# UNIVERSITÀ DEGLI STUDI DI CATANIA

**DIPARTIMENTO ECONOMIA E METODI QUANTITATIVI**

**DOTTORATO DI RICERCA IN ECONOMIA PUBBLICA**

**CICLO XXIII**



DOMENICO LISI


# REGULATION AND PERFORMANCE IN THE LABOUR MARKET

TESI DI DOTTORATO


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ANNO ACCADEMICO 2009 – 2010

# The impact of Temporary Employment on Labour Productivity: Evidence from an Industry-Level Panel of EU Countries

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*September 2009*

## Abstract

*In recent years the availability of new industry-level data allowed to evaluate the impact of labour market policies more consistently than previous standard cross-country studies. In this paper an industry-level panel is exploited to evaluate the impact of less stringent Employment Protection Legislation (EPL) for temporary employment (TE) in EU countries. A reduced form model is estimated to identify the overall effect on labour productivity growth. The advantage of using industry-level data is fourfold. First, as in standard cross-country studies, the cross-country variation of EPL is still exploited. Second, in contrast with the cross-country analysis, the specification allows us to control for unobserved fixed effects, potentially correlated with the level of EPL. Third, as the previous literature emphasised, the within-industry "composition effect" appears to be negligible, allowing us to identify the "independent effect" of TE. Fourth, to the extent that events in a single industry are not able alone to affect the policy in a country, the specification is less subject to the simultaneity problem between variable of interest and policy. The theoretical literature on TE has not established a clear prediction on the sign of the effect, existing different convincing reasons for both directions. Thus, the results of the analysis have potentially important policy implications. Our finding is that the introduction of temporary contracts has a negative, even if small in magnitude, effect on labour productivity growth.*

JEL Classification: J08, J24, O47.

Keywords: labour productivity, temporary employment, EPL, difference-in-differences.

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[*] The author would like to thank Stephen Machin for helpful comments. However, the analysis and any errors remain responsibility of the author alone.

# The impact of Temporary Employment on Labour Productivity: Evidence from an Industry-Level Panel of EU Countries

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### *1. Introduction*

Despite the international differences in the relative importance of temporary employment (TE), it is evident that in the last decades temporary jobs have been becoming an important feature of the labour market landscape in the majority of OECD countries. In particular, the share of TE in most EU countries has grown dramatically, raising the question of the possible effects of this structural change in the labour market.

In the different experiences of EU countries a considerable number of country-specific factors have been playing an important role in determining this change. Nonetheless, as emphasized by a growing literature, some common determinant appear to have been crucial in shaping this feature. In particular, the high protection for permanent employment (PE) along with a less stringent regulation for TE would seem to be the main explanation of the rapid growth of TE in EU countries. Similarly, the low protection of PE in the United States, the United Kingdom and other countries would explain the low use of TE made by employers.

The new scenario has raised worries that TE might increase the dualism in the labour market between high protected workers finding a stable job, after a transition from TE, and those low protected remaining in the trap of precariousness, with little prospect of upward mobility. Moreover, TE frequently offers less access to the welfare system and other fringe benefits, as unemployment insurance, sick leave, paid vacations. This dualism would represent an undesirable difference in the welfare conditions of the two types of workers in the society.

From an efficiency point of view, the increasing share of TE raises the question of what would be the impact on labour productivity. This issue would have potentially very important policy implications, especially since during the last twenty years labour productivity growth accounted for more than half of GDP growth in OECD countries (OECD, 2003).

The theoretical literature available so far has not established a clear prediction on the sign of the effect, existing different convincing reasons for both directions. On one hand, TE is disproportionally filled by younger and less educated workers, and temporary workers often have less access to training programmes. Moreover, given the temporary, and frequently short, duration of contracts it would be rationale for a firm to fix a lower reservation productivity under which to layoff temporary workers than permanent ones, in order to avoid the direct and indirect firing costs. On the other hand, TE allows firms a much more flexible and, in turn, efficient organization of resources and eliminates the disincentive to invest in risky, but potentially valuable, projects. Moreover, it might be rationale for temporary workers to exert a greater effort in order to get the renewal of the contract and/or the passage to a stable job. Therefore, the issue of the direction of the effect remains an empirical question.

While the empirical literature on the theme has already offered a convincing answer to the issue of the role of Employment Protection Legislation (EPL) on employment level, the empirical evidence available so far has not fully clarified what is the impact of EPL on labour productivity. Indeed, the issue has been already the object of interest of few studies, some of which succeed in identifying the negative impact of EPL for regular contracts. However, the strategy to identify the impact of TE does not seem to be as satisfactory as that for regular contracts. Nonetheless, to these studies has to be acknowledged the merit to have introduced an identification strategy more satisfactory than the standard cross-country analysis.

Following this new empirical literature, the aim of this paper is to shed light on this issue by assessing the impact of both EPL for regular contracts and TE on labour productivity growth. To the extent that the level of EPL and TE affects firms decision on investment and, in turn, the level of capital affects labour productivity growth, we estimate a reduced form model to capture the overall effect, assuming a Cobb-Douglas production function with constant returns to scale. The empirical strategy follows the method introduced in the finance literature by Rajan and Zingales (1998) and later extended in the other areas in economics. In the field, the papers by Micco and Pages (2006) and Bassanini and Venn (2007) introduced this approach to evaluate the impact of different labour market policies. The method exploits both cross-country variation in EPL and TE and variation in the relevance of EPL in different industries. The industry-level panel allows us to control for different specific unobserved effects, allowed to be correlated with covariates. Among others, this represents one of the most important advantages of the specification with respect to the standard cross-country analysis.

The main result is that TE has a negative impact on labour productivity growth, even if small in magnitude. In particular, an increase of 10% of the share of TE would lead to a decrease of 1% in labour productivity growth. Furthermore, the analysis confirms the findings of the previous literature that EPL for regular contracts reduce labour productivity growth more in those industries requiring for their own characteristics a greater reallocation.

The paper proceeds as follows: Section 2 introduces the main stylized facts about EPL and TE in EU countries. Section 3 reviews briefly the previous literature and discusses some theoretical issue. Section 4 illustrates the identification strategy and introduces the main features of the dataset. Section 5 presents the results of the analysis and examines the robustness of the findings. Section 6 discusses the policy implications and some final remark.

## *2. Labour Market and Reforms: The Stylized Facts*

In the 1990s the persistency of high level of unemployment in Europe with respect to other OECD countries represented a reason of concern for many governments. Consequently, most of EU countries felt the need to intervene and reform the labour market legislation, identified as one of the main causes of high unemployment.

Despite the different forms of intervention, fairly all reforms followed a typical common scheme: new legislations did not included workers hired pre-reforms, instead affecting deeply the rules for those post-reforms; protection legislations for PE were left untouched; the use of TE was gradually liberalized.

The emergence of these asymmetric institutional changes can be well characterized by Figure 1. It illustrates the evolution of the OECD index of the strictness of EPL for both regular (top) and temporary (bottom) employment between the late 1980s and 2003. In the Figure at the top very few countries are located below the 45° line, suggesting that protection legislations for PE were left unchanged. At this regard, Spain and Portugal constitute an exception, where respectively in 1997 and 2001 protection legislations for permanent contracts were significantly relaxed. Differently, in the Figure at the bottom very few countries lie close to the bisector, symptomatic of the extensive reformatory process concerning the use of TE.

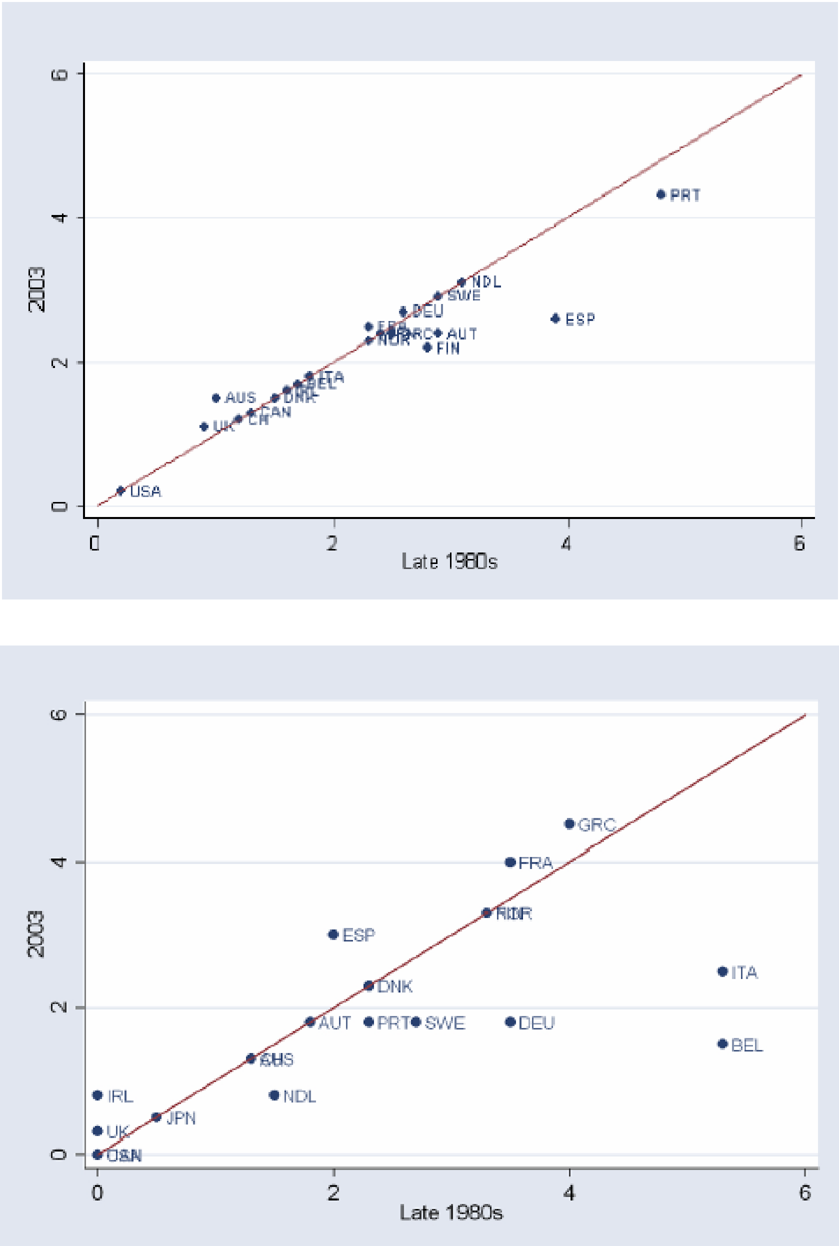
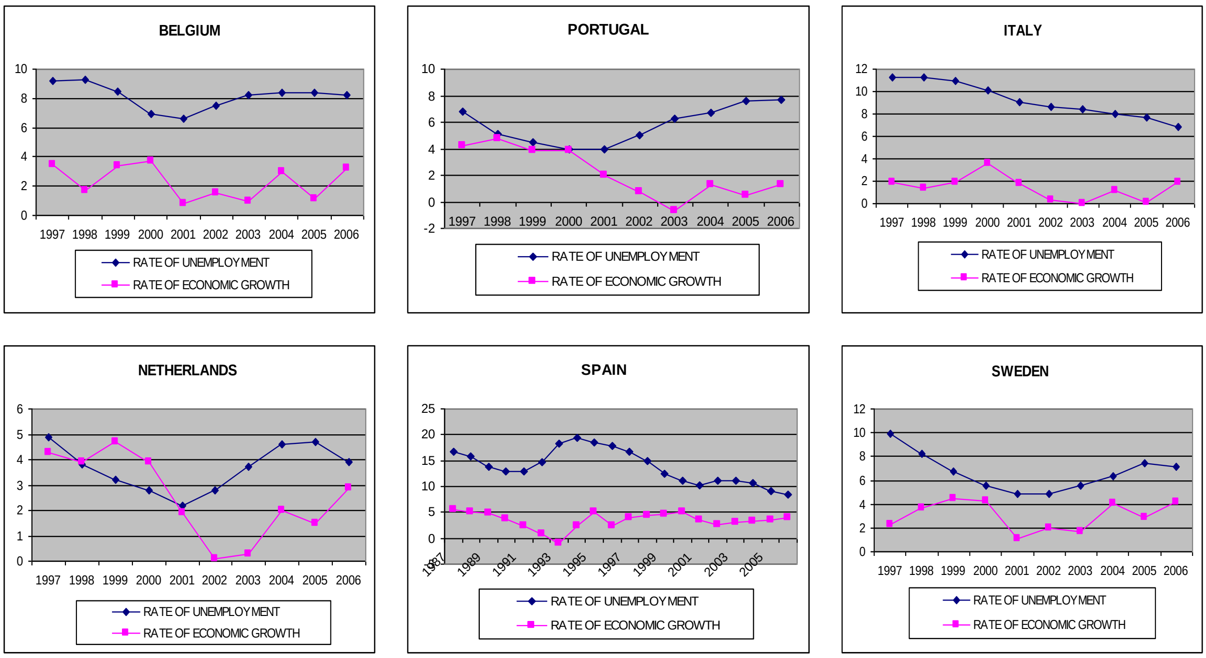



Fig. 1 *OECD index of the strictness of EPL for permanent (top) and temporary (bottom) contracts*

In order to get some insight on the macro-impact of this structural change, in the Figure 2 we report the graphs of unemployment rate and growth rate in the transition time of a representative sample of EU countries. To choose the sample we make use of the Figure 1, selecting those countries staying far from the 45° line in the figure at the bottom. Following this suggestion, an appropriate sample could be: Belgium, the Netherlands, Italy, Portugal, Spain, Sweden. Indeed, as it can be seen from the Figure 1 (bottom), in Spain between the late 1980s to 2003 there was a freeze in the regulation for TE, rather than a liberalization. Nonetheless, the liberalization process in Spain started in the early 1980s, before the time period covered.

Moreover, as can be seen from the Figure 1 (top), in Spain and Portugal there was not only a change in the regulation for TE, but also a relaxation of the protection legislation for PE.

At the bottom of the Figure 2 we report the year of reforms for all countries. For Spain and Portugal we report two dates, the first one concerning the liberalization of TE and the second one the relaxation of the protection for PE. To get the dates of reforms we make use of the *frdb* (Fondazione Rodolfo De Benedetti) inventory of social policy reform. This dataset records detailed information about social reforms, included EPL, in EU15 countries. In all countries in the sample there was more than one reform, as a result of the political convenience to make the reformatory process more gradual. Following the previous literature, we identify the reform date in a country as the date of the most important and crucial intervention in this gradual process.




Reform dates:
Belgium 1997; Portugal 1996-2001; Italy 1997;
Netherlands 1999; Spain 1985-1997; Sweden 1997

Fig. 2 *Unemployment rate and Growth rate in the EU countries*

With the *caveat* of a graphical analysis in mind, from the Figure 2 we can identify some important macrofacts, characterizing those countries experiencing a typical reformatory process. In EU countries, after the liberalization of TE, there was a decrease in unemployment and an increase in growth. After the first years, there was a slackening in growth, despite the employment was keeping to increase, condition often labelled as *growthless job creation*. Finally, there was a realignment of the unemployment rate towards the pre-reform level.

Another common denominator was the strong contribution of temporary contracts to the increase in employment (OECD, 2002). Despite the data deny the common perception that OECD countries failed to generate new permanent jobs, it is certainly true that a big part of employment growth was driven by TE, especially in Europe. The growth of temporary jobs accounted for at least two-thirds of total employment growth in Austria, Finland, France, Germany, Iceland, Italy and it played a considerable part in Belgium, Hungary, the Netherlands, Portugal, Spain, Sweden, Turkey, the United Kingdom.

The evidence of the extensive part of TE on job creation, along with the so called *growthless job creation* condition, raises the worry that the new regime could have had a negative effect on labour productivity growth. And this impact would be particularly problematic, given the predominant role of labour productivity growth in underpinning the income growth. The rest of this paper intend to shed light on this question, in order to clarify if the common lines followed by European governments correspond really to the principles of best practice.

## *3. Previous Literature on EPL and Theoretical Issues*

The previous literature on EPL is an immense object and a complete survey of the theme goes beyond the aim of this paper. Nonetheless, in this section we review briefly a selected (the most relevant for our purpose) part of it, and then discuss some theoretical issue surrounding the impact of TE on labour productivity.

The first focus of the literature has been the effect of EPL on labour demand. The first contribution goes back to Lazear (1990), the so called *critique of bonding*, where with perfect competition and flexible wage EPL are perfectly neutral, being the costs of them perfectly internalized by wages. The traditional analysis of labour demand under uncertainty was pioneered by Nickell (1978, 1986) and extended by Bentolila and Bertola (1990) and Bertola (1990). In these labour demand models with sticky wages and adjustment costs, EPL are not neutral but firing restrictions have a negative impact on both firing and hiring decisions. Labour market general equilibrium models come to the similar conclusion that protection legislations affect negatively job flows and then the speed of adjustment towards the equilibrium (Garibaldi, 1998 and Mortensen and Pissarides, 1999).

A considerable number of empirical studies confirm these theoretical predictions. Autor et al. (2006) make use of a panel at the firm level in the US and find a negative effect of EPL on job reallocation. Blanchard and Portugal (2001) find that job flows are significantly lower in Portugal than in the US, where firing restrictions are notably lower. Among the cross-country studies, OECD (2004) finds that EPL reduce both the inflow rate into unemployment and the outflow rate from it. Similarly, Micco and Pages (2004) find a negative relationship between EPL and job flows. Among the recent empirical studies, Messina and Vallanti (2007) confirm these results.

Nonetheless, the effect on average labour demand is still ambiguous, since there is no reason to believe *à priori* that the disincentive to hire could be greater or smaller than that to fire. Indeed, there are theoretical reasons to propend for both a positive and a negative effect. On one hand, greater EPL and/or the presence of TE could strengthen the bargaining power of protected workers, raising labour costs indirectly and, in turn, reducing employment (Bentolila and Dolado, 1994 and Garibaldi and Violante, 2005). In addition, EPL could be an impediment for the adoption of new technologies and this could prevent the optimal reallocation from declining to growing industries, having a negative impact on the level of employment (Samaniego, 2006 and Bartelsman and Hinloopen, 2005). On the other hand, EPL could promote a greater effort and cooperation through stable relationships (Fella, 2004), and encourage workers to invest more in human capital (Belot et al., 2002), ultimately reducing unemployment.

Thus, it is not surprising that there has been a proliferation of empirical studies trying to solve this question. Still, as emphasized by Baker et al. (2004), both the signs and the magnitudes of the estimated impact on employment and/or unemployment vary considerably to draw a definite conclusion on the direction of the effect. In this study the authors find no effect of EPL on unemployment rate. Similarly, Bertola (1990), Jackman, Layard and Nickell (1996) and OECD (1999) find no effect of EPL on both employment and unemployment. Most recently, Nickell, Nunziata and Ochel (2005) confirm these results.

All studies reviewed so far focus on the structural effect of EPL on labour market performance. Recently, some studies concentrate more on the transitional dynamics of partial EPL reform liberalizing the use of TE and leaving untouched the protection legislation for PE. Boeri and Garibaldi (2007) claim that there is a relation between the *growthless job creation* condition and the asymmetric reformatory process carried out by EU countries. The article solves a dynamic and stochastic labour demand model before and after the introduction of temporary contracts and firing restrictions for workers pre-reform. They find a honeymoon effect, that is a positive but only temporary effect of TE on employment and a fall in labour productivity, due to decreasing returns to scale. Empirically, they make use of a panel of Italian firms to test the main implications of the model, finding empirical properties in line with the theoretical predictions.

In recent years the interest of the literature has shifted more to the impact of EPL on productivity growth. Similarly to the effect on employment, from a theoretical point of view the direction of the effect is ambiguous. On one hand, EPL could distort the efficient allocation of resources, pushing firms to adjust the employment much less speedily, reducing productivity growth (Hopenhayn and Rogerson, 1993, Saint-Paul, 1997, 2002 and Bartelsman and Hinloopen, 2005). Riphahn (2004) and Ichino and Riphahn (2005), focusing on the behavioural component of labour productivity, find that layoff protection reduces the incentive to exert effort for workers, due to the smaller threat of layoff in response to low performance. On the other hand, layoff protection could promote longer job tenure, making both firms and workers more willing to invest in firm-specific human capital, enhancing productivity growth (Belot et al., 2002).

Nonetheless, the cross-country evidence on the effect of EPL on productivity growth is still inconclusive. From a sample of OECD countries, Nickell and Layard (1999) and Koeniger (2005) find in some specification a weak positive effect on both TFP and labour productivity growth, but the effect disappears in others. Differently, from a sample of Latin American and Asian countries, DeFreitas and Marshall (1998) find a negative impact of EPL on labour productivity growth.

Indeed, cross-country studies could suffer from serious drawbacks, making the interpretation of results at least problematic. The majority of these studies could be affected by an endogeneity problem for at least two reasons. First of all, it might be the case that labour market policies are affected by labour market conditions, making the need to deal with the simultaneity problem. Second, since several factors driving cross-country differences are not observable by the econometrician, EPL might pick up the effect of the omitted variables, biasing the estimated coefficients. Another relevant problem could be the use of EPL index as independent variable in the regression analysis. Since EPL for PE have been often left untouched by reforms, it would be questionable if there is sufficient variation on the covariate to reach the identification of the effect. Consequently, many studies are forced to insert the overall EPL index in the regression analysis, without distinguishing between PE and TE, even if it would be certainly more correct to keep the covariates distinct.

Differently from the standard cross-country analysis, some recent empirical studies exhibit a more convincing identification strategy. Autor et al. (2007) exploit cross-state differences in the timing of adoption of wrongful-discharge protection norms (as exceptions to the employment-at-will principle) by state courts in the US, to identify the impact of layoff protection on TFP, finding a significant reduction on productivity.

A new identification strategy (indeed, the same exploited here in this paper) has been the first time introduced to evaluate labour market policies by Micco and Pages (2006). They use a difference-in-differences approach on a cross-country of industry-level dataset for OECD and non-OECD countries, to identify the effect of EPL on the level of labour productivity. Their main identification assumption is that EPL are much more binding in those industries characterized by a larger necessity to reallocate resources, generating an ulterior exogenous source of variation. The main problem with this identification strategy is that, since the actual turnover rates are themselves affected by EPL, they cannot be used as the natural need to reallocate resources in industries. Therefore, to discriminate between *binding industries* and *non-binding industries*, the authors use turnover rates in the US, where firms decision on job flows are taken essentially in a frictionless environment. They find that EPL have a negative impact on the level of labour productivity. However, as the theoretical literature suggests, it would seem more appropriate to allow the empirical specification to control for the effect of EPL on long-run labour productivity growth, rather than only on the level of labour productivity. Additionally, their finding would seem to depend too much on the presence of Nigeria in the sample, invalidating the generalization of results. Moreover, as previous cross-country studies, they use the overall EPL index in the regression analysis, rather than to distinguish between PE and TE.

The same identification strategy has been extended by Bassanini and Venn (2007), OECD (2007) and Bassanini et al. (2008), apparently overcoming the previous drawbacks. First of all, these studies do control for the effect of EPL on productivity growth, even if the main dependent variable is TFP rather than labour productivity. Second, they use a limited sample of OECD countries, eliminating those countries characterized by particular events, and the results do not seem to depend on the inclusion of some observation in the sample. Third, they do distinguish between EPL for regular and temporary contracts. They find that EPL for regular contracts have a negative effect on TFP growth, whereas find no effect of EPL for temporary contracts.

Using a similar methodology, this paper intend to enhance the understanding of the effect of labour market regulation on labour productivity growth, focusing on the introduction of TE. Indeed, though acknowledging all merits to previous studies, main source of inspiration of this paper, it is our opinion that they fail to reach the identification of the effect of TE on productivity growth.

