Labor Contracts and Productivity Dynamics*

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Abstract

This paper studies the effect of the 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. We substantially agree with this view but we question which is the source of the productivity gap. Our analysis suggests that the labor-contract choice may affect the evolution of the firm productivity process and not (or not only) the level of labor productivity for 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 could 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 problem highlighted by Ackerberg, Caves and Frazer (2006). Empirical results show that by: i) not controlling for the effect of the labor contract choice on TFP, permanent workers are characterized by a higher labor-augmenting factor; ii) endogenizing the TFP process, the difference in the labor-augmenting productivity factor is not always significant and the incidence of permanent contracts on total contracts has a positive and significant 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.

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1 Introduction

This paper studies the effect of the 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. We substantially agree with this view but we question which is the source of the productivity gap. Our analysis suggests that the labor-contract choice may affect the evolution of the firm productivity process and not (or not only) the level of labor productivity for 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 could 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 problem highlighted by Ackerberg, Caves and Frazer (2006). Empirical results show that by: i) not controlling for the effect of the labor contract choice on TFP, permanent workers are characterized by a higher labor-augmenting factor; ii) endogenizing the TFP process, the difference in the labor-augmenting productivity factor is not always significant and the incidence of permanent contracts on total contracts has a positive and significant 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.

The productivity slowdown represents a central issue in the current debate about the Italian economy. Indeed, during the last two decades, estimations of the TFP growth rate place Italy among the worst-performing OECD countries. The aggregate TFP showed very low, and even negative, rates of growth while employment constantly increased.[1] In the same time period, the Italian labor market has become less rigid and the use of temporary contracts has increased. Until the second part of the '90s, the Italian labor market was considered very rigid due to the presence of strong labor unions, high firing costs and strict regulations on the use of non-standard labor contracts. In 1997, the so-called Pacchetto Treu represented a turning point for the institutional setting of the Italian labor market, particularly because it introduced new types of labor contracts and deregulated the use of temporary contracts. A synthetic indicator of this institutional change is provided by the OECD and concerns the strictness of the employment protection legislation (EPL) for temporary employment. This index shifted from 5.38, in 1996, to 2, in 2008, where higher values indicate stricter regulation. The new institutional framework permitted Italian firms to modify the use of labor contracts. In fact, the incidence of temporary employment on total employment was 7.5 per cent, in 1996, while it was 14 per cent, in 2008.

Similar patterns, concerning productivity and labor contracts, have characterized other European countries and some economists as Saltari and Travaglini (2003) and Boeri and Garibaldi (2007) argue that labor-market reforms have played an important role. Saltari and Travaglini (2003) use a SVAR approach to support the idea that some European countries (including Italy) were subjected to negative productivity shocks and that labor-market reforms induced a positive shift of labor supply, conciliating the productivity slowdown with employment increase. Boeri

[1] According to the OECD the multi-factor productivity often decreased (by 1.8 per cent only in 2003), while the overall increase in total employment was about 14.7 per cent.

and Garibaldi (2007) highlight the fact that a two-tier labor-market reform, where only a part of the labor market becomes flexible, produces an increase in employment in the short run, but it cannot support a structural and persistent change of labor-market performance; furthermore, the productivity slowdown is exacerbated by the decreasing marginal returns of labor services.

We join in this debate by analyzing the impact of temporary contracts on productivity at firm level. The core of our contribution is represented by the estimation of different effects of the labor-contract choice on productivity.

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, since part of the knowledge is not "kept in secret" but is shared with the firm. Labor contract is 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. Under this view, firms should benefit from the commitment to the duration of the labor relationships. Starting from the standard Cobb–Douglas production function we focus on an effect that, to the best of our knowledge, has not yet been investigated and we find that the incidence of temporary contracts dampens a source of TFP growth.[2] This result suggests that a structural change in the labor-contract composition may induce not only a level effect on productivity but may also affect its evolution. The rest of the paper is organized as follows. Section 2 reviews the related literature. Mainly, it focuses on both the structural approach to the production function estimation and contributions studying 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 concludes.

