged values.[16]

Finally, in line with Doraszelski and Jaumandreu (2009), we endogenize firm productivity by the inclusion, in the polynomial function that controls for TFP, of both labor force composition, since it could affect TFP dynamics, and permanent labor services because, in the presence of

[14] Alternatively, Levinshon and Petrin (2003) suggest using intermediate goods since they are less lumpy than investment.

[15] Here, we follow Ackerberg, Caves, and Frazer (2006) (ACF), who pointed out that the OP procedure suffers a serious collinearity problem because they estimate labor coefficient in the first step, while labor demand depends on the other independent variables included in the polynomial function.

[16] OP use nonlinear least square regression, while ACF use a GMM where the residuals of the second-step regression are imposed to be orthogonal with the current capital and lagged labor.

firing costs, they affect the expected values of future labor services and thus the marginal return of capital.[17] This procedure is consistent with the assumption that investment and labor contracts are chosen simultaneously.

Let's describe the entire procedure more formally. The logarithmic form of the production function equation is:

$$y_t = \omega_t + \alpha k_t + \beta \ln (P_t + sT_t) + \eta_t$$

where y_t and k_t are respectively the log transformation of Y_t and K_t, and $\eta_t \sim N\left(0, \sigma_\eta^2\right)$ is the untransmitted shock. Let us define the investment demand as a polynomial function of the state variables and the variables affecting the expected return of capital, $i_t = f(\omega_t, x_t, p_t, k_t)$. Since investment strictly increases in productivity, it is possible to invert this relationship and define current productivity as a function of investment and firm state variables $\omega_t = f^{-1}(i_t, x_t, p_t, k_t)$. Let us define $\phi_t = \omega_t + \alpha k_t + \beta \ln (P_t + sT_t)$ and substitute ϕ_t in the production function equation, $y_t = \phi_t (i_t, x_t, p_t, k_t) + \eta_t$.[18]

Step 1. Regress y_t on $\phi_t (i_t, x_t, p_t, k_t)$ and estimate

$$\widehat{\phi}_t (i_t, x_t, p_t, k_t) = y_t - \widehat{\eta}_t.$$

Step 2. Since $\omega_t = E[\omega_t|\Omega_{t-1}] + \varepsilon_t = E[\omega_t|\omega_{t-1}, x_{t-1}] + \varepsilon_t = g(\omega_{t-1}) + \gamma x_{t-1} + \varepsilon_t$ (where $\varepsilon_t \sim N\left(0, \sigma_\varepsilon^2\right)$), run a nonlinear least square regression of the estimated TFP on its last value and the lagged value of the labor-contract composition. Specifically, we define $g(\cdot)$ as a polynomial of the fourth order of the lagged value of the estimated TFP:

$$\widehat{\phi}_t = \alpha k_t + \beta \ln (P_t + sT_t) + g\left(\widehat{\phi}_{t-1} - \alpha k_{t-1} - \beta \ln (P_{t-1} + sT_{t-1})\right) + \gamma x_{t-1} + \varepsilon_t.$$

Since labor services are chosen after the realization of the productivity shock (ε_t) observed

[17] Doraszelski and Jaumandreu (2009) include R&D expenditure in the polynomial function, while Aw et al. (2009) include both R&D and export activities.

[18] The polynomial function is defined on permanent contracts and the incidence of permanent contracts, and not on temporary contracts. This choice is due to the fact that once we control for x and P, we are also controlling for T.

by the entrepreneur, P and T are instrumented with their lagged values. In the second step we preferred a nonlinear least square regression (as in the OP procedure) to the GMM (as in the ACF procedure) basically because in our case it is not possible to uniquely identify the moment condition for temporary contracts. This variable is often null and then it is not possible to impose the orthogonality between the residual and the logarithm of temporary contracts. Some manipulations could be possible to bypass the problem related to the presence of the logarithm of a null variable but they were quite discretionary and would affect the numerical solution of the minimization problem.