In particular, while the EPL index for regular contracts is certainly a correct independent variable, the EPL index for temporary contracts would not seem to be the appropriate independent variable to identify the effect of the introduction of TE. The EPL index for regular contracts expresses the degree of layoff protection for permanent workers. Therefore, it certainly influences firms and workers behaviour on investment and effort, affecting directly labour productivity. Differently, the EPL index for temporary contracts does not express the degree of layoff protection but the permissiveness to use temporary contracts, which indeed are the true variable potentially affecting firms and workers behaviour and thus labour productivity. Therefore, the index influences labour productivity only to the extent firms actually use temporary contracts. Evidently, it affects the use of TE by firms, but it is certainly difficult to establish what is the relation between the timing of a reform introducing the use of temporary contracts and their actual use and expansion in the labour market. Thus, it might be more appropriate to use directly the share of TE as independent variable, rather than the EPL index for temporary contracts. In this way we are able to isolate the impact of TE on labour productivity growth, without passing through the relation between the EPL index and actual use. Moreover, using the share of TE as covariate, we do not need to rely on some assumption concerning the way the index affect the behaviour (that is, the use of TE) in different industries.

Another important difference with respect to previous studies is the definition of the natural need to job reallocation in an industry. Instead of using turnover rates in the US, we apply the method proposed by Ciccone and Papaioannou (2006, 2007) to estimate a frictionless natural need to job reallocation in each industry.

From a theoretical point of view it is not clear what would be the effect of the introduction of TE on labour productivity. On one hand, TE is disproportionally filled by younger, less educated and less experienced workers (OECD, 2007, 2002), and temporary workers often have less access to training programmes (OECD, 2002 and Bassanini et al. 2007). Additionally, TE could affect negatively the average labour productivity simply because of decreasing returns to scale (Boeri and Garibaldi, 2007). Moreover, given the temporary, and frequently short, duration of contracts it might be rationale for a firm to fix a lower reservation productivity under which to layoff temporary workers than permanent ones, in order to avoid the direct and indirect firing costs (Lisi, 2007). On the other hand, TE allows firms a much more flexible and, in turn, efficient organization of resources and eliminates the disincentive to invest in risky, but potentially valuable, projects. Moreover, it might be rationale for temporary workers to exert a greater effort in order to get the renewal of the contract and/or the passage to a stable job (Engellandt and Riphahn, 2004). Therefore, the issue of the effect of TE on labour productivity remains an empirical question.

## *4. Empirical Strategy and Data*

In this section we illustrate the empirical strategy used in the study, describing all steps from the initial assumptions to the final estimating equations. Then, the main features of the dataset are introduced.

### Empirical Specification

The empirical strategy follows the method introduced in the finance literature by Rajan and Zingales (1998) to evaluate the impact of some market regulation, then extended in labour policy evaluation by Micco and Pages (2006) and Bassanini and Venn (2007). The main assumption of this approach is that while the degree of regulation is equal for all industries in a given country, the impact of it could be different in different industries, according to the physiological characteristics of each sector, such as technology, stability of tastes, incidence of aggregate shocks. In particular, regarding EPL the main assumptions made in the literature are that firing restrictions affect productivity growth and that they are much more binding in those industries characterized by a higher natural need to job reallocation. In this study we maintain these assumptions only for the EPL index for regular contracts, whereas we do not assume a different binding for temporary contracts, given that we use directly the share of TE as independent variable.

For what concern EPL studies, the main problem is to recover an appropriate measure of natural need to job reallocation in each industry. In fact, since the actual turnover rates are themselves affected by EPL, they cannot be used as the natural need to job reallocation. The method proposed by Rajan and Zingales (1998) to deal with this problem is to use data from a frictionless country as a proxy for the physiological characteristics of each industry. Following this idea, a standard approach to classify industries in EPL studies is to use turnover rates in the US, usually considered the quintessential frictionless country (Micco and Pages, 2006, Bassanini and Venn, 2007 and Bassanini et al., 2008).

Dividing industries in *binding industries* (B) and *non-binding industries* (NB), the difference between total factor productivity growth in B and NB can be modelled as some function of some index of the degree of regulation, in our case EPL index for PE:

$$\overline{\Delta \log TFP}_{it}^{B} - \overline{\Delta \log TFP}_{it}^{NB} = f\,(EPL_{it}) \quad (1)$$

where the first element indicates the average of total factor productivity growth over B in country *i* at time *t*, the second one the same for NB and *f* is some function. As it is the case, EPL does not vary across industries. If we assume that *f* in (1) is linear, then we could estimate the impact of EPL for PE using both a specification in levels or in growth rates:

$$\log TFP_{ijt} = \alpha\left(BI_j * \sum_{k=1}^{t} EPL_{ik}\right) + \beta \sum_{k=1}^{t} EPL_{ik} + \gamma \sum_{k=1}^{t} X_{ijk} + \mu_i + \delta_j + \varphi_t + \varepsilon_{ijt} \quad (2)$$

$$\Delta \log TFP_{ijt} = \alpha\left(BI_j * EPL_{it}\right) + \beta\, EPL_{it} + \gamma\, X_{ijt} + \theta_t + \omega_{ijt} \quad (3)$$

The two specifications are completely identical, in fact specification (3) is the first-difference version of specification (2) with $\theta_t = \varphi_t - \varphi_{t-1}$ and $\omega_{ijt} = \varepsilon_{ijt} - \varepsilon_{ijt-1}$. In both specifications $BI_j$ is a binary indicator equal to 1 if *j* is a binding industry, $X_{ijt}$ are other independent variables affecting TFP growth such as the share of TE, $\alpha$ is the marginal effect of EPL for PE on TFP growth in binding industries, whereas $\mu_i$, $\delta_j$ and $\varphi_t$ represent respectively country, industry and time-specific fixed effects, allowed to be correlated with other covariates.

Indeed, in this specification one is constrained to fix a rule to divide all industries between binding and non-binding and then to consider the impact in all binding industries equal to each other and the impact in all non-binding industries equal to zero. Instead of dividing industries between binding and non-binding, it would be more correct to weight the impact of EPL for PE with some plausible natural rate of job reallocation for each industry. This approach leads to the following difference-in-differences specification:

$$\log TFP_{ijt} = \alpha\left(FJR_j * \sum_{k=1}^{t} EPL_{ik}\right) + \beta \sum_{k=1}^{t} EPL_{ik} + \gamma \sum_{k=1}^{t} X_{ijk} + \mu_i + \delta_j + \varphi_t + \varepsilon_{ijt} \quad (4)$$

where $FJR_j$ is some plausible measure of the natural (frictionless) rate of job reallocation in each industry. The usual approach in EPL literature is to use turnover rates in the US, that is $FJR_j = USJR_j$. In this specification the interpretation of $\alpha$ is less direct than the previous one, but still meaningful. In particular, it tells us how TFP growth in an industry with a relatively high need to job reallocation (HJR) changes with respect that in an industry with a relative low one (LJR) when EPL index increases. For instance, if the estimated coefficient is negative, then this tells us that TFP growth in HJR decreases with respect to that in LJR, meaning that EPL for PE have a negative impact on productivity growth.

Indeed, the use of turnover rates in the US has not been exempt from criticisms in the literature. It has been noted that the appropriateness of this approach relies on the homogeneity of sectors classification across countries in the sample. In a recent paper Cingano et al. (2009) discuss this problem, showing as within sector heterogeneity would limit the validity of the use of the US data as a proxy for the natural rate of job reallocation. Additionally, it has been claimed that this approach would produce a short rather than a long-run measure of job reallocation, due to the incidence of aggregate shocks to the actual data (Fisman and Love, 2003 and Ciccone and Papaioannou, 2006).

In the same paper Ciccone and Papaioannou (2006) developed a method to obtain a measure of physiological rate of job reallocation in each industry, depurated from the frictions introduced by labour market regulation and the effect of aggregate shocks. They regress the actual job reallocation rate at industry level on industry dummies $\pi_j$, industry dummies interacted with the EPL index for PE $\tau_j * EPL_{it}$ and country-time dummies $\vartheta_{it}$:

$$JR_{ijt} = \pi_j + \tau_j * EPL_{it} + \vartheta_{it} + v_{ijt} \quad (5)$$

The presence of country-time dummies $\vartheta_{it}$ controls for any time-varying differences across countries, whereas the interaction term $\tau_j * EPL_{it}$ absorbs the effect of market regulation on job reallocation rate, allowing us to obtain an appropriate estimate $\hat{\pi}_j$ of natural rate of job reallocation in each industry. In the paper by Cingano et al. (2009) the authors compare the results obtained with the two methods to assess the appropriateness of the standard approach to use the US data, concluding in favour of the second method. Hence, in the following empirical analysis we will use the frictionless measure obtained from (5), that is we will use $FJR_j = \hat{\pi}_j$, bounding the use of binding/non-binding approach only for sensitive analysis. Following Davis and Haltiwanger (1992) and Cingano et al. (2009), we define the job reallocation rate as:

$$JR_{ijt} = \frac{|E_{ijt} - E_{ijt-1}|}{(E_{ijt} + E_{ijt-1})/2}$$

where $E_{ijt}$ is the level of employment in industry *j*, in country *i*, at time *t*. Evidently, this measure treats symmetrically job creation and job destruction, in accordance with the theoretical literature (Bentolila and Bertola, 1990 and Bertola, 1990).

We assume a Cobb-Douglas production function with constant returns to scale at the industry level:

$$Y_{ijt} = A_{ijt} K_{ijt}^{\rho} L_{ijt}^{1-\rho} \quad (6)$$

where $Y_{ijt}$ is total output, $A_{ijt}$ is total factor productivity, $K_{ijt}^{\rho}$ is capital and $L_{ijt}^{1-\rho}$ is labour. To obtain the estimating equation we divide for $L_{ijt}$, take the logs and substitute (4) in (6):

$$\log y_{ijt} = \rho \log k_{ijt} + \alpha \left(FJR_j * \sum_{k=1}^{t} EPL_{ik}\right) + \beta \sum_{k=1}^{t} EPL_{ik} + \gamma \sum_{k=1}^{t} X_{ijk} + \mu_i + \delta_j + \varphi_t + \varepsilon_{ijt}$$

where $y_{ijt}$ is labour productivity, $k_{ijt}$ is the capital-labour ratio and the rest is as in (4). Finally, to the extent that the level of EPL and TE affect firms decision on investment and, in turn, the level of capital affects labour productivity growth, we omit the capital-labour ratio and estimate a reduced form model to capture the overall effect on labour productivity growth:

$$\log y_{ijt} = \alpha\left(FJR_j * \sum_{k=1}^{t} EPL_{ik}\right) + \beta \sum_{k=1}^{t} EPL_{ik} + \gamma \sum_{k=1}^{t} X_{ijk} + \mu_i + \delta_j + \varphi_t + \varepsilon_{ijt} \quad (7)$$

In what follows, equation (7) represents the baseline specification for the empirical analysis. We estimate different specifications of (7) to test the robustness of the results. To the extent that firing restrictions affect the behaviour of only permanent workers, in some specification we interact the EPL index for PE with the share of permanent workers.

To some extent, this specification is similar to that of Bassanini and Venn (2007) and Bassanini et al. (2008), with the difference that while they use turnover rates in the US and the same identification strategy for PE and TE, we use the estimates from (5) as measure of FJR and distinguish the identification strategy between PE and TE. One the other hand, the specification is even more similar to that of Cingano et al. (2009), with the difference that while they use the same identification strategy for the two EPL indexes, we distinguish between EPL for PE and TE.

As emphasized by the previous literature, the advantage of using a panel of industry-level data, instead of cross-country, is fourfold. First, not only the cross-country variation of EPL is still exploited, but also the variation on the impact of EPL in different industries. And considering that the amount of variation in EPL index for PE across countries and years is indeed not so high, this advantage could be crucial in yielding the sufficient variation to identify the impact of EPL. Second, in contrast with the cross-country analysis, the specification allows us to control for unobserved fixed effects, allowed to be correlated with covariates. Given the difficulty to control for all factors (potentially correlated with covariates) affecting labour productivity growth, this could be crucial to overcome both omitted variable bias and misspecification. Third, as the previous literature emphasised (OECD, 2007b), the within-industry "composition effect" appears to be negligible, allowing us to identify the "independent effect" of EPL for PE and TE. Fourth, to the extent that events in a single industry are not able alone to affect the policy in a country, the specification is less subject to the simultaneity problem between variable of interest and policy.

Indeed, all previous papers using industry-level data share these advantages. In addition, in this paper we introduce a different (respect to EPL for PE) treatment for TE which, for the reasons argued above, we believe should increase the identification power of the empirical analysis.

**Data**

The empirical analysis is performed on an industry-level panel of EU countries. At the beginning of the data collection the program comprised a wider dataset than the final one, including more countries as the United States, Canada, Australia, a deeper segmentation across sectors and a more extensive time period. However, on one hand the need to include the share of TE as independent variable obligated us to reduce the time period and limit the sample to EU countries. On the other hand, the need to homogenize the sectors segmentation among different data-sources constrained to use the most comprehensive segmentation. At this regard, all data-sources follow the NACE classification, but not at the same level of aggregation. In particular, EUROSTAT data are segmented at the most extensive level of aggregation, therefore we aggregate all the data at that level.

The final sample covers 10 sectors in 13 countries over the years 1992-2005, for a balanced panel of 1820 observations. Despite the sample reduction, it is evident from the data analysis that the final sample exhibits a sufficient amount of variation to reach the identification. Countries included in the sample are Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden and the United Kingdom. The final sectors segmentation satisfies the need of homogeneity among datasets and reflects the EUROSTAT segmentation, including "Agriculture, hunting and forestry", "Manufacturing", "Electricity, gas and water supply", "Construction", "Wholesale and retail trade", "Hotels and restaurants", "Transport, storage and communication", "Financial intermediation", "Real estate, renting and business activities", "Other community, social, personal service activities".

To collect our dataset we make use of different sources. The data on labour productivity and employment level at the industry-level are collected from EU KLEMS dataset. This comprehensive database contains data on economic growth, productivity, employment and other variables at the industry-level for all EU countries, providing an important data-source for policy evaluation. Moreover, productivity measures are developed with growth accounting techniques, coherently with our empirical specification. The mean of labour productivity in the entire sample is 108,57, whereas the mean omitting 1992-1993-1994 is 111,91, telling us that labour productivity grew from 1995 (base year = 100) to 2005 in EU countries, even if not so significantly. The data on employment level are used to construct the actual job reallocation rates, needed to obtain our measures of natural rate of job reallocation for each industry. While the estimated natural rates of job reallocation are contained in a restricted range, the actual job reallocation rates are much more changeable, going from 0,2388 to 0. This large difference confirms the criticism according to which actual job reallocation rates are significantly influenced by aggregate shocks, producing a short rather than a long-run measure of the natural need of job reallocation.

The shares of TE at the industry-level are constructed from EU – Labour Force Survey (EUROSTAT), a labour market survey providing annually and quarterly information about trends on the labour market in EU countries. The mean and the standard deviation in the sample are respectively 0,09 and 0,075, confirming the idea that TE is by now an important feature of the labour market landscape in Europe, but its importance differs significantly across countries. For instance, while in countries as Spain and Portugal the share of TE is far away from the mean, in the UK the mean is no more than 0,05.

As measure of EPL for PE we make use of the cardinal index constructed by OECD (2004), varying in theory from 6 for the most stringent to 0 for the least stringent regulation. The time-series for the EPL index are currently available until 2003, except for some country where there has been some significant change in the regulation after 2003 (e.g. in Portugal 2004). To the extent that from 2003 to 2005 there not seem to have been significant changes in the regulation of PE (and, if any, they are included in the time-series), for the values after 2003 we consider the least value available. In our sample the EPL index ranges from 4,33 in Portugal (1992-2003) to 0,95 in the UK (1992-1999). The mean of the index follows a slightly decreasing trend, going from 2,46 at the beginning of the sample 1992, to 2,31 at the end 2005. Indeed, the decreasing trend in the stringency of regulation of PE is far away from being common to all countries, rather it seems to be driven by changes in Spain and Portugal.

Even if the EPL index for TE is not used in the regression analysis, it is useful to see what happen to the index in our sample. The EPL index for TE ranges from 5,38 in Italy (1992-1996) to 0,25 in the UK (1992-2001). Similarly to PE, the mean of the index for TE follows a decreasing trend, going from 2,92 in 1992 to 1,92 in 2005. But differently to PE, the decreasing trend seems to be a common feature in fairly all EU countries.

Unfortunately no data on trade union density at industry-level are available, therefore they are collected at country-level from OECD – Labour Force Statistics. The mean in the sample is 0,41, telling us how trade union are still an important subject in Europe. However, a standard deviation of 0,23 suggests how different is its importance across EU countries. In the sample trade union density ranges from 0,84 in Sweden (1993) to 0,08 in France (2005).

A full description of all variables and sources can be found in Annex 1, whereas descriptive statistics are in Annex 2.

## *5. Results*

In this section we discuss the main results of the empirical analysis, along with some robustness checks. First of all, we present the results of the baseline specification (7), with and without the interaction of the share of PE with the EPL index. Then, we provide some sensitive analysis to check if our findings are robust to little changes in the specification and sample. Finally, in order to show the advantage of our identification strategy, we re-estimate the model using the EPL index for TE instead of the share of TE as independent variable.

### Baseline Specification

In Table 1 are the coefficients of different specifications of equation (7). In the first two columns we run a POLS regression, in (2) with other covariates. In both specifications the point estimates of EPL*FJR and TE are negative, the coefficient of TE is significant at 1%, but that

**Table 1. LABOUR PRODUCTIVITY (without PE%)**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | POLS | POLS | FE | FE | FE | FE |
| EPL | 0,009<br>(0,001)*** | 0,004<br>(0,001)*** | 0,013<br>(0,001)*** | 0,005<br>(0,002)*** | 0,005<br>(0,002)** | 0,005<br>(0,002)** |
| EPL*FJR | -0,040<br>(0,027) | -0,048<br>(0,026)* | -0,073<br>(0,028)*** | -0,076<br>(0,028)*** | -0,077<br>(0,040)** | -0,077<br>(0,040)** |
| TE% | -0,077<br>(0,006)*** | -0,100<br>(0,007)*** | -0,072<br>(0,009)*** | -0,081<br>(0,009)*** | -0,082<br>(0,009)*** | -0,080<br>(0,009)*** |
| TUD | | -0,001<br>(0,000)*** | | -0,002<br>(0,002) | | -0,002<br>(0,002) |
| TREND | | 0,024<br>(0,002)*** | | 0,022<br>(0,003)*** | | 0,626<br>(0,007)*** |
| CONSTANT | 4,582<br>(0,007)*** | 4,554<br>(0,008)*** | | | | |
| SECTOR DUMMIES | NO | NO | YES | YES | YES | YES |
| COUNTRY DUMMIES | NO | NO | YES | YES | YES | YES |
| YEAR DUMMIES | NO | NO | NO | NO | YES | YES |
| Observations | 1820 | 1820 | 1820 | 1820 | 1820 | 1820 |
| R-squared | 0,1915 | 0,3079 | 0,9992 | 0,9993 | 0,9993 | 0,9993 |

POLS: pooled ordinary least squares; FE: fixed effects (dummy variable regression). EPL: employment protection legislation; FJR: frictionless job reallocation; TE%: the share of temporary employment; TUD: trade union density.
Robust standard errors in brackets. * significant at 10%, ** significant at 5%, *** significant at 1%.

of EPL*FJR is significant only in (2). While these estimates are useful to get an insight on the direction of the effect, they cannot be interpreted as causal impact, given the omitted variable bias. In the other columns we implement a FE regression, where we allow specific factors to be correlated with EPL and TE. In columns (3)-(4) we introduce country and sector dummies to control for institutional and technological specific effects. In both specifications the coefficients of EPL*FJR and TE are negative and significant at 1%. In columns (5)-(6) we include also time dummies to control for differential trends without any sizable difference. Since we are able to control for all unobserved factors, we interpret these results as causal impact of EPL and TE on labour productivity growth. The magnitude of the coefficient of TE is -0,08 or more, implying that an increase of 10% of the share of TE would lead to a decrease of about 1% in labour productivity growth. Furthermore, the coefficient of EPL*FJR is sizably greater than that of EPL, implying that EPL for regular contracts reduce labour productivity growth more in those industries requiring a greater reallocation.

To the extent that firing restrictions affect the behaviour of only permanent workers, in Table 2 we interact the EPL index for PE with the share of permanent workers PE% (= 1 – TE%). This inclusion might improve the identification power of the empirical method for EPL for PE. Indeed, the results are qualitatively similar to those of Table 1, but as expected the coefficients of EPL*FJR are greater in all specifications.

**Table 2. LABOUR PRODUCTIVITY (with PE%)**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | POLS | POLS | FE | FE | FE | FE |
| EPL | 0,010<br>(0,001)*** | 0,004<br>(0,001)*** | 0,014<br>(0,002)*** | 0,006<br>(0,002)*** | 0,006<br>(0,002)** | 0,006<br>(0,002)** |
| EPL*FJR*PE% | -0,043<br>(0,029) | -0,049<br>(0,028)* | -0,091<br>(0,045)** | -0,090<br>(0,030)*** | -0,091<br>(0,046)** | -0,090<br>(0,046)** |
| TE% | -0,058<br>(0,005)*** | -0,096<br>(0,006)*** | -0,049<br>(0,008)*** | -0,077<br>(0,008)*** | -0,079<br>(0,008)*** | -0,076<br>(0,008)*** |
| TUD | | -0,001<br>(0,000)*** | | -0,002<br>(0,002) | | -0,002<br>(0,002) |
| TREND | | 0,024<br>(0,002)*** | | 0,021<br>(0,003)*** | | 0,625<br>(0,008)*** |
| CONSTANT | 4,575<br>(0,007)*** | 4,554<br>(0,008)*** | | | | |
| SECTOR DUMMIES | NO | NO | YES | YES | YES | YES |
| COUNTRY DUMMIES | NO | NO | YES | YES | YES | YES |
| YEAR DUMMIES | NO | NO | NO | NO | YES | YES |
| Observations | 1820 | 1820 | 1820 | 1820 | 1820 | 1820 |
| R-squared | 0,2045 | 0,3077 | 0,9992 | 0,9993 | 0,9993 | 0,9993 |

POLS: pooled ordinary least squares; FE: fixed effects (dummy variable regression). EPL: employment protection legislation; FJR: frictionless job reallocation; TE%: the share of temporary employment; PE%; the share of permanent employment; TUD: trade union density.
Robust standard errors in brackets. * significant at 10%, ** significant at 5%, *** significant at 1%.

**Robustness Checks**

In what follows, we provide some sensitive analysis to check the robustness of our findings. Despite we maintain the supremacy of the method proposed by Ciccone and Papaioannou (2006), we re-estimate the model using a binding/non-binding approach. Following the previous empirical literature, we make use of job reallocation rates in the US to divide between *binding* (B) and *non-binding industries* (NB). We estimate the model with two different *binary indicators* (BI).