2 Related Literature

2.1 Production-Function Estimation

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 production-input choice. In particular, it has been emphasized that econometrician does not observe firm productivity, while it is highly likely that firm productivity (at least partially) enters the entrepreneur's information set before that the decision on the use of easily adjustable inputs is taken. That 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 relied on some implications of the theoretical models to improve the estimation procedure. In particular, we refer to the structural approach that starts with the seminal contribution of Olley and Pakes (1996) (OP).[3] This approach is characterized by the use of theoretical-model

[2] In some way our contribution is related to Iranzo et al. (2006) who investigate the role of skill dispersion within and between status groups of workers. But, while they investigate how labor-specific elements affect labor-specific productivity with no dynamic effect, on the contrary we investigate how labor-specific elements affect also TFP dynamics.

[3] Another approach widely applied follows Blundell and Bond (2000) contribution to the analysis of dynamic panel data. To our knowledge this approach has not been applied when productivity is assumed to be affected by

predictions to define the unobserved firm productivity as a function of some observed firm characteristics and to identify the moment conditions to be taken into account. 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*). OP indicate investment in physical capital as a variable that satisfies the previous conditions, while Levinshon and Petrin (2003) (LP) suggest that intermediate goods can perform better since they are less lumpy than investment.[4]

Both cited contributions follow the same procedure to come through the simultaneity issue.[5] Very briefly, they suggest a two-step regression. In the first one, they estimate the labor coefficient and a polynomial function that should control for capital and TFP contribution to production. This requires that labor does not enter the polynomial function and that labor demand is not exactly defined by the polynomial function. In the second step, they use the characteristics of the dynamic generating process of productivity to disentangle the contribution of capital and TFP in the part of the production not explained by labor.

This approach seems to address quite satisfactorily the endogeneity problem but, as highlighted by Ackerberg, Caves, and Frazer (2006) (ACF), it suffers a serious collinearity problem that may prevent the identification of the labor coefficient in the first step of the procedure. ACF show that following the LP procedure no time structure of the input choice supports the immediate identification of labor coefficient. If labor and intermediate material were chosen simultaneously after observing TFP, they would depend on the same state variables and perfect collinearity between labor and the polynomial function would emerge. If intermediate materials were chosen before labor, the polynomial function would not control for the entire TFP and labor would continue to be correlated with an unobserved and uncontrolled element. If labor were chosen before the intermediate materials, then labor would affect the intermediate-material choice and should enter the polynomial function defining the relationship between intermediate materials and TFP. In all cases the labor coefficient is not identified in the first step.

In the OP approach the collinearity problem may be avoided by assuming that labor is chosen before investment. But that would require arguing, at the same time, that labor services can be adjusted without frictions and that they are set before choosing the accumulation of the next-period capital, which is not really persuasive. Otherwise, labor could be considered a dynamic variable but, in this case, labor coefficient could not be identified in the first step because labor should affect investment choice and thus enter the polynomial function.

ACF propose overcoming the collinearity issue by running a non-parametric regression in the first step, including labor in the polynomial form, aimed at removing the idiosyncratic shock that does not enter the entrepreneur's information set (the untransmitted shock). In the second step they estimate all the parameters of the production function by a GMM. This procedure is consistent with the hypothesis that labor is a dynamic factor and, since labor demand is affected

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other variables. However, some of the contributions cited below become similar to Bundell and Bond (2000) in special cases.

[4] Indeed, they notice that in firm datasets there is a large number of null investment, suggesting that for different levels of productivity, investment may be the same (null). That does not comply with the strict monotonicity condition.

[5] Also the selection issue has emerged as a relevant problem in production-function estimation. It is related to the firms' exit choice that may be affected by the firm capital and, consequently, may bias the estimate. Since our data refer to a short-time-period balanced panel we do not address this issue.

by current productivity while current capital is given, the residuals of the second-step regression are imposed to be orthogonal with the current capital and lagged labor.

All the previous procedures assume that TFP follows an exogenous process. Doraszelski and Jaumandreu (2009) propose to endogenize firm productivity by introducing the R&D expenditure in the TFP process. That requires including R&D expenditure in the polynomial function that controls for TFP.[6] The authors present their approach as more general than the standard knowledge capital approach and show that the procedure is relevant for estimating the effect of R&D on productivity growth and the rate of return on R&D expenditure. They overcome the multicollinearity issue by instrumenting labor services with the current real wage, since it is exogenously given to firms.