4.3 Empirical Results

We report the results obtained by running five types of regressions. We run two types of benchmark estimations based on the structural approach previously presented, one structural estimation without any intertemporal role for the labor-contract composition, and two further types of estimation based on standard procedures. The different estimates of the model parameters are reported in Table 2. The estimation called *OLS* is a standard ordinary least square regression which ignores three main elements: that input services are correlated with the unobserved productivity, that labor services are heterogenous, and that productivity follows an autoregressive process. The estimation called *NLS* is a nonlinear least square regression; it still does not use information about the productivity dynamics and does not deal with the correlation between productivity and input services, but it introduces heterogeneity between labor services. The estimation called *2-steps* follows the structural approach exposed in the previous paragraph except for considering productivity as an exogenous Markov process (i.e., not including labor-service composition, x, in the DGP of firm TFP). The results of the previous types of estimation are reported just for comparison. We propose two types of estimations, *Bench1* and *Bench2*, which are consistent with the model presented in the previous section. They differ in the time reference of x. In *Bench1* x is not instrumented since there is no reason to expect correlation between the composition of the labor contracts at time $t-1$ and the productivity shock at time t, while in *Bench2* x is instrumented with its lagged value in order to preserve time consistency among

labor variables.

In each cell of Table 2, the value in the upper line indicates the estimated value of the parameter in the corresponding column, while the value in the bottom line indicates the estimated standard deviation. Except for the procedure *OLS*, it is necessary to guess an initial value for the parameters. We started with $\alpha = 0.34$ and $\beta = 0.66$ since these are the mean values emerging from national accounts in the corresponding time period; $\gamma = 0$, i.e. no impact of labor composition on productivity dynamics; and finally $s = 1$, i.e. different labor services have the same labor-augmenting productivity. Sensitivity analysis with respect to the starting values (particularly of s and γ) has been conducted supporting the robustness of the estimation results.

Table 2: Estimation results without control variables (n. of obs. 1914)

	α	β	s	γ
guess	.34	.66	1	0
OLS	.258	.766		
	(.012)	(.015)		
NLS	.254	.77	.604	
	(.012)	(.015)	(.065)	
2-steps	.285	.72	.766	
	(.005)	(.007)	(.035)	
Bench1	.284	.723	.969	.108
	(.005)	(.007)	(.104)	(.041)
Bench2	.284	.722	.892	.081
	(.005)	(.007)	(.066)	(.028)

All the coefficients are significant at 5 per cent or less.

The results reported in Table 2 should provide indications about at least three main questions. Is the estimation technique capable of reducing the estimation bias induced by the correlation between unobserved productivity and labor demand? Does a gap in the labor-augmenting factor between permanent and temporary contracts exist? Does the labor composition affect TFP dynamics?

The answer to the first question is definitively positive since shifting from standard methods to the structural approach the gap between the coefficients of capital and labor decreases. Under

OLS and *NLS* estimations this spread is equal to 0.5 per cent points while it is equal to 0.44 under *Benchs* estimations. The answer to the second question is more controversial. The *NLS* and the *2-steps* estimations indicate that s is significantly lower than 1, i.e. temporary contracts are characterized by lower values of the labor-augmenting factor. This result is not supported by the estimates provided by the *Benchs* procedures. Particularly, when x is not instrumented no significant difference in the labor-augmenting factor emerges. Last but not least, the results reported in Table 2 highlight that the incidence of permanent contracts has always a positive and significant effect on TFP dynamics.

Table 3: Estimation results with control variables (n. of obs. 1630)

	α	β	s	γ
guess	.34	.66	1	0
OLS	.249	.768		
	(.012)	(.018)		
NLS	.249	.768	.726	
	(.012)	(.018)	(.085)	
2-steps	.29	.714	.727	
	(.006)	(.008)	(.038)	
Bench1	.29	.717	.998	.141
	(.005)	(.007)	(.146)	(.059)
Bench2	.29	.715	.861	.089
	(.005)	(.008)	(.073)	(.033)

All the coefficients are significant at 5 per cent or less.

Next, we run the same set of regressions but introducing control variables for firm and worker characteristics. Table 3 reports the estimates in the presence of variables that control for workers' levels of education and participation to formation courses, Pavitt's taxonomy, and other firm characteristics (dummy variables that indicate whether firms declare themselves to be financially constrained, engagement in R&D and innovation activity, whether the firm has never employed temporary contracts or temporary agency workers). No striking difference with the results reported in Table 2 emerges and the comparison between the *Benchs* estimates and the other estimates does not change qualitatively. Under the *Benchs* estimates the distance between the

capital and labor coefficient decreases, it is not clear if the labor-augmenting factor of temporary contracts is significantly different from that of permanent contracts, and the dynamic effect of labor-contract composition is still significant.