**Table 3. LABOUR PRODUCTIVITY (with BI1)**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | POLS | POLS | FE | FE | FE | FE |
| EPL | 0,008<br>(0,001)*** | 0,002<br>(0,001)** | 0,010<br>(0,001)*** | 0,002<br>(0,002) | 0,002<br>(0,001)* | 0,002<br>(0,001)* |
| EPL*BI1 | -0,002<br>(0,0003)*** | -0,002<br>(0,0003)*** | -0,002<br>(0,0003)*** | -0,002<br>(0,0004)*** | -0,002<br>(0,0004)*** | -0,002<br>(0,0004)*** |
| TE% | -0,073<br>(0,006)*** | -0,096<br>(0,006)*** | -0,067<br>(0,009)*** | -0,075<br>(0,008)*** | -0,077<br>(0,008)*** | -0,075<br>(0,008)*** |
| TUD | | -0,001<br>(0,000)*** | | -0,002<br>(0,002) | | -0,002<br>(0,002) |
| TREND | | 0,024<br>(0,002)*** | | 0,021<br>(0,003)*** | | 0,631<br>(0,007)*** |
| CONSTANT | 4,582<br>(0,006)*** | 4,553<br>(0,008)*** | | | | |
| SECTOR DUMMIES | NO | NO | YES | YES | YES | YES |
| COUNTRY DUMMIES | NO | NO | YES | YES | YES | YES |
| YEAR DUMMIES | NO | NO | NO | NO | YES | YES |
| Observations | 1820 | 1820 | 1820 | 1820 | 1820 | 1820 |
| R-squared | 0,1999 | 0,3141 | 0,9992 | 0,9993 | 0,9993 | 0,9993 |

POLS: pooled ordinary least squares; FE: fixed effects (dummy variable regression); EPL: employment protection legislation; BI1: binary indicator 1; TE%: the share of temporary employment; TUD: trade union density.
Robust standard errors in brackets. * significant at 10%, ** significant at 5%, *** significant at 1%.

For the first BI1 an industry is B if the job reallocation rate in the US is greater than the average for at least two of the three years 2001-2002-2003. According to BI1, the following four industries are B: “Manufacturing”, “Transport, storage and communication”, “Real estate, renting and business activities”, “Other community, social, personal service activities”. The second BI is slightly less demanding. For BI2 an industry is B if the job reallocation rate in the US is greater than the average for at least two of the four years 2001-2002-2003-2004. According to BI2, the following five industries are B: “Agriculture, hunting and forestry”, “Manufacturing”, “Transport, storage and communication”, “Real estate, renting and business activities”, “Other community, social, personal service activities”.

**Table 4. LABOUR PRODUCTIVITY (with BI2)**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | POLS | POLS | FE | FE | FE | FE |
| EPL | 0,008<br>(0,001)*** | 0,002<br>(0,001)** | 0,010<br>(0,001)*** | 0,002<br>(0,002) | 0,002<br>(0,002) | 0,002<br>(0,002) |
| EPL*BI2 | -0,001<br>(0,001)* | -0,001<br>(0,001)* | -0,002<br>(0,001)** | -0,002<br>(0,001)** | -0,002<br>(0,001)** | -0,002<br>(0,001)** |
| TE% | -0,075<br>(0,006)*** | -0,098<br>(0,006)*** | -0,069<br>(0,009)*** | -0,077<br>(0,008)*** | -0,079<br>(0,009)*** | -0,077<br>(0,009)*** |
| TUD | | -0,001<br>(0,000)*** | | -0,002<br>(0,002) | | -0,002<br>(0,002) |
| TREND | | 0,024<br>(0,002)*** | | 0,022<br>(0,003)*** | | 0,625<br>(0,007)*** |
| CONSTANT | 4,582<br>(0,006)*** | 4,554<br>(0,008)*** | | | | |
| SECTOR DUMMIES | NO | NO | YES | YES | YES | YES |
| COUNTRY DUMMIES | NO | NO | YES | YES | YES | YES |
| YEAR DUMMIES | NO | NO | NO | NO | YES | YES |
| Observations | 1820 | 1820 | 1820 | 1820 | 1820 | 1820 |
| R-squared | 0,1919 | 0,3072 | 0,9992 | 0,9993 | 0,9993 | 0,9993 |

POLS: pooled ordinary least squares; FE: fixed effects (dummy variable regression); EPL: employment protection legislation; BI2: binary indicator 2; TE%: the share of temporary employment; TUD: trade union density.
Robust standard errors in brackets. * significant at 10%, ** significant at 5%, *** significant at 1%.

In Table 3 are the results of BI1model. The coefficients of the share of TE are all negative, significant at 1% and very close to the baseline value -0,08. The coefficients of EPL*BI1 are also negative and significant, but as expected the magnitude is significantly different from the FJR specifications. However, the magnitude is fairly equal to the binding/non-binding specification of Bassanini and Venn (2007) and Bassanini et al. (2008). In fact, apparently the BI used in this paper and those used in Bassanini and Venn (2007) and Bassanini et al. (2008) produce a very similar classification in terms of B and NB industries. In Table 4 we estimate the model with BI2. The results are very close to the BI1, with the only difference that the coefficients of EPL*BI2 are slightly less significant, as a consequence of a lower identification power of the second (less demanding) BI.

In summary, using the binding/non-binding approach does not seem to alter the results of the analysis. Nonetheless, for the theoretical reasons discussed above, we maintain the preference for the FJR specification as source of our interpretation.

To check if the baseline results depend crucially on the inclusion of some country in the sample, we re-estimate the model excluding all countries one-by-one. In particular, we run 13 FE regressions equal to specification (6) in Table 1, but using a reduced sample. In Table 5 are the complete results of the 13 regressions, whereas in the Figure 3 are the coefficients of the share of TE, arranged from the greatest to the smallest.

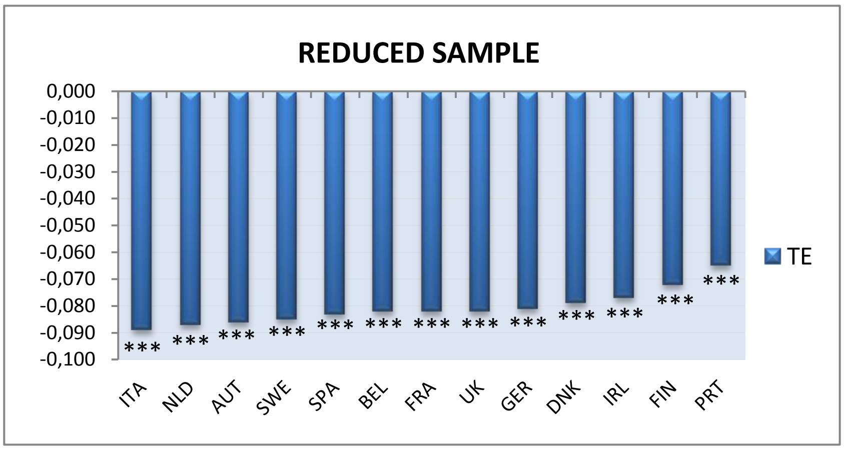



Fig. 3 *Coefficients of TE% from the Reduced Sample*

**Table 5. LABOUR PRODUCTIVITY (Reduced Sample)**

| | FE | FE | FE | FE | FE | FE | FE | FE | FE | FE | FE | FE | FE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Excluded Country | AUT | BEL | DNK | FIN | FRA | GER | IRL | ITA | NLD | PRT | SPA | SWE | UK |
| EPL | 0,006 | 0,004 | 0,004 | 0,004 | 0,005 | 0,006 | 0,004 | 0,004 | 0,004 | 0,005 | 0,006 | 0,002 | 0,006 |
| | (0,002)*** | (0,002)** | (0,002)** | (0,001)*** | (0,002)** | (0,002)*** | (0,002)* | (0,002)** | (0,002)** | (0,002)** | (0,002)*** | (0,001)* | (0,002)*** |
| EPL*FJR | -0,087 | -0,076 | -0,079 | -0,071 | -0,082 | -0,101 | -0,059 | -0,082 | -0,056 | -0,105 | -0,106 | -0,025 | -0,072 |
| | (0,042)** | (0,041)* | (0,028)*** | (0,028)** | (0,042)** | (0,043)** | (0,040) | (0,041)** | (0,029)* | (0,041)** | (0,044)** | (0,028) | (0,029)*** |
| TE% | -0,086 | -0,082 | -0,079 | -0,072 | -0,082 | -0,081 | -0,077 | -0,089 | -0,087 | -0,065 | -0,083 | -0,085 | -0,082 |
| | (0,009)*** | (0,009)*** | (0,009)*** | (0,009)*** | (0,009)*** | (0,009)*** | (0,009)*** | (0,009)*** | (0,009)*** | (0,007)*** | (0,016)*** | (0,009)*** | (0,009)*** |
| TUD | -0,003 | -0,001 | -0,002 | -0,003 | -0,003 | -0,001 | -0,001 | -0,001 | -0,001 | -0,002 | -0,003 | -0,002 | -0,002 |
| | (0,002) | (0,002) | (0,002) | (0,002) | (0,002) | (0,002) | (0,003) | (0,002) | (0,002) | (0,002) | (0,002) | (0,002) | (0,002) |
| TREND | 0,626 | 0,627 | 0,629 | 0,629 | 0,629 | 0,627 | 0,618 | 0,627 | 0,624 | 0,631 | 0,666 | 0,636 | 0,635 |
| | (0,007)*** | (0,007)*** | (0,006)*** | (0,006)*** | (0,008)*** | (0,007)*** | (0,009)*** | (0,007)*** | (0,006)*** | (0,006)*** | (0,024)*** | (0,017)*** | (0,017)*** |
| SECTOR DUMMIES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| COUNTRY DUMMIES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| YEAR DUMMIES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| Observations | 1680 | 1680 | 1680 | 1680 | 1680 | 1680 | 1680 | 1680 | 1680 | 1680 | 1680 | 1680 | 1680 |
| R-squared | 0,9993 | 0,9992 | 0,9993 | 0,9993 | 0,9992 | 0,9993 | 0,9993 | 0,9993 | 0,9992 | 0,9993 | 0,9992 | 0,9993 | 0,9992 |

FE: fixed effects (dummy variable regression); EPL: employment protection legislation; FJR: frictionless job reallocation; TE%: the share of temporary employment; TUD: trade union density.
Robust standard errors in brackets. * significant at 10%, ** significant at 5%, *** significant at 1%.

Evidently, the baseline outcome does not seem to depend on the sample of countries included in the empirical analysis. Indeed, the coefficients of the share of TE are always negative and significant at 1% regardless the sample used.

In conclusion, our findings of a negative impact of both EPL for PE and the share of TE on labour productivity growth are fairly robust to little changes in the estimation method and the sample of countries included in the analysis.

**EPL index for TE vs TE%**

In order to show the advantage of our identification strategy, we re-estimate the model using the EPL index for TE instead of the share of TE as independent variable. In Table 6 are the results of the experiment.

**Table 6. LABOUR PRODUCTIVITY (EPL for TE)**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | POLS | POLS | FE | FE | FE | FE |
| EPL for PE | 0,008<br>(0,002)*** | 0,003<br>(0,002) | 0,011<br>(0,002)*** | 0,004<br>(0,003) | 0,004<br>(0,003) | 0,004<br>(0,003) |
| EPL for PE*FJR | -0,056<br>(0,059) | -0,056<br>(0,057) | -0,073<br>(0,054) | -0,073<br>(0,054) | -0,074<br>(0,055) | -0,074<br>(0,055) |
| EPL for TE | -0,003<br>(0,002) | -0,004<br>(0,002)** | -0,002<br>(0,002) | -0,004<br>(0,002)** | -0,004<br>(0,002)** | -0,004<br>(0,002)** |
| EPL for TE*FJR | 0,042<br>(0,048) | 0,042<br>(0,046) | 0,034<br>(0,036) | 0,034<br>(0,035) | 0,033<br>(0,035) | 0,033<br>(0,035) |
| TUD | | -0,001<br>(0,000)*** | | -0,002<br>(0,002) | | -0,001<br>(0,002) |
| TREND | | 0,023<br>(0,002)*** | | 0,022<br>(0,004)*** | | 0,642<br>(0,008)*** |
| CONSTANT | 4,586<br>(0,007)*** | 4,553<br>(0,009)*** | | | | |
| SECTOR DUMMIES | NO | NO | YES | YES | YES | YES |
| COUNTRY DUMMIES | NO | NO | YES | YES | YES | YES |
| YEAR DUMMIES | NO | NO | NO | NO | YES | YES |
| Observations | 1820 | 1820 | 1820 | 1820 | 1820 | 1820 |
| R-squared | 0,1321 | 0,2282 | 0,9992 | 0,9992 | 0,9992 | 0,9992 |

POLS: pooled ordinary least squares; FE: fixed effects (dummy variable regression); EPL: employment protection legislation; FJR: frictionless job reallocation; TUD: trade union density.
Robust standard errors in brackets. * significant at 10%, ** significant at 5%, *** significant at 1%.

Consistently with our view, the use of the same treatment for PE and TE seems to have reduced significantly the identification power of the empirical analysis. Even though we use the same specifications and sample of Table 1, the coefficients of EPL for TE*FJR are always insignificant and those of EPL for TE are estimated with a very little precision. Moreover, despite the point estimates of EPL*FJR remain negative, they become always insignificant, which would be heavily in contrast with standard findings of this and previous papers in the literature.

In conclusion, for the theoretical reasons discussed above, the identification strategy for PE does not appear to be appropriate for the identification of the effect of TE on labour productivity growth. Indeed, the empirical comparison between the use of the share of TE and the EPL index for TE confirms the theoretical drawbacks highlighted in the paper and suggests a clear preference for the use of the share of TE.

## *6. Policy Implications and Final Remarks*

In this paper we have implemented a well-know method to evaluate the impact of partial labour market reforms in EU countries. Using an industry-level panel we are able to control for unobserved confounding factors, which allow us to identify the causal impact of both regulation for PE and TE on labour productivity growth. Differently from the previous literature, we distinguish the identification strategy between the impact of firing restrictions for PE and the impact of the use of TE, underlining theoretical reasons to make this distinction. Comparing the model with the share of TE to that with the EPL index for TE, we show as the first improves significantly the identification power of the empirical analysis. For this reason, to some extent the empirical strategy presented in this paper would go to improve the previous empirical literature on labour market policy evaluation.

The only problem with the interpretation of the estimates as causal impact could be the inclusion of trade union data at country-level. Indeed, if trade union density in countries is highly dispersed across sectors, then the coefficient of TE% could pick up the effect of trade union as well. Certainly, the availability of trade union data at industry-level data would make the analysis more robust.

The main finding of the paper is that the introduction of TE has a negative impact on labour productivity growth. In particular, an increase of 10% of the share of TE would lead to a decrease of about 1% in labour productivity growth. Furthermore, the analysis confirms the findings of the previous literature that EPL for regular contracts reduce labour productivity growth more in those industries requiring for their own characteristics a greater reallocation.

However, the increase of TE should not be considered *a priori* a negative labour market outcome, rather the important issue here is what role TE is playing in the labour market. Indeed, if temporary contracts were used as a least-cost way of screening new workers and as stepping stone towards more stable jobs, then an increase in the share of TE and its effect on productivity growth could be bounded in the short-run. The problem is that, as emphasised by a growing literature (OECD, 2002), only one-third of temporary workers move to a more stable job within two years, whereas one-fourth of them become unemployed one year later and a large part remain steadily in temporary jobs. Therefore, the negative impact of the increase of TE in Europe on productivity growth cannot be considered a short-run problem, but a dangerous structural change with long-run effects.

In the light of the predominant role of labour productivity growth in driving GDP growth, our findings are much relevant and full of policy implications. In particular, the partial labour market reforms made by the majority of EU countries do not seem to correspond to the optimal way to organize labour market regulation.

The aim of the liberalization of TE was to generate a higher level of employment, removing the disincentive to hire intrinsic in a labour market with permanent contracts and layoff restrictions. And it is certainly true that the introduction of less stringent regulations has initially driven the employment growth. However, it is not clear as this expansion could be considered structural or just a honeymoon effect. Indeed, if the expansion of TE dampen labour productivity growth, not only this could restrain GDP growth, generating the so called *growthless job creation* condition, but also re-absorb in the long-run the initial employment growth, generating the honeymoon effect.

The crucial implication is that the expansion of the level of employment could be only transitory and, if the EU governments strive for generate a structural higher level of employment, they need an ulterior reformatory intervention. At this regard, the main challenge is to find a regulation able at the same time to eliminate the disincentive to hire and to motivate firms and workers towards more stable and productive job relationships.

Although the identification of such regime is not the aim of this paper, some final remarks are proper. In the light of the results of this paper it would seem justified the preference expressed by the most part of the literature for a reduction in EPL for PE, rather than the expansion of TE. However, for both efficiency and equity reasons, it might be more appropriate on one hand to maintain some protection for PE, even if certainly smaller than the actual level in Europe, on the other hand to allow a less intensive use of temporary contracts to facilitate the introduction in the labour market. These considerations would seem to suggest a regime providing for a gradual path from temporary to permanent contracts. For these reasons, on one hand the so called *flexicurity* in Denmark, on the other hand the proposals made by Ichino et al. (Lavoce.info) would seem to prompt the right direction.

In conclusion, I would like to close the discussion surrounding the principles we should keep in mind when we think about such a regime, quoting a brief paragraph by Solow (2002): << If pure unadulterated labour-market reform is unlikely to create a substantial increase in employment, then the main reason for doing it is anticipated gain in productive efficiency, however large that may be. But if we respect the wage earner's desire for job security, and it seems at least as respectable as anyone's desire for fast cars or fat-free desserts, then an improvement in productivity efficiency gained in that way is not a Pareto-improvement. More labour-market flexibility may still be worth having – and I think it is – but then the losers have a claim in equity to some compensation. The trick is to find a form of compensation that does not cancel the initial gain in labour-market flexibility>>.

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# ANNEX 1: DATA DESCRIPTION

**Labour Productivity**

*Definition*: gross value added in volume terms (base 1995 = 100) divided by total hours worked.

*Source*: EU KLEMS database.

**Total Hours Worked**

*Definition*: product of average hours worked and total person engaged.

*Source*: EU KLEMS database.

**Employment Level**

*Definition*: total persons engaged.

*Source*: EU KLEMS database.

**Job Reallocation Rate**

*Definition*: Davis and Haltiwanger measure of job reallocation rate $JR_{ijt} = \frac{|E_{ijt} - E_{ijt-1}|}{(E_{ijt} + E_{ijt-1})/2}$.

*Source*: own calculation from the employment level data from EU KLEMS database.

**Frictionless Job Reallocation Rate**

*Definition*: job reallocation rate depurated from the frictions introduced by labour market regulation and the effect of aggregate shocks ($FJR_j = \hat{\pi}_j$).

*Source*: own estimation.

**Temporary Employment**

*Definition*: total persons engaged with temporary contracts.

*Source*: EUROSTAT Labour Force Survey.

**EPL for Permanent Employment**

*Definition*: OECD index of the stringency of employment protection legislation on regular contracts.

*Source*: OECD *Employment Outlook* (2004).

**EPL for Temporary Employment**

*Definition*: OECD index of the permissiveness on the use of temporary contracts.

*Source*: OECD *Employment Outlook* (2004).

**Trade Union Density**

*Definition*: employees trade union members divided by total number of employees.

*Source*: OECD Labour Force Statistics.

## ANNEX 2: DESCRIPTIVE STATISTICS

**TABLE A2. DESCRIPTIVE STATISTICS**

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Labour Productivity | 1820 | 108,565 | 20,757 | 63,486 | 268,792 |
| Log Labour Productivity | 1820 | 4,672 | 0,170 | 4,151 | 5,594 |
| Job Reallocation | 1820 | 0,028 | 0,027 | 0,000 | 0,239 |
| Frictionless Job Reallocation | 1820 | 0,043 | 0,009 | 0,028 | 0,059 |
| Share of TE | 1820 | 0,089 | 0,075 | 0,000 | 0,488 |
| EPL for Regular Contracts | 1820 | 2,372 | 0,846 | 0,948 | 4,333 |
| EPL for Temporary Contracts | 1820 | 2,259 | 1,278 | 0,250 | 5,375 |
| Trade Union Density | 1820 | 0,408 | 0,232 | 0,080 | 0,839 |

# Cross-Sectors Skill Intensity and Temporary Employment

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*April 2010*

**Abstract**

*Recent papers emphasised as the use of temporary contracts (TE) could have a detrimental effect on labour productivity, particularly because the wrong utilization of TE might induce a reduction in effort. However, there are different reasons to believe that the impact of TE might not be homogeneous across sectors and, in particular, in this paper we wonder if this negative effect differs according to sectors skill intensity. To this extent, we divide sectors between skilled and unskilled and specify a diff-in-diff strategy to identify the different impact of TE. Moreover, the industry-level panel allows us to deal with different endogeneity problems, as simultaneity and omitted variable bias. Our central result is that TE is even more damaging in skilled sectors and this would seem robust to little changes in the skill intensity index and in the sample used. Our main intuition is that the reduction in effort is more harmful in those sectors where production uses skills more intensively. Indeed, this result could have very important policy implications for labour market regulation.*

JEL Classification: J41, J24, O47.

Keywords: labour productivity, temporary employment, skill intensity.

[†] The author would like to thank Sergio Destefanis for the helpful comments. However, the analysis and any errors remain responsibility of the author alone.

# Cross-Sectors Skill Intensity and Temporary Employment

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### *1. Introduction*

In the last decades the use of temporary employment (TE) has grown dramatically in the majority of OECD countries, raising the issue of the possible effects in labour market outcomes. Furthermore, the recent macro stylized-facts and principally the growthless job creation condition have drawn a particular attention to the impact of TE on labour productivity (see e.g. Boeri and Garibaldi, 2007 and OECD, 2007). Indeed, in the light of the predominant role of labour productivity growth in driving GDP growth in the last twenty years, this issue would appear to be really essential for macro considerations (OECD, 2003).

Hence, in recent years a growing literature is trying to answer to these questions. From a theoretical point of view it is not obvious what would be the effect of TE on labour productivity. On one hand, it would seem rationale for a temporary worker to exert a greater effort in order to get the renewal of the contract and/or the passage to a more stable form of job (Engellandt and Riphahn, 2005). However, in a context where the expected probability of the renewal is low, this argument might not be valid (Dolado and Stucchi, 2008). On the contrary, given the short duration of contracts it might be rationale for a firm to fix a lower reservation productivity under which to layoff temporary workers than permanent ones, which induces a reduction in effort (Lisi, 2007). Moreover, TE is usually filled by younger, less educated and less experienced workers, and temporary contracts offer less access to training programmes (OECD, 2002 and Bassanini et al. 2007).

Thus, it is not surprising that there has been a proliferation of empirical studies trying to deal with this question. Still, early empirical papers studying different labour market policies did not found any significant impact of TE on labour productivity, even if they usually found a significant effect of the employment protection legislation (EPL) for PE (see e.g. Bassanini and Venn, 2007, Bassanini et al., 2009 and Cingano et al., 2009). However, in Lisi (2009) we made clear why using the EPL index for temporary contracts as in those papers might not be a good approach to identify the impact of TE. And indeed, using a different identification strategy we found a negative and significant impact on labour productivity, consistent to different robustness checks. Similar results emerge in Dolado and Stucchi (2008), where high conversion rates from temporary to permanent jobs increase firm's productivity whereas high shares of temporary contracts decrease it.

Nonetheless, there are good reasons to believe that the impact of TE might not be homogenous across sectors and, in particular, in this paper we wonder if this negative effect differs according to sectors skill intensity. From a theoretical point of view the answer to this question is far from being immediate, existing different convincing reasons for both directions. On one hand, in skilled sectors the use of TE might be more oriented towards screening new workers respect to unskilled ones, which could induce a higher effort and, in turn, a higher labour productivity (Engellandt and Riphahn, 2005). On the other hand, in skilled sectors the cost in terms of lower workers' effort induced by TE could be heavier, leading to an even greater reduction in labour productivity (Lisi, 2007). Therefore, the empirical investigation turns out to be crucial to shed light on this issue.

Following this empirical literature, we estimate a Cobb-Douglas production function to identify the different impact of TE on labour productivity, according to sectors skill intensity. To make our results easily comparable with previous studies, we estimate also the impact of EPL for PE as standard in this literature. The empirical analysis is performed on an industry-level panel of EU countries, which allows us to divide sectors between skilled and unskilled and specify a diff-in-diff identification strategy. Borrowing from the Skill-Biased Technological Change (SBTC) literature, we consider (un)skilled those sectors with a ratio between skilled and unskilled workers (lower)higher than the average (see the survey Bond and Van Reenen, 2006). To test the robustness of our results, we compute different indexes of sectors skill intensity, using different definitions of skilled workers. The empirical method exploits both cross-country and time variation in TE and, in particular, the exogenous variation in the impact of TE among different industries. Among other advantages, the industry-level panel allows us to control for different specific unobserved fixed effects, which should attenuate the omitted variable bias.