2.2 Temporary and Permanent Contracts

The other field of literature that is related to our paper is the one investigating the differences in the use of temporary and permanent labor contracts. This topic has been studied from both macro and micro perspective and it often overlaps with the study of the influence of the employment protection legislation on markets' performances. Since this literature is too vast to be summarized here, we limit to cite the contributions that mostly add to the understanding of the relationship between productivity and labor contracts. 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 the labor productivity (due to the decreasing marginal return of labor).[7] 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. There are other contributions considering workers with different contracts as perfect substitutes, but with a labor-augmenting factor, that is specific to each type of contract. This kind of productivity gap serves to justify new hirings with both types of contracts in the presence of differences in the (expected) cost. In fact, permanent contracts are generally considered more expensive because they imply lower flexibility (the labor hoarding phenomenon) and higher firing costs. Then a productivity advantage is required to model the demand for permanent contracts. That's the estimation result of Aguirregabiria and Borrego (2009) who analyze the impact of the two-tier labor-market reform implemented in the '80s in Spain. They find significant changes in some structural parameters but, comparing the estimated results with the ones emerging from a simulated economy characterized by a decrease in the firing costs of all types of contracts, they consider the realized reform as not performing well in terms of productivity and firm value.

In Casquel and Cunyat (2008) and in Caggese and Cuñat (2008) productivity emerges as a key element determining the labor-contract choice. The former state that productivity contributes to determine whether the temporary contracts are a way to access permanent contracts or they represent a trap.[8] The latter model labor services as Aguirregabiria and Borrego (2009) calibrating temporary contracts as less productive. They provide evidence of pro-cyclical behavior of the

[6] This procedure is applied by Aw et al. (2009) who include both R&D and export activities in the dynamic generating process of the TFP.

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

[8] Casquel and Cunyat (2008) identify also the institutional factors determining the endogenous transition from temporary to permanent contracts.

incidence of permanent contracts analyzing firm labor demand under positive and negative TFP shocks.[9]

Other contributions try to explain why the difference in workers' productivity should depend on type of labor contract. An explanation focuses on the incentive in investing in productivity for both firm and worker. For example Albert et al. (2005) use Spanish firm data and 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. Another field of research focuses 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. 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 Ghignoni (2009) who finds, 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. Furthermore, looking at international aggregate data, the author casts some doubts on the existence of a positive relationship between effort indicators and productivity. Similarly, Beccarini (2009) analyzes the impact of the Italian labor market reform in a framework with endogenous effort choice. The author argues that a reform at the margin, that leaves the share of permanent contracts very high, reduces temporary workers' ability to affect the probability of the contract-renewal. Using aggregate data, the author shows that temporary workers' productivity is negatively related to the incidence of permanent 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 dynamics and labor productivity. Some examples are Bassanini et al. (2008), Lisi (2009), and Damiani and Pompei (2010). Bassanini et al. (2008) analyze the effect of labor market regulation on TFP dynamics by 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. 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. Even stronger results emerge in Lisi (2009) and Damiani and Pompei (2010) supporting the hypothesis of an inverse relationship between temporary contracts and productivity growth. Their results are fully consistent with our view that supports permanent contracts as a better type of labor relation for productivity growth.

Finally, it is worth citing Altuzarra and Serrano (2010) even if the relationship between type of labor contract and productivity is not direct. The authors use the incidence of temporary contracts as a proxy of corporate flexibility and estimate that only up to a certain threshold does it increase the probability of engaging in innovation and R&D activity.

[9] Caggese and Cuñat (2008) mainly study the effects of financial constraints on the labor contract choice.

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. It 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 an AR(1) process and depends on the relative use of labor contracts with a time period lag. Let $x_t = P_t / (P_t + T_t)$, $\varepsilon_t \sim N\left(0, \sigma_\varepsilon^2\right)$, and z, ρ and γ be parameters, then the production function can be rewritten as $Y_t = e^{z+\rho\omega_{t-1}+\gamma x_{t-1}+\varepsilon_t} K_t^{\alpha} L_t^{\beta}$. 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. Define the function $i_t^p = (1 - \delta_p) P_{t-1} - P_t$, where δ_p is the natural separation rate of permanent workers that does not imply firing cost payment. Define the indicator function $S_t = 1$ if $i_t^p > 0$ 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.

$$V_{j,t}\left(\chi_{j,t}\right) = \max_{\{P_{j,t}, T_{j,t}, I_{j,t}\}} \left\{ Y_{j,t} - W_{P,t} P_{j,t} - W_{T,t} T_{j,t} - F i_{j,t}^p S_{j,t} - I_{j,t} + \frac{1}{1+\zeta} V_{j,t+1}\left(\chi_{j,t+1}\right) \right\},$$