For the sake of completeness, it is worth mentioning the estimates of the coefficients of the control variables. It emerges that the following variables are characterized by a positive and significant coefficient: doing innovation, firm size, workers attending external formation courses. On the other hand, the following variables are characterized by a negative and significant coefficient: being credit constrained, having never used temporary workers. Finally, Pavitt classification, workers' level of education, engagement in R&D, employing temporary agency workers, workers doing R&D or with training contract, show no significant effect.[19]

5 Sensitivity analysis

In this section, as a robustness check, we apply the *Benchs* procedures to different sub-samples of our dataset. Because of the low number of observations and the nonlinearity involved in our estimation procedures we cannot split the dataset into two or more complementary sub-samples.[20] To overcome this problem we define some economic criteria that permit us to get rid of just a part of the full sample and we run our estimations on the remaining part. The first criterion is based on the fact that the employment protection legislation for permanent workers is related to the firm size. Indeed the consequences of an unfair dismissal are different according to the number of workers employed in the firm. If the firm employs more than 15 workers, the firm must reintegrate the worker in his/her job, while just a pecuniary fine is applied under this threshold. In Table 4, we consider firms with more than 15 employees. Another criterion is related to the access to credit. We exclude firms that are self-declared financially constrained, which could be particularly limited in their choices. The other two criteria refer to activities that the literature

[19] We decided to insert two dummy variables that identify the firms that have never employed temporary workers and temporary agency workers because it could signal the presence of some constraints that could impede a free choice of the labor-contract type.

[20] In fact, when we build complementary subsamples, generally, just in one of the subsamples our estimations converge into reasonable results (where "reasonable" means that the estimate of the capital elasticity and labor elasticity range in intervals found in the literature).

has highlighted as related to productivity (see Aw et al., 2009), engagement in R&D and export activity. We consider the sub-samples composed of firms involved in these activities. Table 4 reports the estimates of the labor-augmenting factor of temporary contracts and the estimates of the effect of labor-contract composition on TFP dynamics. The estimates of the other coefficients are very close to those reported in Table 3.

Even if some differences in the estimates emerge (the estimate of s varies between .83 and 1.63, while the estimate of γ varies between .07 and 0.27), the estimations on the selected parts of the dataset still support a positive role for the incidence of permanent contracts on firm TFP growth.

Table 4: Estimation results on sub-samples

		>15 emp.	no fin. const.	doing R&D*	doing export
Bench1	s	.93 (.1)	.958 (.103)	1.628 (.188)	1.023 (.113)
no control vars	γ	.095 (.041)	.095 (.043)	.24 (.058)	.107 (.042)
Bench2	s	.86 (.063)	.888 (.066)	1.346 (.134)	.971 (.076)
no control vars	γ	.069 (.028)	.071 (.03)	.155 (.041)	.098 (.03)
n. of obs. (no control vars)		1,782	1,624	1,028	1,509
Bench1	s	.956 (.141)	1.007 (.14)	1.479 (.238)	1.14 (.162)
with control vars	γ	.126 (.06)	.127 (.058)	.265 (.071)	.163 (.059)
Bench2	s	.833 (.069)	.883 (.074)	1.165 (.157)	.993 (.088)
with control vars	γ	.076 (.033)	.077 (.034)	.183 (.051)	.122 (.035)
n. of obs. (with control vars)		1,510	1,423	890	1,280

All the coefficients are significant at 5 per cent or less. * $g(\cdot)$ is a polynomial of the third order.

6 Conclusion

In this paper, we investigated the effect of the choice between permanent and temporary labor contracts on productivity. We got two main results. First, the view that the use of temporary contracts reduces firm TFP growth is empirically supported by firm-level data. This result is consistent with recent findings based on aggregate data that highlight a negative effect of low restrictions on the use of temporary contracts on productivity growth. Secondly, the estimate of the difference in the labor-augmenting factor between temporary and permanent contracts may

be biased if the effect of labor-contract composition on TFP dynamics is not taken into account. Indeed, our estimations, which do not consider the effect on TFP dynamics, would suggest that temporary contracts are characterized by a labor-augmenting factor lower than that of permanent contracts. Otherwise, this difference is less significant, or not significant at all, when the effect of the labor-contract composition on TFP dynamics is taken into account.

Previous analyses based on firm-level data have highlighted a negative but temporary (transitory) influence of the spread of temporary contracts on productivity dynamics (i) since the reduction of the constraints on the use of temporary contracts positively affects the level of employment and labor is characterized by decreasing marginal returns, or (ii) since temporary contracts are characterized by a labor-augmenting factor lower than that of permanent workers. Instead, consistently with the evidence provided by the analyses of aggregate data, our study suggests that the effect on productivity dynamics may be persistent since labor-contract choice affects not only workers' productivity but also their contribution to firm productivity growth.

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