The main result is that TE is even more damaging in skilled sectors, with a negative effect significantly heavier than in unskilled sectors, and this would seem robust to little changes in the skill intensity index and in the sample used. In particular, an increase of 10% of the share of TE in skilled sectors would lead to a decrease of 1.2% in labour productivity growth, whereas in unskilled ones the reduction would be only of 0.6%. To some extent, this result might support the idea that TE is currently used in the labour market more as a cheaper form of job, instead of as a least-cost way to screen new workers (see e.g. Güell and Petrongolo, 2005). Therefore, our main intuition is that the reduction in effort induced by the wrong way to use TE is more harmful in those sectors where production uses skills more intensively. Indeed, this result could have very important policy implications for labour market regulation.

The paper proceeds as follows: in Section 2 we describe the strategy we pursue to identify the different impact of TE across sectors and, in particular, the method we use to divide sectors. Then, Section 3 introduces the main features of the dataset. In Section 4 we show the results of the empirical analysis. Finally, Section 5 discusses the policy implications and concludes.

## *2. Identification Strategy and Skill Intensity index*

In this section we show the empirical strategy used in the study to identify the different impact of TE across sectors and, in particular, we describe the method used to divide industries in our data between skilled and unskilled sectors. Indeed, this subdivision will turn out to be important to yield the exogenous source of variation to identify the different impact across sectors.

The main inspiration of the paper is that the impact of TE on labour productivity might not be homogenous across sectors and, in particular, we wonder if this effect differs according to sectors skill intensity. Indeed, from a theoretical point of view this idea of a different impact across sectors would seem well-founded. However, we do not expect ex ante a given outcome, existing different convincing reasons for both directions. On one hand, in skilled sectors the use of TE might be more oriented towards screening new workers respect to unskilled ones, which could induce a higher effort and, in turn, a higher labour productivity. On the other hand, in skilled sectors the cost in terms of lower workers' effort induced by TE could be heavier, leading to an even greater reduction in labour productivity. In addition, from an empirical point of view the inclusion of this element in the specification allows us to exploit an exogenous source of variation which, as will be more clear below, should help to reach the identification of the impact of TE.

Thus, dividing sectors between *skilled sectors* (S) and *unskilled sectors* (US), we specify the following diff-in-diff assumption, according to which the difference between the conditional expected total factor productivity growth in S and US can be modelled as some function of the share of TE:

$$\overline{\Delta \log TFP}_{it}^{S} - \overline{\Delta \, log \, TFP}_{it}^{US} = f\left(TE\%_{ijt}\right) \tag{1}$$

where the first element indicates the conditional expected total factor productivity growth in S in country *i* at time *t*, the second one the same for US and *TE%* is the share of TE in country *i* in sector *j* at time *t*.

To divide industries between S and US we compute the ratio between skilled and unskilled workers in each sector for different years and, then, we consider the mean across time as a general index of sector skill intensity (see e.g. Haskel and Slaughter, 2002). Finally, we take the mean of these indexes across sectors and consider (un)skilled those sectors with a skill intensity (lower)higher than the average. This procedure leads us to the binary indicator $SSII_j$, which is equal to 1 if *j* is a skilled sector and equal to 0 if *j* is an unskilled one.

As said before, to make our results easily comparable with previous studies, we estimate also the impact of EPL for PE. As standard in this literature, to identify the impact of EPL for PE we assume that while the degree of regulation is equal for all industries in a given country, the impact of EPL differs in different industries, according to the physiological characteristics of each sector, such as technology, stability of tastes, incidence of aggregate shocks. The usual way to specify this different binding assumption is dividing sectors in *binding sectors* (B) and *non-binding sectors* (NB):

$$\overline{\Delta \log TFP}_{it}^{B} - \overline{\Delta \, log \, TFP}_{it}^{NB} = f\left(EPL_{it}\right) \tag{2}$$

where the first element indicates the conditional expected total factor productivity growth in B in country *i* at time *t*, the second one the same for NB and *EPL* is the degree of regulation in country *i* at time *t* (see e.g. Micco and Pages, 2006 and Bassanini et al., 2009). However, this specification has not been exempt from criticisms in the literature and, accordingly, in this paper we propend for the following identification assumption (see e.g. Cingano et al., 2010):

$$\overline{\Delta logTFP}_{ijt} - \overline{\Delta logTFP}_{ikt} = f\left(FJR_j - FJR_k\right) * EPL_{it} \tag{3}$$

where the first element indicates the conditional expected total factor productivity growth in sector *j* in country *i* at time *t*, the second one the same in sector *k* and *FJR* represent the frictionless job reallocation rate, that is, the natural need to reallocate job in each sector, depurated from labour market regulation frictions and the effect of business cycles.

This assumption states that the difference between the conditional expected total factor productivity growth in two sectors *j* and *k*, in country *i* at time *t*, is a function of the degree of regulation weighted with the natural need of job reallocation of those sectors. Therefore, the underlying idea is the same as (2), but in (3) we specify the different binding with an idiosyncratic weight *FJR* for each sector. And in fact, with weights 1 or 0 specification (3) collapses exactly to (2). To obtain our *FJR* we follow the method proposed by Ciccone and Papaioannou (2006) to obtain a measure of physiological rate of job reallocation in each industry, depurated from market frictions and aggregate shocks (see also Lisi, 2009).

Then, if we assume that $f$ in (1) and (3) is linear, we could estimate the impact of TE and EPL for PE using both a specification in growth rates or in levels:

$$\Delta \log TFP_{ijt} = \alpha \left(FJR_j * EPL_{it}\right) + \beta\, EPL_{it} + \lambda\left(SSII_j * TE\%_{ijt}\right) + \gamma\, TE\%_{ijt} + \eta\, X_{ijt} + \theta_t + \omega_{ijt} \quad (4)$$

$$\log TFP_{ijt} = \alpha \left(FJR_j * \sum_{k=1}^{t} EPL_{ik}\right) + \beta \sum_{k=1}^{t} EPL_{ik} + \lambda \left(SSII_j * \sum_{k=1}^{t} TE\%_{ijk}\right) + \gamma \sum_{k=1}^{t} TE\%_{ijk} + \eta \sum_{k=1}^{t} X_{ijk} + \mu_i + \delta_j + \varphi_t + \varepsilon_{ijt} \quad (5)$$

These two specifications are fully identical, since specification (4) is just the first-difference of specification (5), with $\theta_t = \varphi_t - \varphi_{t-1}$ and $\omega_{ijt} = \varepsilon_{ijt} - \varepsilon_{ijt-1}$. In both specifications $\lambda$ is the marginal structural difference between the impact of TE on TFP growth in skilled sectors compared to unskilled ones. On the other hand, $\gamma$ represents the impact of TE in unskilled sectors and, indeed, its inclusion turns out to be important, since it allows the structural difference $\lambda$ to adjust upon a non-zero impact in the control group (US). In addition, $\alpha$ is the marginal impact of EPL for PE in a sector with a relative high *FJR* compared to a sector with a relatively low *FJR*. Finally, $X_{ijt}$ are other independent variables affecting TFP growth such as trade union density TUD, whereas $\mu_i$, $\delta_j$ and $\varphi_t$ represent respectively country, industry and time-specific fixed effects, allowed to be correlated with other covariates.

We assume a Cobb-Douglas production function with constant returns to scale at sector level:

$$Y_{ijt} = A_{ijt}\, K_{ijt}^{\rho}\, L_{ijt}^{1-\rho} \tag{6}$$

where $Y_{ijt}$ is total output, $A_{ijt}$ is total factor productivity, $K_{ijt}$ is capital and $L_{ijt}$ is labour. Then, we divide for $L_{ijt}$, take the logs and plug equation (5) in (6), to get the following:

$$\log y_{ijt} = \rho\, log\, k_{ijt} + \alpha\left(FJR_j * \sum_{k=1}^{t} EPL_{ik}\right) + \beta \sum_{k=1}^{t} EPL_{ik} + \lambda\left(SSII_j * \sum_{k=1}^{t} TE\%_{ijk}\right) + \gamma \sum_{k=1}^{t} TE\%_{ijk} + \eta \sum_{k=1}^{t} X_{ijk} + \mu_i + \delta_j + \varphi_t + \varepsilon_{ijt}$$

where $y_{ijt}$ is labour productivity and $k_{ijt}$ is the capital-labour ratio. Finally, to the extent that the level of capital is affected by the labour market regulation, we omit the capital-labour ratio and estimate a reduced form model to capture the overall effect on labour productivity growth:

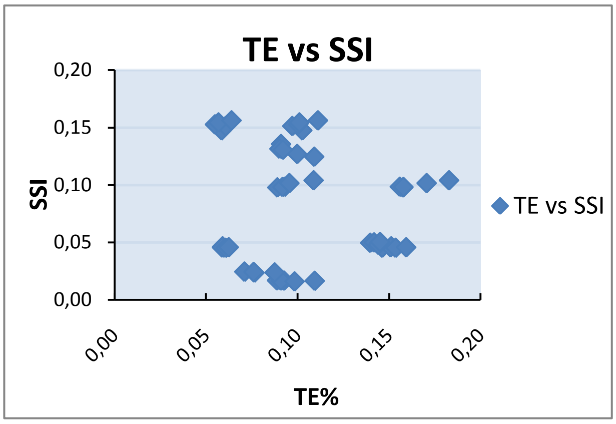
$$\log y_{ijt} = \alpha\left(FJR_j * \sum_{k=1}^{t} EPL_{ik}\right) + \beta \sum_{k=1}^{t} EPL_{ik} + \lambda\left(SSII_j * \sum_{k=1}^{t} TE\%_{ijk}\right) + \gamma \sum_{k=1}^{t} TE\%_{ijk} + \eta \sum_{k=1}^{t} X_{ijk} + \mu_i + \delta_j + \varphi_t + \varepsilon_{ijt} \tag{7}$$

In the following empirical analysis equation (7) represents our baseline specification. Indeed, this specification is similar to Lisi (2009), with the difference that while there we identify an average impact of TE across sectors, in this paper we introduce a diff-in-diff assumption for the impact of TE in different sectors, according to sectors skill intensity. On one hand, this should offer a more accurate description of the impact of TE; on the other hand, since we exploit the exogenous source of variation on the different impact across sectors, this should increase the identification power of the empirical analysis.

Furthermore, as emphasized by the previous literature, the advantage of using industry-level panel data, instead of cross-country, is manifold. First, not only the variation of TE and EPL is exploited, but also the exogenous variation on their impact in different industries. And considering that the use of the share of TE as covariate might be at least questionable for an endogeneity consideration, the inclusion of this exogenous variation to identify the impact of TE should give more consistency to our result. Still, the industry-level panel allows us to control for unobserved fixed effects, allowed to be correlated with other covariates, which should help to alleviate both omitted variable bias and misspecification. Moreover, as the previous literature emphasised (OECD, 2007), the within-industry "composition effect" appears to be negligible, allowing us to identify the "independent effect" of TE on labour productivity.

Possible drawbacks of the specification are basically about the exogeneity of our diff-in-diff assumption (1). In particular, if the use of TE changes extensively the skill composition of our sectors and, in turn, the subdivision of them in S and US, then assumption (1) would not be useful anymore. In fact, in that case we are not exploiting the exogenous variation on the impact of the treatment (TE%) between control group (US) and treatment group (S), because groups themselves are endogenously determined by the treatment. Differently, if sectors skill composition and, in turn, control group and treatment group are exogenously set by sectors production functions, then our diff-in-diff assumption should allow us to exploit the exogenous variation on the impact of TE across sectors.

Indeed, the clear picture emerging from our data is that the correlation between the share of TE and sectors skill composition is almost null. In particular, in Figure 1 we report the scatter plot between TE% and SSI, along with the results of the OLS regression. As we can see, both the cloud and the OLS estimation suggest that there is no correlation between TE% and SSI. Therefore, the different skill composition across sectors would seem more driven by the technology underpinning the production function in each sector, which leads us to pursue this identification assumption in the following empirical analysis.




| SSI | OLS | s.e. | p-value |
|---|---|---|---|
| TE% | -0,154 | 0,197 | (0,438) |
| CONSTANT | 0,098 | 0,022 | (0,000)*** |

Fig. 1 *Correlation between TE% and SSI*

### 3. Data-set

The empirical specification is performed on an industry-level panel of EU countries. In particular, the sample covers 10 sectors in 13 countries over the years 1992-2005, for a balanced panel of 1820 observations. Countries included in the sample are Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden and the United Kingdom. Since we make use of data sources with different levels of sectors classification, we did some aggregation and the final sectors segmentation reflects the EUROSTAT classification (see Annex 2). As usual in this literature (see e.g. Bassanini et al., 2009), we excluded some important industries as public sector, where labour productivity is not easily measured. With this sectors classification, our diff-in-diff strategy produces two groups of five sectors and it is evident from the data analysis that the final sample exhibits a sufficient amount of variation to reach the identification of the different impact of TE.

The data on labour productivity and employment level at the industry-level are collected from EU KLEMS dataset. This comprehensive database contains data on economic growth, productivity, employment and other variables at the industry-level for all EU countries, providing an important data-source for policy evaluation. Moreover, productivity measures are developed with growth accounting techniques, coherently with our empirical specification. The mean of labour productivity in the entire sample is 108,57, whereas the mean omitting 1992-1993-1994 is 111,91, telling us that labour productivity grew from 1995 (base year = 100) to 2005 in EU countries, even if not so significantly. The data on employment level are used to construct the actual job reallocation rates, needed to obtain our measures of natural rate of job reallocation for each industry. While the estimated *FJR* are contained in a restricted range, the actual job reallocation rates are much more changeable, which confirms the idea that actual rates are significantly influenced by aggregate shocks, producing a short rather than a long-run measure of the natural need of job reallocation.

The shares of TE at the industry-level are constructed from EU – Labour Force Survey (EUROSTAT), a labour market survey providing annually and quarterly information about trends on the labour market in EU countries. The mean and the standard deviation in the sample are respectively 0,09 and 0,075, confirming the idea that TE is by now an important feature of the labour market landscape in Europe, but its importance differs significantly across countries. For instance, while in countries as Spain and Portugal the share of TE is far away from the mean, in the UK the mean is no more than 0,05.

To construct our sector skill intensity index, we divide workers between skilled and unskilled using two main indicators. Indeed, at the beginning the idea was to use more than two indicators of workers skill, to test as much as possible our results. However, all other plausible indicators led us to the same dichotomy between sectors of those two, therefore in the paper we show the results only for these. For both indicators the data are collected form Science, technology and innovation database (EUROSTAT), which collects data from many different publications on these themes as R&D expenditure, workers knowledge, HRST, innovations.

The first indicator concerns the level of education and we consider skilled those workers with a tertiary education (level 5 – 6 ISCED 1997). Differently, the second indicator concerns the kind of task workers make in their job. In particular, the database gives us these values as a share of total employment, for each sector from 2001 to 2007. Indeed, these two indicators lead us to a similar, but still slightly different, subdivision of sectors between skilled and unskilled.

As measure of EPL for PE we make use of the cardinal index constructed by OECD (2004), varying in theory from 6 for the most stringent to 0 for the least stringent regulation. The time-series for the EPL index are currently available until 2003, except for some country where there has been some significant change in the regulation after 2003 (e.g. in Portugal 2004). To the extent that from 2003 to 2005 there not seem to have been significant changes in the regulation of PE (and, if any, they are included in the time-series), for the values after 2003 we consider the least value available. In our sample the EPL index ranges from 4,33 in Portugal (1992-2003) to 0,95 in the UK (1992-1999). The mean of the index follows a slightly decreasing trend, going from 2,46 at the beginning of the sample 1992, to 2,31 at the end 2005. Indeed, the decreasing trend in the stringency of regulation of PE is far away from being common to all countries, rather it seems to be driven by changes in Spain and Portugal.

Even if the EPL index for TE is not used in the regression analysis, it is useful to see what happen to the index in our sample. The EPL index for TE ranges from 5,38 in Italy (1992-1996) to 0,25 in the UK (1992-2001). Similarly to PE, the mean of the index for TE follows a decreasing trend, going from 2,92 in 1992 to 1,92 in 2005. But differently to PE, the decreasing trend seems to be a common feature in fairly all EU countries.

Unfortunately, no data on trade union density at industry-level are available, therefore they are collected at country-level from OECD – Labour Force Statistics. The mean in the sample is 0,41, telling us how trade union are still an important subject in Europe. In our data trade union density ranges from 0,84 in Sweden (1993) to 0,08 in France (2005).

A description of variables and sources can be found in Annex 1, whereas the subdivisions of sectors between skilled and unskilled produced by the two indicators, along with descriptive statistics, are in Annex 2.

### *4. Results*

In this section we show the results of the empirical analysis. First, we discuss the outcomes of the baseline equation (7), then we provide some sensitive analysis to check if our findings are robust to little changes in the skill intensity index and in the sample used in the estimation.

In Table 1 we estimate different specifications of the baseline equation, using the first sector skill intensity index, that is, the index concerning the level of workers education (see Annex 1 and 2). In the first two columns we run a POLS regression, with a technology trend and trade union density in (2). In both specifications the point estimates of TE% and TE%*SSII1 are negative and significant at 1%. Moreover, both the R-squared are greater than the corresponding ones in the estimation without SSII (see Lisi 2009). Therefore, the inclusion in the estimation of this exogenous source of variation SSII allows us to explain a greater portion of variance of labour productivity. However, these coefficients cannot be interpreted as causal impact but just as a simple correlation, given the evident omitted variable bias in this POLS estimation.

Differently, from (3) on we implement a FE regression, where we allow specific factors to be correlated with EPL, TE and SSII. In columns (3)-(4) we include country and sector dummies in the estimation, to control for institutional and technological specific effects. Still, in both specifications the coefficients of TE% and TE%*SSII1 are negative and significant at 1%. Interestingly, the coefficient of TE% is significantly lower than the corresponding one in the estimation without SSII; on the other hand, the sum of TE% and TE%*SSII1 is bigger than the coefficient of TE in the estimation without SSII (see Lisi 2009). Indeed, this suggests that in the estimation without SSII we identify the average impact of TE across sectors, whereas with the inclusion of SSII we are able to capture a more accurate description of the impact of TE.

In columns (5)-(6) we include also time dummies to control for differential trends without any sizable difference. Since we are able to control for all unobserved factors, we interpret these results as the causal impact of these labour market policies and, in particular, the coefficient of TE%*SSII1 as the structural difference of the impact of TE on labour productivity between skilled and unskilled sectors. The main result is that TE is even more damaging in skilled sectors, with a negative effect significantly heavier than in unskilled ones. In particular, an increase of 10% of the share of TE in skilled sectors would lead to a decrease of 1.2% in labour productivity growth, whereas in unskilled ones the reduction would be only of 0.6%.

**Table 1. LABOUR PRODUCTIVITY (SSII1)**

| | (1)_ | (2)_ | (3)_ | (4)_ | (5)_ | (6)_ |
|---|---|---|---|---|---|---|
| | POLS | POLS | FE | FE | FE | FE |
| EPL | 0,010<br>(0,001)*** | 0,004<br>(0,001)*** | 0,014<br>(0,002)*** | 0,006<br>(0,002)*** | 0,006<br>(0,002)*** | 0,006<br>(0,002)** |
| EPL*FJR | -0,054<br>(0,026)** | -0,061<br>(0,025)** | -0,090<br>(0,039)** | -0,093<br>(0,039)** | -0,094<br>(0,039)** | -0,093<br>(0,040)** |
| TE% | -0,061<br>(0,007)*** | -0,084<br>(0,007)*** | -0,056<br>(0,009)*** | -0,065<br>(0,009)*** | -0,066<br>(0,009)*** | -0,065<br>(0,009)*** |
| TE%*SSII1 | -0,039<br>(0,008)*** | -0,040<br>(0,007)*** | -0,051<br>(0,008)*** | -0,051<br>(0,008)*** | -0,051<br>(0,008)*** | -0,051<br>(0,008)*** |
| TUD | | -0,001<br>(0,000)*** | | -0,002<br>(0,002) | | -0,002<br>(0,002) |
| TREND | | 0,024<br>(0,002)*** | | 0,022<br>(0,003)*** | | 0,355<br>(0,012)*** |
| CONSTANT | 4,582<br>(0,006)*** | 4,554<br>(0,008)*** | | | | |
| SECTOR DUMMIES | NO | NO | YES | YES | YES | YES |
| COUNTRY DUMMIES | NO | NO | YES | YES | YES | YES |
| YEAR DUMMIES | NO | NO | NO | NO | YES | YES |
| Observations | 1820 | 1820 | 1820 | 1820 | 1820 | 1820 |
| R-squared | 0,2025 | 0,3193 | 0,9992 | 0,9993 | 0,9993 | 0,9993 |

POLS: pooled ordinary least squares; FE: fixed effects (dummy variable regression); EPL: employment protection legislation; FJR: frictionless job reallocation; TE%: the share of temporary employment; SSII1: sector skill intensity index concerning the level of workers education; TUD: trade union density.

Robust standard errors in brackets. * significant at 10%, ** significant at 5%, *** significant at 1%.

To the extent that a subdivision between skilled and unskilled sectors has to be necessarily based on a discretional criteria, in Table 2 we repeat the same estimations using our second sector skill intensity index, that is, the index concerning the kind of task workers make in their job (see Annex 1 and 2). As said before, this second index leads to a similar, but slightly different, subdivision of sectors and, therefore, represents a perfect candidate to test the stability of our findings.

**Table 2. LABOUR PRODUCTIVITY (SSII2)**

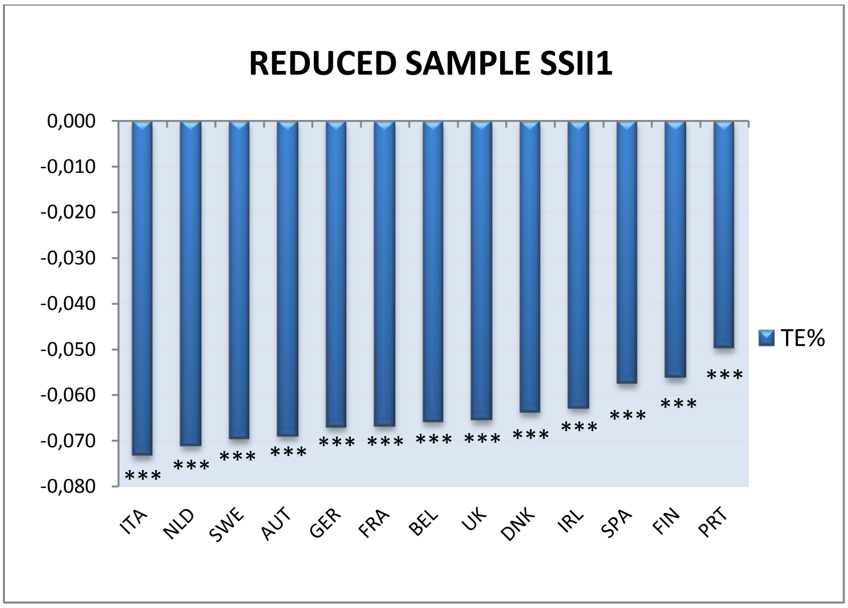
| | (1)_ | (2)_ | (3)_ | (4)_ | (5)_ | (6)_ |
|---|---|---|---|---|---|---|
| | POLS | POLS | FE | FE | FE | FE |
| EPL | 0,010<br>(0,001)*** | 0,004<br>(0,001)*** | 0,014<br>(0,002)*** | 0,006<br>(0,002)*** | 0,006<br>(0,002)*** | 0,006<br>(0,002)*** |
| EPL*FJR | -0,051<br>(0,026)** | -0,061<br>(0,025)** | -0,088<br>(0,039)** | -0,092<br>(0,039)** | -0,093<br>(0,040)** | -0,092<br>(0,040)** |
| TE% | -0,065<br>(0,007)*** | -0,087<br>(0,007)*** | -0,060<br>(0,009)*** | -0,069<br>(0,009)*** | -0,070<br>(0,009)*** | -0,069<br>(0,009)*** |
| TE%*SSII2 | -0,034<br>(0,008)*** | -0,040<br>(0,007)*** | -0,048<br>(0,009)*** | -0,051<br>(0,008)*** | -0,051<br>(0,008)*** | -0,051<br>(0,008)*** |
| TUD | | -0,001<br>(0,000)*** | | -0,002<br>(0,002) | | -0,002<br>(0,002) |
| TREND | | 0,025<br>(0,002)*** | | 0,022<br>(0,003)*** | | 0,354<br>(0,012)*** |
| CONSTANT | 4,583<br>(0,007)*** | 4,555<br>(0,008)*** | | | | |
| SECTOR DUMMIES | NO | NO | YES | YES | YES | YES |
| COUNTRY DUMMIES | NO | NO | YES | YES | YES | YES |
| YEAR DUMMIES | NO | NO | NO | NO | YES | YES |
| Observations | 1820 | 1820 | 1820 | 1820 | 1820 | 1820 |
| R-squared | 0,1994 | 0,3188 | 0,9992 | 0,9993 | 0,9993 | 0,9993 |

POLS: pooled ordinary least squares; FE: fixed effects (dummy variable regression); EPL: employment protection legislation; FJR: frictionless job reallocation; TE%: the share of temporary employment; SSII2: sector skill intensity index concerning the kind of task workers make in their job; TUD: trade union density.