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

The optimal choice of labor with temporary contracts is described by the following condition:

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

Equation (1) states that firms hire temporary workers until their current marginal productivity is equal to the real wage plus the 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.

$$\frac{\partial Y_t}{\partial P_t} = W_{P,t} - F S_t + \frac{1}{1+\zeta}(1 - \delta^p) F * E\left[S_{t+1}\right] - \frac{1}{1+\zeta} E\left[\frac{\partial Y_{t+1}}{\partial x_t}\frac{\partial x_t}{\partial P_t}\right]. \tag{2}$$

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 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 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.

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

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.[10] We limit ourselves to focusing on the choice of recruitment. Permanent contracts imply higher expected costs due to the probability of paying firing costs.[11] That requires that new permanent contracts are signed only if they provide a comparative advantage in terms of revenues, i.e. higher productivity. This view is largely accepted in the literature and the way this is formalized is by imposing $s < 1$. We don't feel fully comfortable with that because it does not capture the intertemporal effect of the labor-contract choice, while the temporal dimension is the element characterizing the type of contract. Our model suggests a way to take into account an intertemporal effect of the labor-contract choice and it is defined by the second element on the left side of equation (3). Under our assumption TFP is positively 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 can not be excluded *a priori* that the labor-contract choice implies, for example, a trade-off between a short-run and a long-run benefit (i.e. $s > 1$ and $\gamma > 0$). That is what we are going to investigate empirically in the next section.

Finally, it is worth considering 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 to control for the unobserved productivity.

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

Eq. (4) indicates that capital accumulation is increasing in the elasticity of output to capital (α) and decreasing in the time discount factor (ζ) and depreciation rate (δ). It is more important, to our purposes, to highlight that investment is increasing 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 expected labor services imposes to include in the generic function describing the investment choice also the current level of permanent contracts, since they 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 – Unicredit dataset that consists of quantitative and qualitative information about a representative sample of Italian manufacturing firms. In particular, it includes

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

[11] We didn't find many contributions studying the difference in wages between permanent and temporary workers in Italy. Institutional reports generally highlight that temporary workers receive lower salaries. Picchio (2006) deals with the endogeneity issues related to the estimation of the wage gap confirming temporary workers' disadvantage.

information about firm balance sheets and 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.[12] We measure the starting capital taking the item "net fixed asset" reported in the 2001 firm balance sheet. The capital stocks for 2002 and 2003 are obtained by adding firm investment and applying a depreciation rate equal to 0.1.[13] We drop outliers and firms with missing data.[14] Table 1 reports some statistics characterizing our sample and some similar works. In particular, capital per worker is in line with that estimated by Iranzo et al. (2006). The last six rows of the table report the correlations between value added per worker, permanent workers, temporary workers and incidence of permanent workers. To our purposes, it is worth noting that the value added per worker (often used as a measure of productivity) is positively correlated with the lagged value of the incidence of permanent workers. This last element is negatively correlated with temporary workers. That implies that excluding x, in a regression where it would be supposed to be included, may induce a serious bias in the estimation of the temporary contract coefficient.

Table 1. Descriptive Statistics

	sample	*references*
No. of firms	1,936	
% firms with no temp. workers	61	67****
No. of workers (L)	156	198** – 142***
st. dev. of L	447	949**
share of perm. workers (x)	0.96	0.90* - 0.96****
st. dev. of x	0.11	
capital per worker (KL)	0.065	0.07**
st. dev. of KL	0.047	
value added per worker (YL)	0.048	0.041**
st. dev. of YL	0.020	
correlation (YL,P)	0.07*°	
correlation (YL,T)	−0.04	
correlation (P,T)	0.31*°	
correlation (YL,x(-1))	0.1*°	
correlation (P,x(-1))	0.05	
correlation (T,x(-1))	−0.57*°	

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

[12] 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 is used in other studies, among the others: Caggese and Cuñat (2008) and Hall et al. (2006).

[13] The same value is applied, for example, by Aguirregabiria and Borrego (2006).

[14] 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, respectively, higher than 3, 0.8, 0.15, and 0.3 (where all the monetary values are reported in millions of 2001 euros).