Robust standard errors in brackets. * significant at 10%, ** significant at 5%, *** significant at 1%.

Nonetheless, as can be clearly seen from Table 2, this change in the SSII used in the estimation does not change at all our conclusions. Still, the coefficients of TE% and TE%*SSII2 are negative and significant at 1%, even with a magnitude very close to the SSII1 estimation.

Furthermore, to check if our results depend crucially on the inclusion of some country in the sample, we re-estimate the model excluding all countries one-by-one. Therefore, we run as many FE regressions as countries in our sample, where in each regression we exclude one different country. Then, in Fig. 1 and 2 we show the coefficients of TE% and TE%*SSII, using



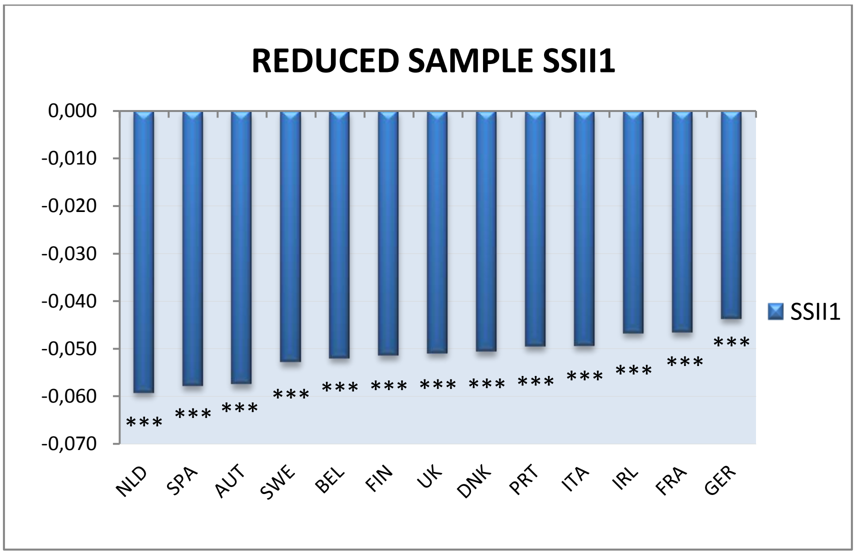
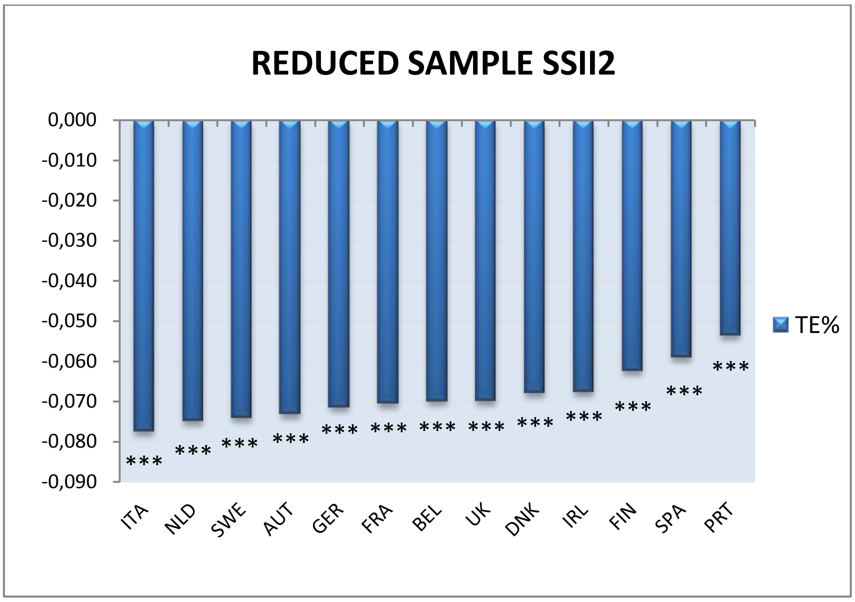




Fig. 2 *Coefficients of TE% and TE%*SSII1 from the Reduced Sample*

respectively SSII1 and SSII2, arranged from the greatest to the smallest. In particular, in both Fig. the value associated with a country (e.g. *ITA*) is the estimated coefficient from the reduced sample excluding that country. Finally, in Table 3 and 4 we report the complete results of the 13 regressions, using respectively SSII1 and SSII2.



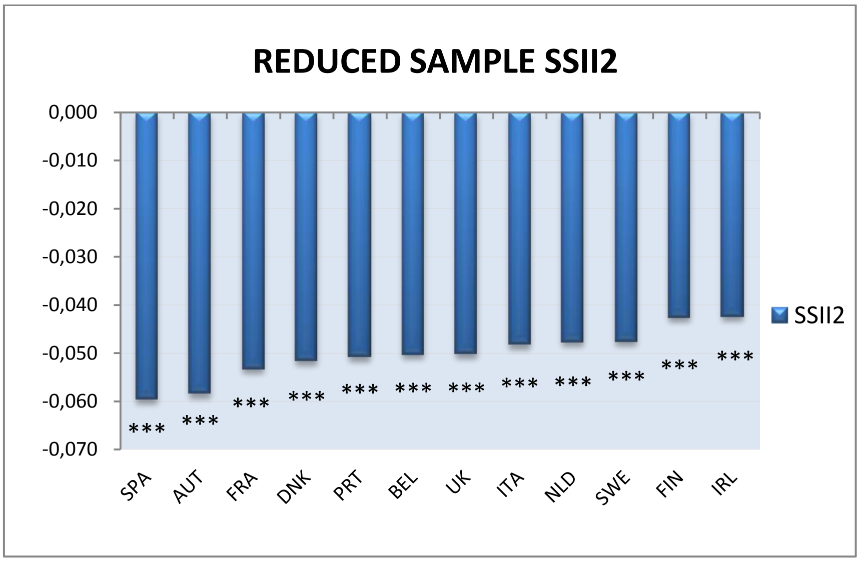




Fig. 3 *Coefficients of TE% and TE%*SSII2 from the Reduced Sample*

## Table 3. LABOUR PRODUCTIVITY (Reduced Sample SSII1)

| | FE | FE | FE | FE | FE | FE | FE | FE | FE | FE | FE | FE | FE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AUT | BEL | DNK | FIN | FRA | GER | IRL | ITA | NLD | PRT | SPA | SWE | UK |
| EPL | 0,007 | 0,005 | 0,005 | 0,005 | 0,006 | 0,007 | 0,005 | 0,005 | 0,005 | 0,007 | 0,007 | 0,004 | 0,007 |
| | (0,002)*** | (0,002)** | (0,002)** | (0,002)** | (0,002)*** | (0,002)*** | (0,002)** | (0,002)** | (0,002)** | (0,002)*** | (0,002)*** | (0,002)* | (0,002)*** |
| EPL*FJR | -0,107 | -0,093 | -0,097 | -0,088 | -0,097 | -0,116 | -0,088 | -0,098 | -0,076 | -0,130 | -0,117 | -0,044 | -0,089 |
| | (0,040)*** | (0,040)** | (0,041)** | (0,041)** | (0,041)** | (0,042)*** | (0,040)** | (0,040)** | (0,042)* | (0,039)*** | (0,043)*** | (0,039)_ | (0,041)** |
| TE% | -0,069 | -0,066 | -0,064 | -0,056 | -0,067 | -0,067 | -0,063 | -0,073 | -0,071 | -0,050 | -0,058 | -0,070 | -0,066 |
| | (0,009)*** | (0,009)*** | (0,009)*** | (0,009)*** | (0,009)*** | (0,009)*** | (0,009)*** | (0,009)*** | (0,009)*** | (0,009)*** | (0,017)*** | (0,009)*** | (0,009)*** |
| TE%*SSII1 | -0,057 | -0,052 | -0,051 | -0,051 | -0,047 | -0,044 | -0,047 | -0,049 | -0,059 | -0,050 | -0,058 | -0,053 | -0,051 |
| | (0,008)*** | (0,008)*** | (0,008)*** | (0,008)*** | (0,008)*** | (0,008)*** | (0,008)*** | (0,008)*** | (0,008)*** | (0,008)*** | (0,015)*** | (0,008)*** | (0,008)*** |
| TUD | -0,003 | -0,001 | -0,001 | -0,003 | -0,003 | -0,002 | -0,001 | -0,001 | -0,001 | -0,002 | -0,003 | -0,002 | -0,002 |
| | (0,002)_ | (0,002)_ | (0,002)_ | (0,002)_ | (0,002)_ | (0,002)_ | (0,003)_ | (0,002)_ | (0,002)_ | (0,002)_ | (0,002)_ | (0,002)_ | (0,002)_ |
| TREND | 0,630 | 0,630 | 0,633 | 0,632 | 0,632 | 0,630 | 0,620 | 0,630 | 0,635 | 0,649 | 0,652 | 0,638 | 0,639 |
| | (0,007)*** | (0,007)*** | (0,007)*** | (0,007)*** | (0,008)*** | (0,007)*** | (0,009)*** | (0,007)*** | (0,023)*** | (0,022)*** | (0,024)*** | (0,022)*** | (0,021)*** |
| SECTOR DUMMIES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| COUNTRY DUMMIES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| YEAR DUMMIES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| Observations | 1680 | 1680 | 1680 | 1680 | 1680 | 1680 | 1680 | 1680 | 1680 | 1680 | 1680 | 1680 | 1680 |
| R-squared | 0,9993 | 0,9993 | 0,9993 | 0,9993 | 0,9992 | 0,9993 | 0,9993 | 0,9993 | 0,9993 | 0,9993 | 0,9992 | 0,9993 | 0,9992 |

FE: fixed effects (dummy variable regression); EPL: employment protection legislation; FJR: frictionless job reallocation; TE%: the share of temporary employment; SSII1: sector skill intensity index concerning the level of workers education; TUD: trade union density.

Robust standard errors in brackets. * significant at 10%, ** significant at 5%, *** significant at 1%.

## Table 4. LABOUR PRODUCTIVITY (Reduced Sample SSII2)

| | FE | FE | FE | FE | FE | FE | FE | FE | FE | FE | FE | FE | FE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AUT | BEL | DNK | FIN | FRA | GER | IRL | ITA | NLD | PRT | SPA | SWE | UK |
| EPL | 0,007 | 0,005 | 0,005 | 0,005 | 0,006 | 0,007 | 0,005 | 0,005 | 0,005 | 0,007 | 0,007 | 0,004 | 0,007 |
| | (0,002)*** | (0,002)** | (0,002)** | (0,002)** | (0,002)*** | (0,002)*** | (0,002)** | (0,002)** | (0,002)** | (0,002)*** | (0,002)*** | (0,002)* | (0,002)*** |
| EPL*FJR | -0,106 | -0,092 | -0,097 | -0,086 | -0,100 | -0,114 | -0,072 | -0,097 | -0,071 | -0,130 | -0,119 | -0,041 | -0,088 |
| | (0,040)*** | (0,040)** | (0,041)** | (0,041)** | (0,041)** | (0,042)*** | (0,040)** | (0,040)** | (0,042)* | (0,040)*** | (0,043)*** | (0,039) | (0,041)** |
| TE% | -0,073 | -0,070 | -0,068 | -0,062 | -0,071 | -0,071 | -0,068 | -0,077 | -0,075 | -0,054 | -0,059 | -0,074 | -0,070 |
| | (0,009)*** | (0,009)*** | (0,009)*** | (0,009)*** | (0,009)*** | (0,009)*** | (0,009)*** | (0,009)*** | (0,009)*** | (0,008)*** | (0,016)*** | (0,009)*** | (0,009)*** |
| TE%*SSII2 | -0,060 | -0,051 | -0,053 | -0,048 | -0,058 | -0,042 | -0,043 | -0,050 | -0,048 | -0,052 | -0,069 | -0,048 | -0,050 |
| | (0,008)*** | (0,008)*** | (0,008)*** | (0,008)*** | (0,008)*** | (0,008)*** | (0,008)*** | (0,008)*** | (0,008)*** | (0,008)*** | (0,015)*** | (0,008)*** | (0,008)*** |
| TUD | -0,002 | -0,001 | -0,001 | -0,002 | -0,003 | -0,002 | -0,001 | -0,001 | -0,001 | -0,002 | -0,002 | -0,001 | -0,002 |
| | (0,002)_ | (0,002)_ | (0,002)_ | (0,002)_ | (0,002)_ | (0,002)_ | (0,003)_ | (0,002)_ | (0,002)_ | (0,002)_ | (0,002)_ | (0,002) | (0,002)_ |
| TREND | 0,649 | 0,630 | 0,632 | 0,646 | 0,652 | 0,629 | 0,621 | 0,630 | 0,635 | 0,646 | 0,632 | 0,638 | 0,637 |
| | (0,022)*** | (0,007)*** | (0,007)*** | (0,023)*** | (0,024)*** | (0,007)*** | (0,009)*** | (0,007)*** | (0,023)*** | (0,022)*** | (0,008)*** | (0,022)*** | (0,021)*** |
| SECTOR DUMMIES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| COUNTRY DUMMIES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| YEAR DUMMIES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| Observations | 1680 | 1680 | 1680 | 1680 | 1680 | 1680 | 1680 | 1680 | 1680 | 1680 | 1680 | 1680 | 1680 |
| R-squared | 0,9993 | 0,9992 | 0,9993 | 0,9993 | 0,9992 | 0,9993 | 0,9993 | 0,9993 | 0,9993 | 0,9993 | 0,9992 | 0,9993 | 0,9992 |

FE: fixed effects (dummy variable regression); EPL: employment protection legislation; FJR: frictionless job reallocation; TE%: the share of temporary employment; SSII2: sector skill intensity index concerning the kind of task workers make in their job; TUD: trade union density.

Robust standard errors in brackets. * significant at 10%, ** significant at 5%, *** significant at 1%.

As both Fig. 1 and 2 clearly show, the estimated coefficients of TE% and TE%*SSII do not appear to depend on countries included in the estimation. Indeed, the coefficients are always negative and significant at 1%, and even the magnitudes appear to be rather stable across the sample and the sector skill intensity index used in the empirical analysis.

In conclusion, our result of a negative and double effect of TE in skilled sectors would seem to be fairly robust to the sector skill intensity index and the sample of countries used in the analysis. Moreover, the stability of our estimates despite the robustness checks, along with the fact we control for many different confounding factors, lead us to interpret our estimates as the causal impacts on labour productivity and, in particular, the coefficient of TE%*SSII as the structural difference of the impact of TE between skilled and unskilled sectors.

### *5. Conclusions*

In this study we have implemented a well-known method in policy evaluation to identify the different impact of TE on labour productivity, according to sectors skill intensity. In particular, making use of an industry-level panel of EU countries, we divided industries between skilled and unskilled and, then, specified a diff-in-diff assumption to exploit the exogenous source of variation in the impact of TE among different sectors. Moreover, the industry-level panel allowed us to control for different unobserved confounding factors, which should attenuate significantly the omitted variable and other endogeneity problems. Indeed, the empirical analysis on this question turns out to be crucial, given that from a theoretical point of view is ambiguous what sectors might be more affected by TE.

The main finding of the paper is that TE is even more damaging in skilled sectors, with a negative effect significantly heavier than in unskilled sectors, robust to little changes in the skill intensity index and in the sample used. In particular, an increase of 10% of the share of TE in skilled sectors would lead to a decrease of 1.2% in labour productivity growth, whereas in unskilled ones the reduction would be only of 0.6%. Indeed, this result could have very important policy implications and, certainly, leads us to question if the actual European regulation corresponds exactly to the lines of the best practice. In particular, it might support the growing feeling that TE is currently used in the labour market more as a cheaper form of job, instead of as a least-cost way to screen new workers and, to some extent, this wrong use might incentive workers to reduce the effort, instead of growing it in order to get the passage to a more stable job. Consequently, this undesirable practice in the labour market could damage more exactly the skilled sectors, where production uses skills more intensively.

The main implication raising from this picture is that TE does not harm labour market outcomes per se, rather is the actual use done in the labour market that distorts the incentives and damages labour productivity. Therefore, the real challenge for labour regulation is to find a design to address the use of temporary contracts as a flexible way to enter in the market allowing firms to screen new workers towards more stable form of jobs, instead of as a structural cheaper form of job. Probably, only in those conditions labour market outcomes could be able to benefit from all the advantages in terms of flexibility induced by TE, without suffering the secondary consequences on labour productivity.

Hence, the future agenda of labour market research should certainly include the identification of such kind of regulation. Even if we leave the answer to this issue for future research, a first starting point might be to make the renewal of a temporary contract less cheaper than the first one and/or less than a permanent contract. On the other hand, a reduction on the consistent level of firing costs in Europe might help to make a labour market with many temporary contracts less attractive for firms. Therefore, a regime with a gradual path towards more stable forms of job, with increasing firing costs, would apparently be a good compromise between short-term flexibility and long-term stability.

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## ANNEX 1: DATA DESCRIPTION

### Labour Productivity

*Definition*: gross value added in volume terms (base 1995 = 100) divided by total hours worked.

*Source*: EU KLEMS database.

### Total Hours Worked

*Definition*: product of average hours worked and total person engaged.

*Source*: EU KLEMS database.

### Employment Level

*Definition*: total persons engaged.

*Source*: EU KLEMS database.

### Job Reallocation Rate

*Definition*: Davis and Haltiwanger measure of job reallocation rate $JR_{ijt} = \frac{|E_{ijt} - E_{ijt-1}|}{(E_{ijt} + E_{ijt-1})/2}$.

*Source*: own calculation from the employment level data from EU KLEMS database.

### Frictionless Job Reallocation Rate

*Definition*: job reallocation rate depurated from the frictions introduced by labour market regulation and the effect of aggregate shocks ($FJR_j = \hat{\pi}_j$).

*Source*: own estimation.

### Temporary Employment

*Definition*: total persons engaged with temporary contracts.

*Source*: EUROSTAT Labour Force Survey.

**SSII1 – 2**

*Definition*: binary indicators equal to 1 for skilled sectors and equal to 0 for unskilled ones. Indicator 1 concerns the workers' level of education, 2 the task workers made in their job.

*Source*: own calculation.

**Share of skilled workers in SSII1**

*Definition*: share of workers with a tertiary education (level 5 – 6 ISCED 1997).

*Source*: EUROSTAT Science, technology and innovation database.

**Share of skilled workers in SSII2**

*Definition*: share of workers occupied in science and technology tasks (HRST).

*Source*: EUROSTAT Science, technology and innovation database.

**EPL for Permanent Employment**

*Definition*: OECD index of the stringency of employment protection legislation on regular contracts.

*Source*: OECD *Employment Outlook* (2004).

**EPL for Temporary Employment**

*Definition*: OECD index of the permissiveness on the use of temporary contracts.

*Source*: OECD *Employment Outlook* (2004).

**Trade Union Density**

*Definition*: employees trade union members divided by total number of employees.

*Source*: OECD Labour Force Statistics.

## ANNEX 2: SUBDIVISION OF SECTORS AND DESCRIPTIVE STATISTICS

**SKILLED AND UNSKILLED SECTORS PRODUCED BY SSII1**

| SKILLED SECTORS | UNSKILLED SECTORS |
|---|---|
| Manufacturing | Agriculture, hunting and forestry |
| Wholesale and retail trade | Electricity, gas and water supply |
| Hotels and restaurants | Construction |
| Financial intermediation | Transport, storage and comunication |
| Real estate, renting and business activities | Other community, social and personal services |

**SKILLED AND UNSKILLED SECTORS PRODUCED BY SSII2**

| SKILLED SECTORS | UNSKILLED SECTORS |
|---|---|
| Manufacturing | Agriculture, hunting and forestry |
| Wholesale and retail trade | Electricity, gas and water supply |
| Financial intermediation | Construction |
| Real estate, renting and business activities | Hotels and restaurants |
| Other community, social and personal services | Transport, storage and comunication |

**DESCRIPTIVE STATISTICS**

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Labour Productivity | 1820 | 108,565 | 20,757 | 63,486 | 268,792 |
| Log Labour Productivity | 1820 | 4,672 | 0,170 | 4,151 | 5,594 |
| Job Reallocation | 1820 | 0,028 | 0,027 | 0,000 | 0,239 |
| Frictionless Job Reallocation | 1820 | 0,043 | 0,009 | 0,028 | 0,059 |
| Share of TE | 1820 | 0,089 | 0,075 | 0,000 | 0,488 |
| EPL for Regular Contracts | 1820 | 2,372 | 0,846 | 0,948 | 4,333 |
| Trade Union Density | 1820 | 0,408 | 0,232 | 0,080 | 0,839 |

# The Impact of EPL on Labour Productivity in a General Equilibrium Matching Model

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*September 2010*

**Abstract**

*The standard analysis of the impact of EPL on labour market outcomes concentrates mainly on unemployment, disregarding the possible effect on productivity. In this paper we make (a component of) labour productivity endogenous and analyze how the presence of a stringent protection legislation affects labour market in an equilibrium matching model with endogenous job destruction. Indeed, considering labour productivity an endogenous could be important not only in the case of EPL, but also for all kind of personnel policy evaluation. In this framework high labour productivity on one hand is costly in terms of effort, on the other hand is beneficial in terms of lower job destruction. We find that high firing costs partially substitute high labour productivity in reducing job destruction and this, consequently, brings down the optimal level of productivity. Moreover, the impact of EPL on unemployment is ambiguous but numerical exercises show unambiguously how higher firing restrictions reduce different measures of aggregate welfare. To some extent, the clear emergence of these results is full of policy implication and, indeed, rationalizes the recent empirical evidence on the impact of EPL.*

JEL Classification: J24, J38, J63, J64.

Keywords: Employment protection; Endogenous labour productivity; Job destruction.

[‡] The author would like to thank Robert Shimer for useful suggestions. However, the analysis and any errors remain responsibility of the author alone.

# The Impact of EPL on Labour Productivity in a General Equilibrium Matching Model

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### *1. Introduction*

Recent empirical evidence from European countries and the U.S. shows that the presence of stringent employment protection legislation (EPL) affects significantly the level of productivity. In particular, both cross-country (DeFreitas and Marshall, 1998), Dif-in-Dif (Micco and Pages, 2006; Autor et al., 2006, 2007; Bassanini and Venn, 2007; Bassanini et al., 2009; Lisi, 2010) and other studies (Riphahn, 2004; Ichino and Riphahn, 2005) found that a higher EPL have a negative impact on labour productivity.

Nonetheless, the theoretical analysis of the impact of EPL focused mainly on unemployment and job flows, disregarding the effects on labour productivity. In fact, both standard analysis of labour demand under uncertainty (Bentolila and Bertola, 1990; Bertola, 1990; Bentolila and Saint-Paul, 1992; Bentolila and Dolado, 1994; Boeri and Garibaldi, 2007) and general equilibrium models (Mortensen and Pissarides, 1994, 1999b; Garibaldi, 1998; Pissarides, 2000; Cahuc and Postel-Vinay, 2002) consider the level of productivity an exogenous parameter, not influenced by the presence of firing costs. Indeed, the issue has been already the object of interest of some papers. However, these studies analyze the role of EPL in distorting the adjustment of employment and investment and, in turn, productivity growth (Hopenhayn and Rogerson, 1993; Saint-Paul, 1997, 2002; Bartelsman and Hinloopen, 2005).

In this paper, in the spirit of Ichino and Riphan (2005), we concentrate more on the behavioral component of productivity, therefore we make (a component of) labour productivity an endogenous object of the model and then study the impact of a stringent protection legislation. Since our concern is to understand the equilibrium impact on productivity, unemployment and welfare, we need to embed the analysis into an equilibrium model of the labour market. To this extent, it is our conviction that the Mortensen and Pissarides matching approach to equilibrium unemployment is the best candidate for this kind of analysis.

In this framework, the matching between any single job vacancy and unemployed worker is a costly and sticky process, governed by a matching function assumed with constant returns. The job productivity has a common component and an idiosyncratic component, due to either demand or technology shocks, which makes the value of product job-specific. The idiosyncratic component follows a jump process characterized by a Poisson arrival frequency and it is drawn by a common price distribution whenever it jumps.

The usual assumption in the literature is that technology is fully flexible at the beginning of creation, but investment is irreversible. Therefore, at the moment of creation firms choose the most profitable job in the market, with the idiosyncratic component at the upper support of the price distribution. Thus, every new match generates a positive surplus, which is divided between wages and profits according to bilateral bargain. However, whenever a shock arrives an existing job cannot be switched to one more profitable and wages are revised in the face of new productivity. Nonetheless, large negative shocks generate a negative surplus, which makes optimal for a firm to destroy the job. In the presence of a stringent protection legislation, modeled as firing costs, job destruction is costly for the firm. Moreover, there exist a zero-profit condition for the opening of new vacancies, which determines the tightness of the market and, along with the destruction rule, the level of unemployment.

In this paper we imagine that an employed worker has to exert effort to produce and this generates disutility. Following this argument, we assume that the common component of productivity is determined by the level of effort exerted by workers. Therefore, high labour productivity on one hand is costly in terms of effort, on the other hand is beneficial in terms of lower job destruction. This is, as far as we are aware, a novelty as the common component of productivity is usually considered an exogenous parameter of the model, not influenced by the level of institutional variables. In the light of the micro-founded nature of the matching approach to equilibrium unemployment, this extension could be a good suggestion to capture in the framework the recent evidence on the impact of EPL on productivity. Moreover, the approach to put labour market outcomes and personnel economics together when we address policy questions has already turned out to be successful (see e.g. Shapiro and Stiglitz, 1984).

An equilibrium is a job destruction and job creation rule, a labour productivity and a level of unemployment implied by the rational expectations behavior of individual firms and workers and by the matching technology. We study how the presence of a stringent protection legislation affects productivity, unemployment and welfare in the aggregate steady-state. We find that high firing costs partially substitute high labour productivity in reducing job destruction and this, consequently, brings down the equilibrium labour productivity. Moreover, the impact of EPL on unemployment is ambiguous but numerical exercises show unambiguously how higher firing restrictions reduce different measures of aggregate welfare. To some extent, the clear emergence of these results is full of policy implication and, indeed, rationalizes the recent empirical evidence on the impact of EPL.

The paper proceeds as follows: in Section 2 we describe the basic theoretical framework and in Section 3 characterize its steady-state. Section 4 studies qualitatively the impact of a stringent protection legislation on the equilibrium level. In Section 5 we conduct some numerical exercises to study the effect on productivity, but also on different measure of aggregate welfare. Section 6 concludes.

## *2. The theoretical framework*

The basic theoretical framework is the matching approach to equilibrium unemployment with endogenous job destruction, in the version of Pissarides (2000). In this economy there is an endogenously sized continuum of jobs, characterized by a common component of productivity $p$ and an idiosyncratic component $x$. Each product commands in the market a price of $px$, which evidently differ to each other for the presence of the idiosyncratic component. In the standard versions of the model $p$ is considered an exogenous parameter, capturing the macro events that affect productivity in all jobs by the same amount and in the same direction. Differently, in our interpretation $p$ is the endogenous labour productivity and $x$ is the idiosyncratic condition in the market, due to demand or technology. Therefore, in our model we do not consider $p$ a parameter capturing the macro shocks, because our aim is exactly to study how firing costs affect the level of the behavioural component of productivity. Nonetheless, it is evident that there is no difficulty in introducing such a parameter in our model.

The stochastic process governing the idiosyncratic component $x$ is Poisson with arrival rate $\lambda$. Whenever a jump arrives, the new level of $x$ is drawn from the distribution $G(x)$ with finite upper support $\bar{x}$ and no mass point. The Poisson process implies that shocks are persistent, but conditional on change the new draws are independent by the initial level of $x$.

Each firm has only one job that can be either filled and producing some good (state $J(x)$), according to the idiosyncratic level and the behavioural productivity, or vacant and searching for a worker (state $V$), which costs $pc$ per unit of time. Firms have full information on technology and market condition, therefore they create always the most profitable job, that is, with the idiosyncratic level at the upper support of the price distribution. Furthermore, the Nash bargaining rule implies that new jobs offer the highest wage as well. However, investment are irreversible and when a shock arrives firms have no choice over their productivity. Filled jobs not always resist to negative productivity shocks and, in particular, they are destroyed whenever the new draw of $x$ falls below a certain level of *reservation productivity* $R$. This implies that each job has a probability of being destroyed equal to $\lambda G(R)$. Job destruction is not costless, rather whenever a job is destroyed firm has to pay the firing costs $pF$.

Respectively, each worker can be in one of two states, employed and producing some good (state $W(x)$) or unemployed and searching for a job (state $U$). Employed worker receives the wage $w(x)$ and has to choose how much effort $e$ to exert in the job, which determines the common component of productivity $p = f(e)$. Even if not necessary, we assume a linear relation $p = e$ between effort and productivity[§]. On the contrary, unemployed worker does not exert effort and benefits only from $z$, which can be interpreted either as unemployment compensation or as leisure. Wages are the outcome of the Nash bargaining, according to which workers receive a fraction $0 < \beta < 1$of the match surplus, where $\beta$ can be interpreted as the workers' bargaining power. Since the match surplus is conditional on idiosyncratic productivity, wages are revised whenever a productivity shock occurs. In particular, it is intuitive that both match surplus and wage are increasing function of $x$. Following the previous literature, we assume that workers are risk neutral and impatient, which implies zero saving and full consumption. Furthermore, exerting effort generates an increasing disutility. Therefore, an employed worker enjoys conditional on $x$ the instantaneous utility

$$u(x) = w(x) - \frac{1}{2}\gamma e^2,$$

where $\gamma$ is the parameter governing marginal disutility of effort (see e.g. Garibaldi, 2006), whereas the instantaneous utility of the unemployed worker is simply

$$u = z.$$

The number of matches between vacant jobs and unemployed workers is governed by the matching function $m(v, u)$, where $v$ and $u$ are respectively the number of vacant jobs and unemployed workers. Labour force is normalized to 1, so that in this economy the number of

[§] Notice that this specification is without loss of generality, given that for the utility function below an additional parameter on the relation $p = \varphi e$ would not be identified, but only $\frac{\gamma}{\varphi^2}$ would be identified.

unemployed workers $u$ is the unemployment rate. As standard in the literature, we assume that the matching function is twice continuously differentiable, increasing and concave in both its arguments and homogeneous of degree one, with elasticity strictly between $0 < \xi < 1$. By linear homogeneity, the transition rate from vacant to filled job is $m(v, u)/v = m(1, u/v) = q(\theta)$, with $q'(\theta) < 0$, where $\theta = v/u$ identifies the *labour market tightness*. Moreover, the elasticity of $q(\theta)$ is strictly between $-1 < \eta < 0$ and it is related with the elasticity of the matching function (respect to $v$) by $\eta = \xi - 1$. Similarly, the transition probability from unemployed to employed is $m(v, u)/u = m(v/u, 1) = \theta q(\theta)$, an increasing function of $\theta$**.

The endogenous variables of the model are the level of market tightness $\theta$, the level of reservation productivity $R$, the level of effort $e$ and, in turn, labour productivity $p$ and the level of unemployment $u$. In the next section we derive their steady-state values.

## *3. Steady-state equilibrium*

In steady-state the choices of opening a vacancy and destroying a job for a firm and the level of effort for a worker are based on the asset values of the various conditions. Indeed, these asset values are close to Pissarides (2000), therefore not much time will be spent on their derivation. As said before, the crucial difference in this paper is the introduction of effort in the worker utility function, which formally does not change heavily the asset values, but it does change significantly the subsequent steady-state analysis.

From the assumptions on vacancy cost, idiosyncratic component and firing costs, we have that the asset values of a vacancy and a filled job satisfy the Bellman equations

$$rV = -pc + q(\theta)[J(\bar{x}) - V] \quad (1)$$

$$rJ(x) = px - w(x) + \lambda \int_R^{\bar{x}} J(s)dG(s) - \lambda G(R)pF - \lambda J(x) \quad (2)$$

In (1) a firm has to pay the vacancy cost per unit of time $-pc$ and with probability $q(\theta)$ matches with an unemployed worker, gives up the value of a vacancy $V$ and gets the value of a filled job at the upper support of the price distribution $J(\bar{x})$. In steady-state vacancies are opened until all rents are exhausted. Therefore, the equilibrium zero-profit condition is

** In the Appendix we show that all properties of $q(\theta)$ derive exclusively by the standard assumptions of the matching function.

$$rV = 0 \quad \Longrightarrow \quad J(\bar{x}) = \frac{pc}{q(\theta)} \tag{3}$$

In (2), conditional on the idiosyncratic component, a firm enjoys the value of product *px* and pay the wage *w(x)*, then with probability $\lambda$ a shock arrives and a new level of *x* is drawn from the price distribution *G(x)*. In this case the firm has to give up the value *J(x)* and gets the new value *J(s)* if *s* is over the reservation productivity *R*, or destroys the job and pay *pF* otherwise.

Similarly, from the assumptions on unemployment compensation (or leisure) and instantaneous utility function, the asset values of unemployed and employed worker solve

$$rU = z + \theta q(\theta)[W(\bar{x}) - U] \tag{4}$$

$$rW(x) = w(x) - \frac{1}{2}\gamma e^2 + \lambda \int_R^{\bar{x}} W(s)dG(s) + \lambda G(R)U - \lambda W(x) \tag{5}$$

In (4) an unemployed worker enjoys the unemployment compensation *z* and with probability $\theta q(\theta)$ matches with a vacant job, gives up the value *U* and gets the value of employed at the upper support of the price distribution $W(\bar{x})$. In (5), conditional on the idiosyncratic component, an employed worker enjoys the wage *w(x)* but suffers the effort exerted $-\frac{1}{2}\gamma e^2$, then with probability $\lambda$ a shock arrives and a new level of *x* is drawn from the price distribution *G(x)*. In this case the worker has to give up the value *W(x)* and gets the new value *W(s)* if *s* is over the reservation productivity *R*, or the value of unemployed *U* otherwise. Furthermore, the choice of the effort level is one of rationale expectations, that is, *e* is the effort that maximizes the asset value of being employed.

Wages are split so that workers receive a fraction $\beta$ of the total match surplus and are revised whenever a productivity shock occurs. However, with the presence of firing costs the match surplus of a new job is different from that of an existing job, because only in the second case firms save the firing costs for the continuation of the match. Thus, we have to distinguish between the outside $w_0$ and the inside wage *w(x)*. In the case of a new job the match surplus is

$$S_0(\bar{x}) = J(\bar{x}) - V + W(\bar{x}) - U$$

and the sharing rule implies

$$W(\bar{x}) - U = \beta[J(\bar{x}) - V + W(\bar{x}) - U] \tag{6}$$

Using the relation $p = e$, the zero-profit condition (3), the asset equations for a filled job (2), unemployed (4) and employed worker (5) and the sharing rule (6), gives the outside wage equation (see the Appendix for the derivation)

$$w_0 = (1-\beta)\left(z + \frac{1}{2}\gamma p^2\right) + \beta p(\bar{x} + c\theta - \lambda F) \tag{7}$$

Differently, in the case of an existing job a firm saves the firing costs for the continuation of the match and thus the match surplus is different

$$S(x) = J(x) - V + pF + W(x) - U$$

and the sharing rule implies

$$W(x) - U = \beta[J(x) - V + pF + W(x) - U]$$

Similar calculation gives the inside wage equation

$$w(x) = (1-\beta)\left(z + \frac{1}{2}\gamma p^2\right) + \beta p(x + c\theta + rF) \tag{8}$$

Equations (7) and (8) differ only for the impact of firing costs *F* and this difference indeed emphasizes the conflict between insiders and outsiders. On one hand, inside a match the prospect of paying *F* leads firms to concede marginally a higher wage to avoid the destruction of job. On the other hand, outside the match the expectation of paying *F* sooner or later once a job is created leads firms to start the match with a lower wage to partially recoup the future payment. As (7) shows, the impact of *F* on the outside wage is higher when λ is higher, because the probability of job destruction per unit of time is greater.

The choice of destroying a job is taken inside a match, therefore we have to use the inside wage equation to derive the job destruction condition. Substituting (8) in (2), we get a more explicit expression of the asset value of a filled job as a function of the idiosyncratic component

$$(r+\lambda)J(x) = (1-\beta)\left(px - z - \frac{1}{2}\gamma p^2\right) - \beta p(c\theta + rF) + \lambda \int_R^{\bar{x}} J(s)dG(s) - \lambda G(R)pF \tag{9}$$

From (9) we can see that the asset value *J(x)* is a monotonically increasing function of *x*, which means that there exists a unique value *x** such that *J(x*) = 0* and for any *x* greater (smaller) than *x**, then *J(x) > 0* (*J(x) < 0*). In the model without firing costs, this implies that the reservation productivity *R* under which a firm destroys the job satisfies the reservation property *J(R) = 0*. In the model with firing costs, for a firm is optimal to continue even a negative match, as soon as the negative surplus is smaller than the cost of destroying a job *pF*. That is, with firing costs the reservation property is *J(R) = – pF* (or *W(R) = U*), which allows us to characterize the reservation productivity *R*. Subtracting the generic asset equation (9) from the equation evaluated at *x = R* and using *J(R) = – pF*, we get

$$(r+\lambda)J(R) = (1-\beta)\left(pR - z - \frac{1}{2}\gamma p^2\right) - \beta p(c\theta + rF) + \lambda \int_R^{\bar{x}} J(s)dG(s) - \lambda G(R)pF \tag{10}$$

$$(r+\lambda)[J(x) - J(R)] = (1-\beta)p(x-R)$$

$$J(x) = \frac{(1-\beta)p(x-R)}{(r+\lambda)} - pF \tag{11}$$

Now, substituting (11) in the integral expression of (10) and dividing by (1 – β)p, we get an implicit expression for *R* as a function of market tightness *θ*, labour productivity *p* and the parameters of the model

$$R - \frac{z}{p} - \frac{1}{2}\gamma p - \frac{\beta}{1-\beta}c\theta + \frac{\lambda}{r+\lambda}\int_R^{\bar{x}}(x-R)dG(s) + rF = 0 \tag{12}$$

Equation (12) is the first steady-state condition of the model and in what follow we will refer to this as the job destruction rule (JD), when we emphasize the relation between *R* and *θ*, or as the reservation equation (RE), when we emphasize the relation between *R* and *p*. The value of *pR* is the lowest acceptable price to continue a job. From (12), we can see that *pR* is less than the reservation wage $\left(rU = z + \frac{\beta}{1-\beta}pc\theta\right)$, which is the lowest acceptable wage for a worker. One reason standard in this literature is the presence of some labour hoarding, represented by the integral expression. Given the probability that *x* might change in the future, for a firm is optimal to continue some currently negative match and wait for a higher price, in order to avoid the hiring cost. As intuitive, labour hoarding is increasing in the probability of a change *λ*. The second one is the presence of firing costs, which are paid by firms but not enjoyed by workers.

The choice of creating a job is taken outside the match, therefore we have to use the outside wage equation and evaluate the value of a filled job at the upper support of the price distribution. Substituting (7) in (2), subtracting (10) and using *J(R) = – pF*, we get

$$(r+\lambda)[J(\bar{x}) - J(R)] = (1-\beta)p(\bar{x}-R) + \beta pF(r+\lambda)$$

$$J(\bar{x}) = \frac{(1-\beta)p(\bar{x}-R)}{(r+\lambda)} - (1-\beta)\,pF \tag{13}$$

Now, inserting the zero-profit condition (3) in (13), we get an implicit expression for *θ* as a function of the reservation productivity *R* and the parameters of the model

$$\frac{c}{q(\theta)} = (1-\beta)\left(\frac{\bar{x}-R}{r+\lambda} - F\right) \tag{14}$$

Equation (14) is the second equilibrium condition and we will refer to this as the job creation condition (JC). The left hand side of (14) is the cost of a vacancy for the expected duration of a vacancy. The right hand side is the discounted additional surplus a firm gets from a new job. Therefore, this condition says that in equilibrium the expected hiring cost has to be equal to the expected gain from a new job.

Equations (12) and (14) jointly determine $R$ and $\theta$, as illustrated in Figure 1. Let define (12) as $B(R,\theta,p,\omega) = 0$ and (14) as $D(\theta,R,\omega) = 0$, where $\omega$ is the set of parameters. Then we have

$$\frac{\partial R}{\partial \theta} = -\frac{\partial B/\partial\theta}{\partial B/\partial R} = \frac{c\beta/(1-\beta)}{\left[\frac{r+\lambda G(R)}{r+\lambda}\right]} > 0 \tag{15}$$

$$\frac{\partial \theta}{\partial R} = -\frac{\partial D/\partial R}{\partial D/\partial \theta} = \frac{(1-\beta)/(r+\lambda)}{\frac{c}{q(\theta)^2}q'(\theta)} < 0 \tag{16}$$

As (15) shows, the curve JD slopes up because a higher $\theta$ increases the probability of finding a job and, thus, the opportunity cost for a worker $\left(\frac{\beta}{1-\beta}c\theta\right)$, who now pretends a higher wage to accept a job and so more jobs are marginally destroyed. As (16) shows, the curve JC slopes down because a higher $R$ increases the probability that a job is destroyed $\lambda G(R)$ and, in turn, reduces the expected gain from a new job $\left((1-\beta)\frac{\bar{x}-R}{r+\lambda}\right)$, so less vacancies are opened.

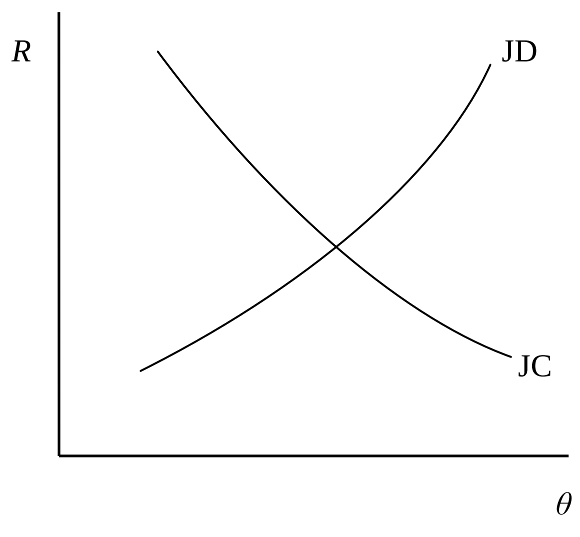


**Figure 1**

Steady-state reservation productivity and market tightness

So far, the joint determination of $R$ and $\theta$ has been done as in the previous literature for a given level of labour productivity $p$ and, indeed, besides the different specification of the worker utility function, no significant novelty are introduced. However, in our model labour productivity is not a parameter but an ulterior unknown. Following our interpretation of $p$ as the behavioural component of productivity, we assumed that its level is determined by the level of effort $e$ exerted by the employed worker and, in particular, that $p = e$.

The choice of effort is rationally taken by worker when he matches with a vacant job, therefore in equilibrium $e$ maximizes the value of being employed at the upper support of the price distribution $W(\bar{x})$. Since our equilibrium is one of rational expectations, when a worker takes this choice he actually knows the job destruction rule $R$ and takes into account the impact on it. Moreover, given the choice of effort is taken individually, the single worker considers the impact on market tightness $\theta$ marginally negligible. From this, it can be easily seen that the same effort level maximizes the asset value of unemployment, being $U$ a monotonically increasing function of $W(\bar{x})$

$$\left(r + \theta q(\theta)\right)U = z + \theta q(\theta) W(\bar{x})$$

The maximization of $W(\bar{x})$ in the form of Bellman equation (5) is not a trivial calculus. However, using $p = e$ and the reservation property $W(R) = U$, equations (4) and (5) can be solved for the permanent income form as a function of $R$, $\theta$, $p$ and the parameters of the model (see the Appendix for the derivation)

$$rW(\bar{x}) = (1 - \beta)z + \beta p\left(\bar{x} + c\theta - \frac{1}{2}\gamma p\right) + \frac{\lambda\beta p}{r+\lambda}\left[G\big(R(p)\big)R(p) + \int_{R(p)}^{\bar{x}} s\, dG(s) - \bar{x}\right] \qquad (17)$$

As intuitive, since there is a non-zero probability of a productivity shock and, all the more so, of being fired, the permanent income of an employed worker at the upper support of the price distribution is less than the instantaneous utility. This form (17) allows us to take the F.O.C. and characterize the equilibrium condition for labour productivity $p$

$$\frac{\partial rW(\bar{x})}{\partial p} = 0$$

$$\bar{x} + c\theta - \gamma p + \frac{\lambda}{r+\lambda}\left[\left(G(R)R - \bar{x}\right) + pG(R)\frac{\partial R}{\partial p} + \int_{R}^{\bar{x}} s\, dG(s)\right] = 0 \qquad (18)$$

Equation (18) represents the equilibrium condition for labour productivity $p$ (or effort $e$)[††] and from now on will be called the productivity equation (PE). From (18), we can notice that the optimal level of $p$ depends on $R$ and $\theta$, but from (12) and (14) only RE depends on $p$. Therefore, for any level of market tightness $\theta$, PE and RE jointly determine $R$ and $p$, as illustrated in Figure 2. The shape of these curves is a bit more complicated then JC and JD, but still intuitive. Let define equation (18) as $M(p, R, \theta, \omega) = 0$. Then we have

$$\frac{\partial R}{\partial p} = -\frac{\partial B/\partial p}{\partial B/\partial R} = -\frac{\frac{z}{p^2} - \frac{\gamma}{2}}{\left[\frac{r + \lambda G(R)}{r+\lambda}\right]} = \begin{cases} > 0, & \forall p > \sqrt{\frac{2z}{\gamma}} \\ = 0, & p = \sqrt{\frac{2z}{\gamma}} \\ < 0, & \forall p < \sqrt{\frac{2z}{\gamma}} \end{cases} \tag{19}$$

$$\frac{\partial p}{\partial R} = -\frac{\partial M/\partial R}{\partial M/\partial p} = -\frac{\frac{\lambda}{r+\lambda}\left[G(R) + pf(R)\frac{\partial R}{\partial p}\left(1 - \frac{\lambda G(R)}{r + \lambda G(R)}\right)\right]}{-\gamma + \frac{\lambda G(R)}{r + \lambda G(R)}\left(\frac{z}{p^2} + \frac{\gamma}{2}\right)} > 0 \tag{20}$$

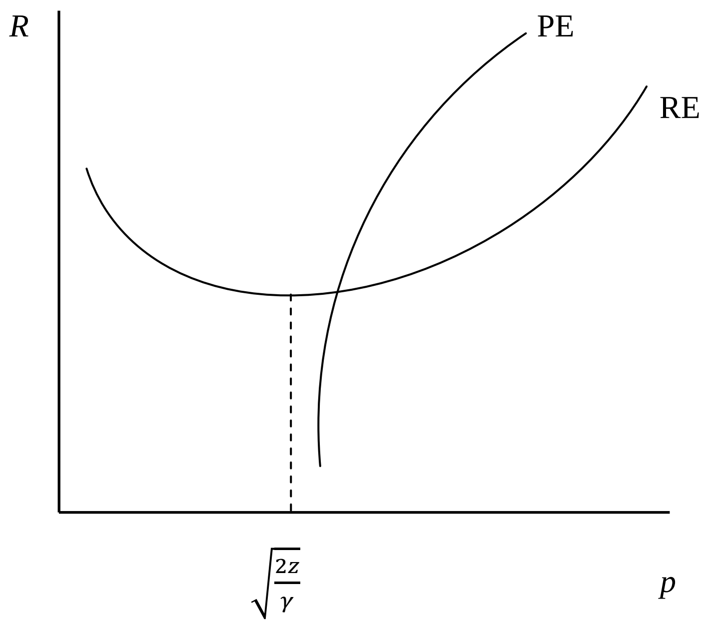


**Figure 2**

Steady-state reservation productivity and labour productivity

[††] At first sight, the S.O.C. for this maximization problem would depend on the value of parameters

$$\frac{\partial^2 rW(\bar{x})}{\partial p^2} = -\gamma + \frac{\lambda G(R)}{r + \lambda G(R)}\left(\frac{z}{p^2} + \frac{\gamma}{2}\right)$$

However, for a very large set of values, indeed all the plausible ones, numerical computations unequivocally show that the condition $\frac{\partial^2 rW(\bar{x})}{\partial p^2} < 0$ is respected.