4.2 Estimation Procedure

As previously anticipated, we adopt a structural approach to the production function estimation assuming that a polynomial function of firm investment and firm state variables can control for firm productivity. As in the OP procedure, there is a one to one relationship between current investment and current productivity (via the relationship of both variables with the expected productivity). But, since in our framework productivity is endogenous, it is necessary to take into account the elements determining the expected productivity. We assume that investment and labor contracts are chosen simultaneously so that the polynomial function controls for the whole productivity affecting labor choice. Furthermore, differing from Aguirregabiria and Borrego (2009), we include in the polynomial function the current (and not the previous) values of the labor variables because they affect the expected productivity and, via firing costs, the expected labor services and thus the marginal return of capital. It follows that, since labor variables enter the polynomial function controlling for productivity, the regression of the output on its components permits us only to disentangle the stochastic component, that is not observed by the entrepreneur (the untransmitted shock), from the rest of the output.[15] Then, all the parameters are estimated in a second step by implementing a non-linear estimation consistent with the assumed characteristics of the dynamic generating process of firm TFP.

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 $\eta_t \sim N\left(0, \sigma_\varepsilon^2\right)$ is the untransmitted shock. Define the investment demand as a polynomial function of productivity ω_t, and state variables, $I_t = f(\omega_t, x_t, P_t, K_t)$. Since investment is assumed to be strictly increasing in productivity, it is possible to invert this relationship and define current productivity as a function of investment and state variables $\omega_t = f^{-1}(I_t, x_t, P_t, K_t)$. Define $\phi_t = \omega_t + \alpha k_t + \beta \ln (P_t + sT_t)$ and substitute in the production function equation, $y_t = \phi_t (I_t, x_t, P_t, K_t) + \eta_t$.[16]

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 $\omega_t = E[\omega_t|\Omega_{t-1}] + \varepsilon_t = E[\omega_t|\omega_{t-1}, x_{t-1}] + \varepsilon_t = z + \rho\omega_{t-1} + \gamma x_{t-1} + \varepsilon_t$, run a non-linear regression of TFP on its last value and the other determinants:

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

Since labor services are chosen after the realization of the productivity shock, P and T are instrumented with their lagged values.

[15] More precisely, the same problem characterzing capital services would emerge for permanent contracts, while the multicollinearity problem highlighted by ACF would emerge for temporary contracts, since temporary contracts are determined by the variables composing the polynomial function.

[16] 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 x is never equal to zero, while temporary contracts are often equal to zero. Otherwise, once you control for x and P, you are also controlling for T.

4.3 Empirical Results

Tables 2 reports parameter estimates obtained by applying different estimation procedures. The estimation called *OLS* is a standard OLS regression that ignores that input services are correlated with the unobserved productivity, that labor services are not homogenous, and that productivity evolves over time. The estimation called *OLS-nl* 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. *2-steps* estimation applies the procedure previously exposed except for considering productivity as an exogenous Markov process (i.e., not including labor-service composition, x). Finally, *Bench1* and *Bench2* represent our benchmark estimation procedures. The only difference is that in *Bench1* x is not instrumented, while in *Bench2* x is instrumented with its lagged value in order to preserve time consistency among the labor variables. In each cell of Tables 2, the value in the upper line indicates the estimated value, while the values in the bottom line define the 95 per cent confidence interval. Except for the first procedure, 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; $\rho = 0.9$ is between the unstationary hypothesis and the value estimated by Foster et al. (2008); $\gamma = 0$, i.e. no impact of labor composition on productivity dynamics; and finally $s = 1$, i.e. labor services have the same productivity. Sensitivity analysis with respect to the starting values (particularly of s) has been conducted supporting the robustness of the estimation results.

Table 2. Estimation results without dummies (n. of firms = 1936)

	α	β	s	ρ	γ
OLS	.302 .28 | .33	.729 .70 | .76			
OLS-nl	.299 .28 | .32	.732 .71 | .75	.570 .48 | .66		
2-steps	.325 .32 | .34	.696 .68 | .71	.686 .63 | .75	.433 .40 | .47	
Bench1	.325 .31 | .34	.692 .68 | .71	1.130 .83 | 1.43	.472 .44 | .51	.199 .09 | .31
Bench2	.325 .31 | .34	.692 .68 | .71	.814 .70 | .93	.472 .44 | .51	.080 .03 | .13