From (19), labour productivity $p$ has two opposite effects on optimal reservation productivity $R$, the *disutility-wage effect* and the *production effect*. On one hand, a higher $p$ increases the disutility of worker and consequently the wage $\left(-\frac{1}{2}\gamma p\right)$, thus more jobs are marginally destroyed. On the other hand, a higher $p$ increases the value of production $(pR)$ and partially compensates a lower $x$, leading to a fall in $R$. Nonetheless, because of the increasing marginal disutility of effort, we can establish that when $p$ is low the effect on wage is small and the effect on production dominates, whereas when $p$ is high the disutility increases more than proportionally and the effect on wage dominates. Therefore, RE has a standard u-shape, with a minimum in the point in which *disutility-wage effect* and *production effect* exactly compensate.

Similarly, reservation productivity $R$ affects labour productivity $p$ for the *continuation value effect*. In fact, a marginal increase in $R$ does not change the instantaneous utility of worker, but obviously it does change his continuation value. In particular, a higher $R$ not only increases the probability of being fired $\left(\lambda G(R)\right)$, shortening the expected period of employment, but also decreases the probability of finding a job $\left(\theta q(\theta)\right)$, increasing the expected period of unemployment. Both these impacts affect negatively the continuation value and, therefore, the worker chooses $p$ so as to address optimally its level, knowing that $R$ is chosen optimally by firms through (12). This continuation value effect is included in the numerator of (20) and it is greater for $R$ and $p$ high, which implies that PE has a shape as in Fig. 2.

The last equation of the model is the steady-state condition for unemployment, usually called the Beveridge curve. There are different ways to derive this condition, here we state it in terms of flows in and flows out unemployment. In equilibrium the number of workers who enter unemployment $(1-u)\lambda G(R)$ equals the number of workers who leave unemployment $u\theta q(\theta)$, so the steady-state condition is

$$u = \frac{\lambda G(R)}{\lambda G(R) + \theta q(\theta)} \tag{21}$$

Equation (21) is the final condition of the model and implies that in equilibrium for any $R$ and $\theta$ there is a unique unemployment rate $u$ and, in turn, a unique number of vacant jobs $v$.

The Beveridge curve is often drawn in vacancy-unemployment space by a downward sloping and convex curve. Indeed, as highlighted by Mortensen and Pissarides (1994), in the matching model with endogenous job destruction the precise shape of the Beveridge curve is ambiguous. In particular, differentiation of (21) shows that there are two opposite effects

$$\frac{\partial v}{\partial u} = -\frac{\partial T/\partial u}{\partial T/\partial v} = -\frac{-\lambda G(R) + (1-u)\lambda f(R)\left(\frac{\partial R}{\partial \theta}\frac{\partial \theta}{\partial u}\right) + \theta q(\theta)\eta}{(1-u)\lambda f(R)\left(\frac{\partial R}{\partial \theta}\frac{\partial \theta}{\partial v}\right) - q(\theta)(1+\eta)} = -\frac{<0}{\gtreqless 0} \tag{22}$$

On one hand, more vacancies increase the number of job matches, implying a lower unemployment rate, captured by the second term of the denominator of (22). On the other hand, more vacancies increase the number of jobs destroyed, implying a higher unemployment rate, the first term of the denominator. Since the empirical evidence seems to identify this form, it is common to assume that the matching effect is stronger than the destruction one and to draw the Beveridge curve as a downward sloping and convex curve. Moreover, numerical simulations of the model with the equilibrium values fairly always confirm the conventional shape. As usual, in Figure 3 we draw the Beveridge curve with a straight line through the origin, representing all the possible values for *v* and *u* compatible with the equilibrium market tightness *θ*.

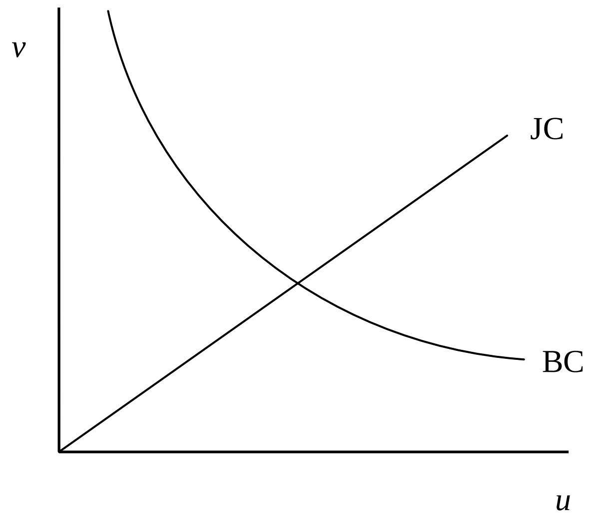


**Figure 3**

Steady-state unemployment and vacancies

In conclusion, we are ready to define the rational expectations equilibrium of the model:

*Steady-state equilibrium – The rational expectation equilibrium is a quadruple (R*, θ*, p*, u*) that satisfies the job destruction condition (12), the job creation condition (14), the productivity equation (18) and the Beveridge curve (21) implied by the rational expectations behavior of individual firms and workers and by the matching technology.*

For any value of labour productivity $p$, equations (12) and (14) determine reservation productivity $R$ and market tightness $\theta$. Then, from all these equilibrium triple, equation (18) identifies the unique value of equilibrium productivity $p$, compatible with job creation and job destruction conditions. Finally, with knowledge of $R$ and $\theta$, from (21) there is a unique value of equilibrium unemployment $u$ and, in turn, a unique value of $v$.

To avoid to weigh down the content of the paper, here we do not address rigorously the analysis of the dynamics of the model out-of-steady-state, however some remarks are proper. The usual assumptions in this kind of analysis are that firms are able to open up or close vacancies instantaneously and that wage can be renegotiated at any time; that is, vacancies and wage are jump variables. These assumptions ensure that the zero-profit condition from a new vacancy (3) and the sharing rule (8) hold out of equilibrium as well. Similarly, the natural assumptions to make for the other two unknowns of the model are that firms can shut down unprofitable jobs instantaneously and that workers exert the optimal level of effort at any time; that is, reservation productivity and labour productivity are jump variables as well. These assumptions imply that the reservation property (12) and the optimal productivity (18) hold both in and out of steady state. Differently, the dynamic behaviour of unemployment, governed by the job flows in and out, is anyhow constrained by the matching technology, which does not allow jumps in job creation. Therefore, unemployment is the unique sticky variable of the model, because of the friction in the job creation process due to the matching technology.

Finally, from (12), (14) and (18) it can be easily seen that neither the job destruction condition, nor the job creation condition, nor the productivity equation, depends on sticky variables and so all these endogenous ($R$, $\theta$, $p$) indeed do not exhibit transitional dynamics but must be on their steady state values even during the adjustments, being all the dynamics discharged on vacancies and unemployment. Notice that market tightness is still a jump variable even if unemployment is sticky, but this only because firms can adjust instantaneously the optimal vacancies during the transitional dynamics of unemployment. Therefore, with these premises it is natural to imagine the out-of-steady-state dynamics as a saddle path, with one stable root for unemployment and three unstable ones for the other endogenous[‡‡].

[‡‡] A much more rigorous analysis of the transitional dynamics in this kind of models has been pursued in Pissarides (1985 or 1990) and can be found also in Pissarides (1990). Nonetheless, here we follow the same line and arguments of Pissarides (2000).

## *4. Qualitative analysis*

In this section we address the main question of the impact of EPL on steady-state and, in particular, on endogenous labour productivity. However, to highlight the relevance of the extension pursued in the paper, we start pre-emptively the analysis of the impact of $F$ considering $p$ a parameter and only subsequently we allow $p$ to change.

Indeed, the impact of firing costs on job creation and job destruction, considering $p$ a parameter, retraces basically the analysis of Pissarides (2000). From (12) and (14) we have that

$$\frac{\partial R}{\partial F} = -\frac{\partial B/\partial F}{\partial B/\partial R} = -\frac{r}{\left[\frac{r+\lambda G(R)}{r+\lambda}\right]} < 0 \tag{23}$$

$$\frac{\partial \theta}{\partial F} = -\frac{\partial D/\partial F}{\partial D/\partial \theta} = -\frac{(1-\beta)}{\frac{c}{q(\theta)^2}\,q'(\theta)} < 0 \tag{24}$$

As (23) and (24) show, firing costs reduce both $R$ and $\theta$. The impact on $R$ is due to the fact that destroying a job is more costly, whereas the impact on $\theta$ is because, once a job is created, firm will pay sooner or later the firing costs and this reduces the expected profit from a new job. To get the equilibrium impact we need to consider the overall impact of $F$, so we differentiate (12) and (14) respectively as $B(R^*, \theta(R^*, F), p, F, \omega) = 0$ and $D(\theta^*, R(\theta^*, F), F, \omega) = 0$ and we get

$$\frac{\partial R^*}{\partial F} = -\frac{\partial B/\partial F}{\partial B/\partial R^*} = -\frac{\frac{\beta q(\theta)^2}{|q'(\theta)|} + r}{\left[\frac{r+\lambda G(R^*)}{r+\lambda}\right] - \left[\frac{\beta q(\theta)^2}{(r+\lambda)\,q'(\theta)}\right]} < 0 \tag{25}$$

$$\frac{\partial \theta^*}{\partial F} = -\frac{\partial D/\partial F}{\partial D/\partial \theta^*} = -\frac{(1-\beta)\left(\frac{r}{r+\lambda G(R)} - 1\right)}{\frac{c}{q(\theta^*)^2}\,q'(\theta^*) - \frac{c\beta}{r+\lambda G(R)}} < 0 \tag{26}$$

Therefore, in equilibrium firing costs reduce both job destruction and job creation. In particular, the equilibrium impact on job destruction (25) is even stronger than the initial impact (23) because higher firing costs reduce market tightness and in turn wage, so less jobs are destroyed marginally (see (15) and (24)). On the other hand, the equilibrium impact on job creation (26) is weaker than the initial impact (24) because firing costs increases the duration of jobs and this partially attenuates the loss of the expected profit due to $F$ (see (16) and (23)). The equilibrium impact is illustrated in Figure 4, where higher $F$ shifts JD down and JC left. As the diagram shows, job destruction decreases unambiguously whereas the effect on job creation would seem ambiguous, but we know from (26) that job creation decreases as well.

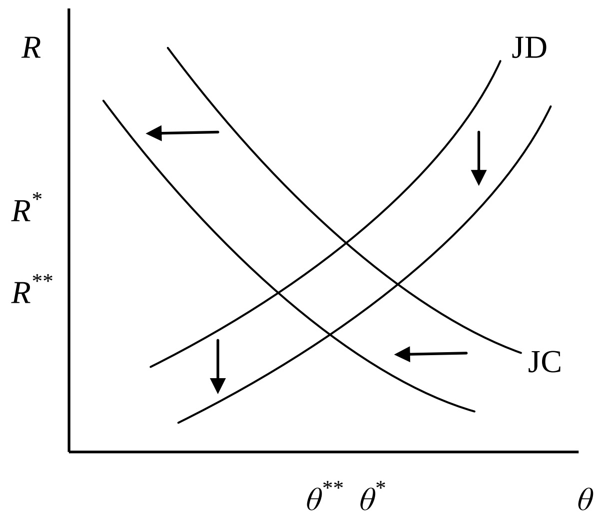


**Figure 4**

Impact of firing costs on reservation productivity and market tightness (with *p* fixed)

Because of the symmetric impact on job creation and job destruction, the impact of firing costs on unemployment in this models is usually ambiguous, as differentiation of (21) clearly shows

$$\frac{\partial u}{\partial F} = \frac{\lambda f(R)\theta q(\theta)\frac{\partial R}{\partial F} - \lambda G(R)q(\theta)\xi\frac{\partial \theta}{\partial F}}{[\lambda G(R) + \theta q(\theta)]^2} = \gtreqless 0$$

The equilibrium impact is illustrated in Figure 5. Higher firing costs shift the Beveridge curve in and rotate the job creation line clockwise, therefore the impact on unemployment is ambiguous, but vacancy decreases unambiguously.

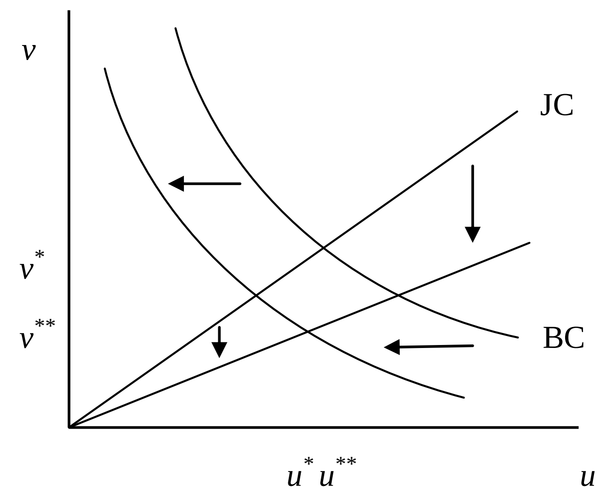


**Figure 5**

Impact of firing costs on unemployment and vacancies

So far we considered $p$ a parameter unaffected by firing costs and basically we get the same results of the previous literature without significant novelty. Nonetheless, in our model labour productivity is an endogenous object, so now we allow $p$ to respond to a change in $F$. Intuitively, we expect that firing costs affect in some way labour productivity for different reasons. Firstly, as (7) and (8) show firing costs affect directly the actual and future wage. Moreover, they affect indirectly wage through the probability of finding a job $\left(\theta q(\theta)\right)$. Finally, they influence the probability of being fired $\left(\lambda G(R)\right)$ affecting the continuation value of (17).

From (18) we have that the initial impact of firing costs on optimal productivity is null, that is

$$\frac{\partial p}{\partial F} = -\frac{\partial M/\partial F}{\partial M/\partial p} = -\frac{0}{-\gamma + \frac{\lambda G(R)}{r+\lambda G(R)}\left(\frac{z}{p^2}+\frac{\gamma}{2}\right)} = 0$$

The economic intuition of this result is that firing costs have a negative effect on the outside wage and a positive one on the inside wage, so in expectations these two impacts on the permanent income of a new worker compensate, as showed by (17). This interpretation is made evident by the difference between (17) and the permanent income of a worker inside a match

$$rW(x) = (1-\beta)z + \beta p\left(x + c\theta + rF - \frac{1}{2}\gamma p\right) + \frac{\lambda\beta p}{r+\lambda}\left[G\left(R(p)\right)R(p) + \int_{R(p)}^{\bar{x}} s\, dG(s) - x\right]$$

where firing costs certainly have a positive effect on wage and, in turn, on labour productivity. Thus, all the effect of $F$ on $p$ is induced by the impact on the other endogenous. And in fact, as long as $R$ and $\theta$ do not vary there is no change on the continuation value and the permanent income of a new worker, so there is no impact on labour productivity. To get the equilibrium impact we differentiate (18) as $M(p^*, R(\theta, p^*, F), \theta(R, F), \omega) = 0$ and we get the following:

$$\frac{\partial p^*}{\partial F} = -\frac{\partial M/\partial F}{\partial M/\partial p^*} = -\frac{\frac{\partial M}{\partial R}\frac{\partial R}{\partial F}+\frac{\partial M}{\partial \theta}\frac{\partial \theta}{\partial F}}{\frac{\partial M}{\partial p^*}+\frac{\partial M}{\partial R}\frac{\partial R}{\partial p^*}} = -\frac{<0}{<0} \qquad (27)$$

*Proposition 1 – A higher level of EPL reduces the equilibrium labour productivity through the impact on reservation productivity and market tightness*[§§].

[§§] At first sight, there might be an ambiguity on the denominator of (27). However, both graphical analysis and numerical computations with a large set of values, indeed the most plausible ones, unequivocally show that the (27) is negative.

The economic intuition of this result is the following. As (12) shows, labour productivity has a negative impact on reservation productivity through the *production effect*, therefore in the choice of the optimal *p* the *production effect* induces worker to choose marginally a higher *p* to shut down *R*. When we analyze the impact of firing costs on reservation productivity we can easily realise that the effect is of the same magnitude of the *production effect*. To see this point let multiply (12) for *p* and concentrate on the *production effect* and the *firing costs effect*, ignoring for a while the other elements

$$pR + rpF = 0 \tag{28}$$

As (28) shows, the *production effect* is partially substituted by the *firing costs effect* in lowering *R* and so a higher *F*, amplifying the relevance of the *disutility effect*, induces worker to choose marginally a lower *p*. Moreover, a higher *F* reduces $\theta$ and consequently both outside and inside wage, inducing worker to choose a lower *p* (see (24)). The equilibrium impact is illustrated in Figure 6, when a higher *F* shifts RE down and PE left.

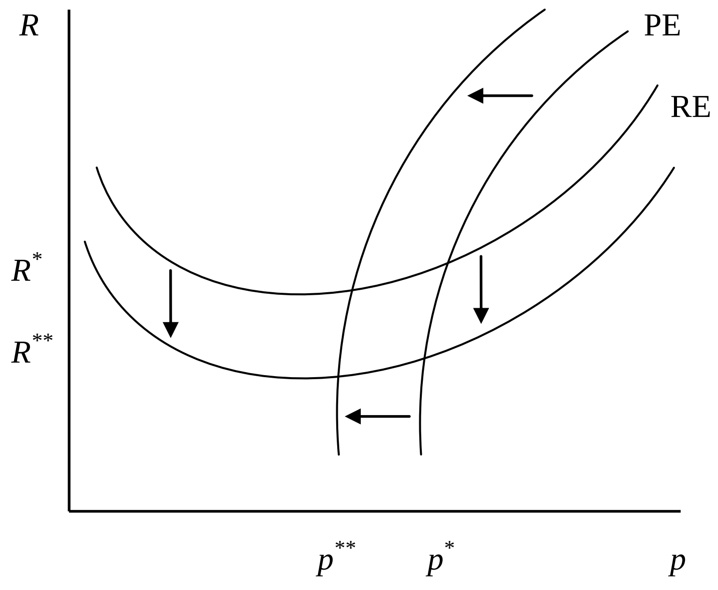


**Figure 6**

Impact of firing costs on reservation productivity and labour productivity

Considering *p* an endogenous object leads us to reassess the equilibrium impact of *F* on job creation and job destruction. In particular, now we differentiate (12) and (14) respectively as $B(R^*, \theta(R^*, F), p(R^*, \theta), F, \omega) = 0$ and $D(\theta^*, R(\theta^*, F, p(R, \theta^*)), F, \omega) = 0$ and we get

$$\frac{\partial R^*}{\partial F} = -\frac{\partial B/\partial F}{\partial B/\partial R^*} = -\frac{\frac{\partial B}{\partial \theta}\frac{\partial \theta}{\partial F}+\frac{\partial B}{\partial F}}{\frac{\partial B}{\partial R^*}+\frac{\partial B}{\partial \theta}\frac{\partial \theta}{\partial R^*}+\frac{\partial B}{\partial p}\frac{\partial p}{\partial R^*}} < 0 \tag{29}$$

$$\frac{\partial \theta^*}{\partial F} = -\frac{\partial D/\partial F}{\partial D/\partial \theta^*} = -\frac{\frac{\partial D}{\partial R}\frac{\partial R}{\partial F}+\frac{\partial D}{\partial F}}{\frac{\partial D}{\partial \theta^*}+\frac{\partial D}{\partial R}\frac{\partial R}{\partial \theta^*}+\frac{\partial D}{\partial R}\frac{\partial R}{\partial p}\frac{\partial p}{\partial \theta^*}} < 0 \tag{30}$$

where we can easily establish the following $|(29)| > |(25)|$ and $|(30)| < |(26)|$, that is:

*Proposition 2 – Compared to the standard equilibrium with p as a parameter of the model, in the equilibrium with endogenous labour productivity EPL reduces even more job destruction, but reduces less job creation.*

The economic intuition of this result is that, as we have seen before (28), the presence of a more stringent protection legislation reduces the role of the *production effect* and amplifies that of the *disutility-wage effect*, leading to a lower labour productivity which decreases both outside and inside wage and, in turn, the optimal reservation productivity. Consequently, lower job destruction increases the expected duration of job and partially attenuates the loss of the expected profit due to a more severe legislation, leading to a smaller reduction of job creation. The equilibrium impact on $R$ and $\theta$ with endogenous labour productivity and the difference with $p$ exogenous is illustrated in Figure 7.

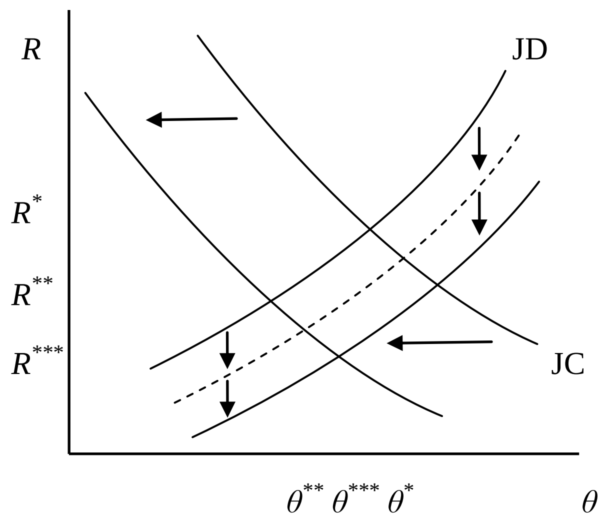


**Figure 7**

Impact of firing costs on reservation productivity and market tightness (with *p* endogenous)

In conclusion, considering $p$ an endogenous variable changes only quantitatively the equilibrium impact of $F$ on job creation and job destruction, but not the direction. However, firstly the extension of the model with endogenous labour productivity should be important per sé, especially in the light of the recent empirical evidence on the impact of EPL on labour productivity. Moreover, as will be clear in the next section, considering $p$ an endogenous is very much relevant for the quantitative exercise and, in particular, for the welfare analysis and policy implications not only concerning EPL, but also for all kinds of policy evaluation.