The results reported in Table 2 should answer to three main questions. Is the estimation technique capable of reducing the estimation bias induced by the correlation between the unobserved productivity and labor demand? Does the labor composition affect TFP dynamics? Does a productivity gap between permanent and temporary contracts exist? The answer to the first question is definitively positive since the estimated value for the labor coefficient is lower when we use the relationship between investment and TFP to control for the unobserved productivity. In fact, β is always lower under *2-steps* and *Benchs* than under *OLS* and *OLS-nl* procedures. With regard to the second question, that synthesizes the main scope of this paper, γ is always positive and significantly different from zero. That means that the incidence of permanent contracts supports productivity growth. Compared to *Bench1*, *Bench2* suggests a less strong effect, but still significant.[17] Finally, both *OLS-nl* and *2-steps* estimate the productivity of temporary contracts to be significantly lower than the productivity of permanent contracts; indeed, $s < 1$ is consistent with most of the literature previously cited. But this result is not always confirmed under the *Benchs* procedures. Once we take into account the role of the labor composition, only *Bench2* confirms the significance of the productivity gap while no clear difference between the labor-augmenting factor of permanent and temporary contracts emerges under *Bench1*. However, it is worth noting that both *Benchs* procedures provide estimates of s, higher than those of *OLS-nl* and *2-steps*. This result is likely related to the correlations reported in Table 1 which suggest that, not taking into account the labor-contract composition, may induce an estimation bias of the coefficient of temporary contracts.

Table 3. Estimation results with all the dummies (n. of firms = 1643)

	α	β	s	ρ	γ
OLS	.291 .27 | .32	.739 .70 | .77			
OLS-nl	.290 .27 | .31	.739 .72 | .76	.664 .56 | .77		
2-steps	.309 .30 | .32	.702 .69 | .71	.738 .68 | .80	.389 .35 | .43	
Bench1	.310 .30 | .32	.699 .69 | .71	1.122 .78 | 1.46	.437 .40 | .48	.169 .03 | .31
Bench2	.310 .30 | .32	.699 .69 | .71	.902 .77 | 1.03	.437 .40 | .48	.084 .02 | .14

We run other regressions in order to control for firms' and workers' characteristics. In Table A1 (reported in the Appendix) we control for Pavitt's taxonomy. In Table A2 (reported in the Appendix) we control for other firm characteristics: whether firms declare themselves to be financially constrained, whether have engaged in R&D activity, whether have never employed temporary contracts. In Table A3 (reported in the Appendix) we control for workers' skill by taking into account three levels of education. Table 3 reports the regressions that include dummies for all the previous elements. No striking difference with the results reported in Table 2 emerges. The dynamic effect of labor-contract composition is still positive and significant. Under *Bench1* procedure s is still not significantly different from 1 but under *Bench2* the level of confidence in considering $s < 1$ decreases. Finally, it is worth commenting the results concerning the chosen dummies (even if dummies' coefficients are not reported in the tables). Most of them provide reasonable results: workers' education level has positive and significant influence; to be classified as a specialized supplier or science-based firm has a positive and significant effect (science-based is not significant only when also workers' skill is taken into account); the coefficient of R&D dummy

[17] In order to get an easy intuition of the numerical relevance of the different estimates of γ, consider that an increase in the incidence of permanent contracts of 5 percent points induce 1 and 0.4 percent points increase in TFP growth rate, according to (respectively) *Bench1* and *Bench2* estimates.

is positive and significant; to be financially constrained and to have never employed temporary contracts have negative and significant influence.[18]

4.3.1 (In)consistency analysis

The benchmark procedure, previously presented, requires full consistency between theoretical assumptions and estimation procedure. In particular, the polynomial function used to control for the firm TFP must include all the variables that are assumed to enter the DGP of the TFP and that may affect the relationship between firm investment and productivity. Since the labor-contract composition was assumed to be a determinant of the TFP dynamics, it was necessary to include the incidence of the permanent contracts in the polynomial function that was estimated in the first step. However, this procedure may let the incidence of the permanent contracts emerge as significant by construction. Running the previous two-step procedure without including the incidence of the permanent contracts in the first step, but including this element only in the second step, represents a rough way to check the presence of this kind of self-fulfilling prophecy. This procedure does not grant consistency between the different steps of the procedure but it limits the risk that γ is relevant just because that has been assumed in the first step. All the other elements are kept unchanged. Table 4 shows the estimation results of the procedures that are affected by the change in the first step (the benchmark procedures with and without dummies).

Table 4. Estimation results with inconsistent procedure

	α	β	s	ρ	γ
Bench1 (no dummies)	.325 .32 | .34	.696 .68 | .71	1.101 .78 | 1.42	.434 .40 | .47	.196 .07 | .32
Bench2 (no dummies)	.325 .32 | .34	.696 .68 | .71	.800 .69 | .91	.433 .40 | .47	.073 .02 | .13
Bench1 (with dummies)	.309 .30 | .32	.702 .69 | .71	1.070 .70 | 1.44	.386 .35 | .43	.176 .01 | .34
Bench2 (with dummies)	.309 .30 | .32	.702 .69 | .71	.852 .73 | .97	.386 .35 | .43	.079 .02 | .14

The only significant change emerging from Table 4, with respect to the previous results, concerns the estimate of the labor-augmenting factor under the *Bench2* procedure in the presence of the selected dummies. While the fully consistent procedure casts some doubts about the significance of the difference between the labor-augmenting factors of temporary and permanent contracts, the inconsistent procedure suggests that the labor-augmenting factor of temporary contracts is significantly lower than that of permanent contracts. However, the most important result that emerges from this alternative procedure is that the significance and the direction of the effect of the incidence of the permanent contracts on the TFP dynamics is not built on its inclusion in the polynomial function of the first step.

[18] While the explanation of the role of the other dummies is quite immediate, a brief comment is necessary for the dummy that identifies the firms that have never employed temporary workers. We decided to insert this element because it could signal the presence of some constraints that could impede a free choice of the labor-contract type.

5 Conclusion

In this paper, we investigated the effect of the choice between permanent and temporary contracts on firm productivity. We got two main results. First, the view that the use of temporary contracts reduces 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. Second, the estimate of the difference in the labor-augmenting factor between temporary and permanent contracts may be biased if the effect of the labor-contract composition on TFP dynamics is not taken into account.

Other interpretations of the influence of the spread of temporary contracts on productivity slowdown consider the effect on productivity dynamics as temporary (*i*) since the reduction of the constraints on the use of temporary contracts affects positively the level of employment and labor is characterized by decreasing marginal returns, or (*ii*) since temporary workers are characterized by lower labor-augmenting factor than permanent workers. Instead, our analysis suggests that the effect on productivity dynamics may be persistent since the labor-contract choice affects not only workers' productivity but also their contribution to firm productivity growth.

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6 Appendix

Table A1. Estimation results — sectoral dummies (n.firms 1936)

	α	β	s	ρ	γ
OLS	.302 .28 | .33	.727 .69 | .76			
OLS-nl	.299 .28 | .32	.729 .71 | .75	.621 .53 | .71		
2-steps	.323 .31 | .33	.693 .68 | .71	.731 .67 | .79	.441 .40 | .48	
Bench1	.323 .31 | .33	.693 .68 | .71	1.138 .82 | 1.45	.440 .40 | .48	.183 .06 | .31
Bench2	.323 .31 | .33	.693 .68 | .71	.838 .73 | .95	.441 .40 | .48	.065 .01 | .12

Table A2. Estimation results — dummies for other firms' characteristics (n.firms 1862)

	α	β	s	ρ	γ
OLS	.301 .28 | .33	.720 .69 | .75			
OLS-nl	.298 .28 | .31	.723 .70 | .74	.553 .47 | .64		
2-steps	.320 .31 | .33	.680 .67 | .69	.676 .61 | .74	.495 .46 | .53	
Bench1	.320 .31 | .33	.680 .67 | .69	1.076 .81 | 1.34	.492 .46 | .53	.189 .09 | .29
Bench2	.320 .31 | .33	.680 .67 | .69	.813 .70 | .92	.492 .46 | .53	.093 .04 | .14

Table A3. Estimation results — dummies for workers' levels of education (n.firms 1663)

	α	β	s	ρ	γ
OLS	.293 .27 | .32	.746 .71 | .78			
OLS-nl	.292 .27 | .31	.748 .73 | .77	.655 .55 | .76		
2-steps	.316 .30 | .33	.703 .69 | .72	.798 .72 | .87	.494 .46 | .53	
Bench1	.316 .30 | .33	.704 .69 | .72	1.170 .85 | 1.49	.488 .45 | .53	.159 .04 | .28
Bench2	.316 .30 | .33	.704 .69 | .72	.934 .80 | 1.07	.488 .45 | .53	.077 .02 | .13