### *4. Quantitative analysis*

In this section we attempt a rough calibration of the model to evaluate quantitatively the impact of firing costs on labour market performance, but also on some measure of aggregate welfare. As usual in this literature, we adopt the following Cobb-Douglas matching function with constant returns to scale, generally the specification most suited to match the data on job creation (see e.g. Layard, Nickell and Jackman, 1991, for the UK; Blanchard and Diamond, 1989, for the US)

$$m(u, v) = Au^{\alpha}v^{1-\alpha}$$

The distribution of the idiosyncratic component of productivity is taken uniform over the support [0, 1][***], i.e. $G(x) = (x - \underline{x})/(\overline{x} - \underline{x}) = x$. Following the literature, the baseline parameters reported in Table 1 are set so as to match some typical features of the empirical data (see e.g. Davis and Haltiwanger, 1992). The parameters of the matching function are set as usual at $A$ = 0.15 and $\alpha$ = 0.5, close to empirical estimates. The workers' bargaining power is set at $\beta$ = 0.5 equal to the elasticity of the matching function, so as to get constrained efficiency at least in the economy without firing costs. To generate in the simulation reasonable job flows, the arrival rate of the idiosyncratic shock is set $\lambda$ = 0.081 (see Mortensen and Pissarides, 1994).

[***] Usually in the literature (with labour productivity exogenous) the idiosyncratic component is an additive component of total price and the distribution is taken uniform over $[\underline{x}, \overline{x}]$, whit $\underline{x}$ a negative number. However, the level of labour productivity is fixed so that the total price is quite everywhere positive (see e.g. Mortensen and Pissarides, 1994, 1999a,b). In our model we make a preference for the interpretation of the idiosyncratic component as a multiplicative component of total price (see Lilien, 1982; Blanchard and Diamond, 1989; Pissarides, 2000), therefore we adopt a positive support for the distribution, so that the total price is always positive. Nonetheless, both the interpretations maintain the same mechanism underpinning the reservation productivity.

Table 1
Baseline parameters

| A | α | β | Λ | r | Z | c | γ | $[\underline{x}, \overline{x}]$ |
|---|---|---|---|---|---|---|---|---|
| 0.15 | 0.5 | 0.5 | 0.081 | 0.03 | 0.35 | 0.05 | 0.5 | [0, 1] |

Similarly, the preference parameter governing the disutility of effort is set at γ = 0.5, which induces an increasing disutility of effort but generates very reasonable values of utility and labour productivity. Finally, in our simulation we consider a semester as the unit of time and, accordingly, we set the interest rate at r = 0.03 (see e.g. Cahuc and Postel-Vinay, 2002).

In order to assess the impact of firing costs on labour market performance, we compute[†††] different equilibrium of the model with *F* varying from 0 to 4. This should cover a significant range, from the *laissez–faire* case to the *substantial firing restrictions* case, where firing costs are more than three times the semester wage (see e.g. for Italy Garibaldi, 2006). In Table 2 we report the equilibrium values of unemployment rate, job flows, labour productivity, reservation productivity, market tightness and unemployment spell duration for different levels of firing restrictions.

Table 2
Impact of *F* on labour market equilibrium

| | *U* | *JF* | *P* | *R* | θ | *ud* |
|---|---|---|---|---|---|---|
| *F* = 0 | 0.212 | 5.5 | 2.29 | 0.87 | 3.03 | 3.83 |
| *F* = 1 | 0.205 | 4.9 | 2.09 | 0.77 | 2.57 | 4.15 |
| *F* = 2 | 0.197 | 4.3 | 1.92 | 0.67 | 2.15 | 4.55 |
| *F* = 3 | 0.188 | 3.7 | 1.76 | 0.56 | 1.75 | 5.03 |
| *F* = 4 | 0.176 | 3.1 | 1.62 | 0.47 | 1.39 | 5.65 |

First, we can see that more stringent firing restrictions reduce significantly the equilibrium labour productivity. In particular, a level of firing costs equal to two times the wage (*F* = 2) is enough to reduce labour productivity more than 10% respect to the *laissez–faire* case, whereas in the *substantial firing restrictions* case the reduction is even of the 30%. Similarly, firing costs reduce both reservation productivity and market tightness and, in turn, job flows. As we can see, job flows in the *substantial firing restrictions* case are less than 60% of those in the

[†††] Fix point algorithm written in Matlab available under request by the author.

*laissez–faire* case. Nonetheless, as standard in these models (e.g. Mortensen and Pissarides, 1999a), the overall impact on unemployment is positive, because the impact on job destruction overcomes that on job creation. It is worth noting as the difference in the level of job flows between the economies with low firing costs (5.5 – 4.9) and those with high firing costs (3.7 – 3.1), seems to match very reasonably the real data in the U.S., the quintessential frictionless country, and the European countries, where notoriously firing restrictions are consistent. Finally, mirror to the decrease on job creation, higher firing costs increase significantly the unemployment spell duration. In particular, in the *substantial firing restrictions* case the unemployment duration increases more than 50% respect to the *laissez–faire* case.

In Table 3 we show the equilibrium values of reservation productivity and market tightness in the model with $p$ exogenous, along with the values for the complete specification. In the model with exogenous labour productivity, we set $p$ at the equilibrium level get in the *laissez–faire* case ($p$ = 2.29) and we do not allow $p$ to respond to change in our policy tool $F$. In this way we make clear what happen to job creation and job destruction when we allow labour productivity to adjust optimally to change in firing costs. As we can see, this numerical exercise confirms exactly the result of the qualitative analysis (see (29), (30) and Figure 7). In particular, when we allow $p$ to respond optimally to change in $F$, this leads to an even stronger reduction of the equilibrium reservation productivity, but to a smaller reduction of the equilibrium market tightness.

Table 3

Job creation and Job destruction with $p$ fixed ($p$ = 2.29)

| | $R$ ($p$ = 2.29) | θ (p = 2.29) | $R$ | θ |
|---|---|---|---|---|
| $F$ = 0 | 0.87 | 3.03 | 0.87 | 3.03 |
| $F$ = 1 | 0.78 | 2.08 | 0.77 | 2.57 |
| $F$ = 2 | 0.69 | 1.26 | 0.67 | 2.15 |
| $F$ = 3 | 0.61 | 0.59 | 0.56 | 1.75 |
| $F$ = 4 | 0.53 | 0.11 | 0.47 | 1.39 |

Finally, to assess the impact of firing costs on well-being of the economy, we compute the value of different measures of aggregate welfare from the *laissez–faire* to the *substantial firing restrictions* case. In particular, we consider two main measures of aggregate welfare, the first concerning the production net of recruiting costs ($Y$ – $RC$), the second the utility of agents

($AWF$). Our consistent measures of production and aggregate utility in the economy are (see the Appendix for the derivation)

$$Y = u\,\theta q(\theta)\,p\overline{x}\left[1 + (1-\lambda)\left(1-u-u\,\theta q(\theta)\right)\right] + \left(1-u-u\,\theta q(\theta)\right)p\,E(x \mid x \geq R)$$
$$\left[\lambda + (1-\lambda)\left(1-u\,\theta q(\theta)\right)\right] \tag{31}$$

$$AWF = u\,\theta q(\theta)\,rW(\overline{x})\left[1 + (1-\lambda)\left(1-u-u\,\theta q(\theta)\right)\right] + \left(1-u-u\,\theta q(\theta)\right)rW\left(E(x \mid x \geq R)\right)$$
$$\left[\lambda + (1-\lambda)\left(1-u\,\theta q(\theta)\right)\right] + u\,rU \tag{32}$$

where $E(x \mid x \geq R)$ indicates the conditional expectation of $x$ over the truncated distribution [R, $\overline{x}$], that is

$$E(x \mid x \geq R) = \frac{\int_R^{\overline{x}} x\,g(x)\,dx}{G(\overline{x}) - G(R)}$$

In Table 4 we report the equilibrium values of these two measures of aggregate welfare for different levels of firing restrictions. Along with these main measures, we report some other index of well-being in the economy, as the permanent income of unemployed and employed worker in different conditions.

Table 4

Impact of *F* on aggregate welfare

| | *Y* | *Y – RC* | *rW(1)* | *rW(E(x))* | rU | *AWF* |
|---|---|---|---|---|---|---|
| *F* = 0 | 1.70 | 1.62 | 0.73 | 0.71 | 0.69 | 0.71 |
| *F* = 1 | 1.49 | 1.43 | 0.66 | 0.65 | 0.61 | 0.64 |
| *F* = 2 | 1.30 | 1.26 | 0.58 | 0.59 | 0.55 | 0.58 |
| *F* = 3 | 1.14 | 1.11 | 0.52 | 0.55 | 0.50 | 0.54 |
| *F* = 4 | 1.01 | 0.98 | 0.48 | 0.52 | 0.46 | 0.50 |

As standard in the literature, firing restrictions reduce unambiguously all measures of aggregate welfare, regardless we think about well-being in terms of production or utility of agents[‡‡‡]. This is not surprising, since we know that under restriction $\alpha = \beta$ the *laissez–faire* economy gets the constrained efficiency. More interesting is the size of the reduction of production. In particular,

[‡‡‡] For what concern the welfare measures in terms of utility we should remember that we have assumed that workers are risk neutral and impatient, which implies zero saving and full consumption. This is usually done in this literature to avoid to solve the consumption problem, so as we can work with the maximized Bellman equation to derive the steady-state equilibrium of the model. Nonetheless, to some extent such limitation should be taken in mind when we think about the policy implications of our results.

a middle level of firing restrictions is sufficient to yields a production lower than 25% respect to the *laissez–faire* case, whereas in the *substantial firing restrictions* case the production is lower than 40%. Indeed, despite the negative impact of EPL on aggregate welfare is well-known (see e.g. Cahuc and Postel-Vinay, 2002), such worrying reduction in production is not standard:

*Proposition 3 – Compared to the standard equilibrium with p as a parameter of the model, in the equilibrium with endogenous labour productivity EPL reduces even more the aggregate welfare, regardless we consider the well-being of the economy in terms of production or aggregate utility.*

Nonetheless, hidden under this result there is exactly the negative impact of firing restrictions on labour productivity, which not only reduces the total production of the economy, but also the surplus from job matches and, therefore, the utility of agents. Unsurprisingly, the inclusion in the analysis of this element enriches the picture of our model and, certainly, tells us an alarming result we should worry about.

## *5. Conclusion*

The matching model studied in this paper has revealed that, indeed, the level of labour productivity in the economy can be influenced by labour market policies usually implemented by governments. Stimulated by the recent empirical evidence, we have focused on EPL and have shown that a higher level of firing restrictions partially substitute high labour productivity in reducing job destruction and this, consequently, brings down the optimal level of productivity. Furthermore, the response of productivity to EPL reasonably affects the level of production and, in fact, numerical simulation of the model has shown that a higher level of firing costs induces a consistent reduction on production, beyond the standard reduction found in the literature. Moreover, despite the reduction on the disutility of effort, higher EPL reduce unambiguously our measures of aggregate welfare (*AWF*), inducing a worsening on the well-being of both employed and unemployed workers. Therefore, in the light of the predominant role of labour productivity growth in driving the income growth in the last twenty years (OECD, 2003, 2007), the result of this paper bring in a further element in support of the consolidated voice of the literature for a reduction of EPL especially in European countries.

To conclude, the extension of the endogenous labour productivity pursued in this paper allows us to rationalize within the already fruitful matching approach the well-established empirical evidence on the impact on EPL on labour productivity, which indeed assumes the appearance of a macro-stylized fact in the European economies and, thus, should be explained in a macro model of the labour market. On the other hand, the inclusion of the optimal workers' response to political tools should be a positive element for any other policy evaluations. In particular, including both optimal agents' responses and market outcomes, the matching approach might turn out to be an ideal framework to address crucial questions usually analyzed in microeconomic contexts, but that certainly present significant macro implications.

## APPENDIX

### *Properties of the matching function*

*Proof of* $\frac{\partial q(\theta)}{\partial \theta} < 0.$

$$q(\theta) = \frac{m(v,u)}{v} = \frac{m(v,u)/u}{v/u} = \frac{m(\theta,1)}{\theta}$$

$$\frac{\partial q(\theta)}{\partial \theta} = \frac{\partial\left[\frac{m(\theta,1)}{\theta}\right]}{\partial \theta} = \frac{\frac{\partial m(\theta,1)}{\partial \theta}\theta - m(\theta,1)}{\theta^2} = \frac{m(\theta,1)}{\theta^2}\left[\frac{\partial m(\theta,1)}{\partial \theta}\frac{\theta}{m(\theta,1)} - 1\right] = q(\theta)\left(\frac{\xi-1}{\theta}\right)$$

therefore, we have $\frac{\partial q(\theta)}{\partial \theta} < 0$ because $0 < \xi < 1$. ■

*Proof of* $\frac{\partial \theta q(\theta)}{\partial \theta} > 0.$

$$\theta q(\theta) = \frac{m(v,u)}{u} = m(\theta, 1)$$

$$\frac{\partial \theta q(\theta)}{\partial \theta} = \frac{\partial m(\theta,1)}{\partial \theta}$$

therefore, we have $\frac{\partial \theta q(\theta)}{\partial \theta} > 0$ because the matching function is increasing in both arguments. ■

*Proof of* $\eta = \xi - 1$.

$$\frac{\partial q(\theta)}{\partial \theta} = q(\theta)\left(\frac{\xi-1}{\theta}\right) \quad \Longrightarrow \quad \frac{\partial q(\theta)}{\partial \theta}\frac{\theta}{q(\theta)} = \xi - 1 \quad \Longrightarrow \quad \eta = \xi - 1.$$ ■

### *Outside wage equation (7)*

The sharing rule implies that in equilibrium the outside wage solves

$$W(\bar{x}) - U = \beta[J(\bar{x}) - V + W(\bar{x}) - U]$$

which gives us

$$J(\bar{x}) = \frac{(1-\beta)}{\beta}[W(\bar{x}) - U] \tag{33}$$

or

$$\beta rJ(\bar{x}) - (1-\beta)rW(\bar{x}) + (1-\beta)rU = 0 \tag{34}$$

where we have used the equilibrium zero–profit condition (3).

Similarly, the sharing rule states that inside a match in equilibrium has to hold

$$W(x) - U = \beta[J(x) - V + pF + W(x) - U]$$

which gives us

$$J(x) = \frac{(1-\beta)}{\beta}[W(x) - U] - pF \tag{35}$$

From the asset value of a filled job (2) we have that

$$\beta rJ(\bar{x}) = \beta p\bar{x} - \beta w_0 + \beta\lambda \int_R^{\bar{x}} \frac{(1-\beta)}{\beta}[W(s) - U]\, dG(s) - \beta\lambda \int_R^{\bar{x}} pF\, dG(s) - \beta\lambda G(R)pF - \beta\lambda \frac{(1-\beta)}{\beta}[W(\bar{x}) - U] \tag{36}$$

where we have used (33) and (35).

Similarly, from the asset value of employed worker (5) we have that

$$(1-\beta)rW(\bar{x}) = (1-\beta)w_0 - (1-\beta)\frac{1}{2}\gamma p^2 + (1-\beta)\lambda \int_R^{\bar{x}} W(s)\, dG(s) + (1-\beta)\lambda G(R)U - (1-\beta)\lambda W(\bar{x}) \tag{37}$$

where we have used the productivity relation $p = e$.

Using (36) and (37) we have that

$$\beta rJ(\bar{x}) - (1-\beta)rW(\bar{x}) = \beta p\bar{x} - w_0 + (1-\beta)\frac{1}{2}\gamma p^2 - \beta\lambda pF$$

and knowing that in equilibrium (34) has to hold, we have that the outside wage solves

$$\beta p\bar{x} - w_0 + (1-\beta)\frac{1}{2}\gamma p^2 - \beta\lambda pF + (1-\beta)rU = 0 \tag{38}$$

From the asset value of unemployed worker (4) we have that

$$rU = z + \theta q(\theta)[W(\bar{x}) - U] = z + \frac{\beta}{(1-\beta)}\theta q(\theta)J(\bar{x}) = z + \frac{\beta}{(1-\beta)}pc\theta \quad (39)$$

where we have used first (33) and then the zero–profit condition (3).

Finally, we substitute (39) in (38) and get the outside wage equation (7)

$$w_0 = (1-\beta)\left(z + \frac{1}{2}\gamma p^2\right) + \beta p(\bar{x} + c\theta - \lambda F) \quad \blacksquare$$

Starting from the sharing rule inside a match, same calculation gives the inside equation (8).

***Worker permanent income at the upper support of the price distribution (17)***

There are different ways in which the permanent income equation (17) can be derived using the equilibrium conditions, here we show one of these which allow us to establish different interesting relations.

First from the asset value of unemployed worker (4) we have that

$$U = \frac{z}{r+\theta q(\theta)} + \frac{\theta q(\theta)}{r+\theta q(\theta)} W(\bar{x}) \quad (40)$$

From the asset value of employed worker (5) we have that

$$(r+\lambda)W(x) = w(x) - \frac{1}{2}\gamma p^2 + \lambda \int_R^{\bar{x}} W(s)dG(s) + \lambda G(R)U \quad (41)$$

Evaluating (41) at the upper support of the price distribution and at the reservation productivity

$$(r+\lambda)W(\bar{x}) = w_0 - \frac{1}{2}\gamma p^2 + \lambda \int_R^{\bar{x}} W(s)dG(s) + \lambda G(R)U \quad (42)$$

$$(r+\lambda)W(R) = w(R) - \frac{1}{2}\gamma p^2 + \lambda \int_R^{\bar{x}} W(s)dG(s) + \lambda G(R)U \quad (43)$$

Now subtracting (43) from (42) and using the reservation property *W(R) = U* we get

$$(r+\lambda)[W(\bar{x}) - W(R)] = \beta p(1-R) - \beta pF(r+\lambda)$$

$$W(\bar{x}) - U = \beta p\left[\frac{(1-R)}{(r+\lambda)} - F\right] \quad (44)$$

Substituting (40) in (44) we obtain

$$rW(\bar{x}) = z + \left(r + \theta q(\theta)\right) \beta p \left[\frac{(1 - R)}{(r + \lambda)} - F\right] \qquad (45)$$

Similarly, subtract (43) from (41) to get

$$W(x) - U = \beta p \frac{(x - R)}{(r + \lambda)}$$

and now substitute (40) and use (45) to obtain

$$rW(x) = rW(\bar{x}) - r\beta p \left[\frac{(1 - x)}{(r + \lambda)} - F\right] \qquad (46)$$

This expression is extremely interesting because establishes the relation between the permanent income of a new worker at the upper support of the price distribution and that of a generic employed worker. In particular, it says that when firing costs are low the permanent income of a generic worker is always lower than that of a new worker, being the difference due to the different level of the idiosyncratic productivity. However, when firing costs are high the advantage of being already inside a match, which leads to a higher wage (see (7) and (8)), overturns the relation in favour of the generic worker. Indeed, this is exactly what we observe with the numerical simulation of the model in Table 4.

Finally, insert (46) in the integral expression of the asset value of a new worker to get

$$rW(\bar{x}) = w_0 - \frac{1}{2}\gamma p^2 + \lambda \int_R^{\bar{x}} \left\{W(\bar{x}) - \beta p \left[\frac{(1 - s)}{(r + \lambda)} - F\right]\right\} dG(s) + \lambda G(R)U - \lambda W(\bar{x})$$

$$= w_0 - \frac{1}{2}\gamma p^2 - \lambda G(R)[W(\bar{x}) - U] + \frac{\lambda\beta p}{(r + \lambda)}\left[\int_R^{\bar{x}} s\, dG(s) - \left(1 - G(R)\right)\right] + \lambda\beta p F\left(1 - G(R)\right)$$

and now using (44) and substituting the outside wage equation (7) gives us (17)

$$rW(\bar{x}) = (1 - \beta)z + \beta p\left(\bar{x} + c\theta - \frac{1}{2}\gamma p\right) + \frac{\lambda\beta p}{r + \lambda}\left[G\left(R(p)\right)R(p) + \int_{R(p)}^{\bar{x}} s\, dG(s) - \bar{x}\right] \quad \blacksquare$$

Similarly, inserting (46) in the asset value of the generic worker gives his permanent income.

***Total production (31) and aggregate welfare function (32)***

In equilibrium there are *(1 – u)* producing workers, who differ only for the level of the idiosyncratic productivity *x*. Among these *uθq(θ)* workers are in the first period of employment, therefore produce at the upper support of the price distribution $\bar{x}$. Instead, the other *(1 – u – uθq(θ))* workers were employed already the previous period and indeed their level of *x* is not the same for all of them. In particular, a fraction $\lambda$ faced a productivity shock and changed the level of *x* in a new value between $\bar{x}$ and *R*, whereas the complement *(1 – λ)* maintained the same level of the previous period. In turn, among these old workers maintaining the level of *x*, a fraction *uθq(θ)* entered two period ago and therefore produce at the upper support of the price distribution $\bar{x}$, whereas the others (*1 – uθq(θ)*) entered more than two period ago and indeed we should distinguish again between those who faced a productivity shock and those who not and so forth. Therefore, the total production is

$$Y = u\,\theta q(\theta)\,p\bar{x} + \left(1-u- u\,\theta q(\theta)\right)\left\{\lambda\, pE(x \mid x \geq R) + (1-\lambda)\left[u\,\theta q(\theta)\,p\bar{x} + \right.\right.$$
$$1-u\,\theta q\theta\,\lambda\, pEx\ \ x\geq R + 1-\lambda\, u\,\theta q\theta\, px + 1-u\,\theta q\theta\ldots\ldots\ldots$$

As intuitive, the precise computation of the level of idiosyncratic productivity of producing workers in steady state is troubling, due to the recursive computation. Nonetheless, given that our aim is to evaluate the impact of firing restrictions on total production, it would be harmless to make an assumption to simplify the computation which affects in the same way the value of production between the *laissez–faire* and the *substantial firing restriction* case. Obviously, more an employed worker is old higher is the probability that he faced a productivity shock and changed his level of *x*. For simplicity, in (31) we assume that all workers older than two periods faced a productivity shock. Therefore, our measure of total production is

$$Y = u\,\theta q(\theta)\,p\bar{x} + \left(1-u- u\,\theta q(\theta)\right)\left\{\lambda\, pE(x \mid x \geq R) + (1-\lambda)\left[u\,\theta q(\theta)\,p\bar{x} + \right.\right.$$
$$1-u\,\theta q\theta\, pEx\ \ x\geq R$$

which after some easy algebra gives us (31). ■

Moreover, to check if our assumption is really harmless for our purpose, we repeated a similar numerical exercise of Table 4 when we derived the total production assuming that all workers older than three periods faced a productivity shock. In this case the total production is

$$Y = u\,\theta q(\theta)\,p\bar{x} + \left(1-u- u\,\theta q(\theta)\right)\left\{\lambda\, pE(x \mid x \geq R) + (1-\lambda)\left[u\,\theta q(\theta)\,p\bar{x} + \right.\right.$$
$$1-u\,\theta q\theta\,\lambda\, pEx\ \ x\geq R + 1-\lambda\, u\,\theta q\theta\, px + 1-u\,\theta q\theta\, pEx\ \ x\geq R$$

The conclusion was that as intuitive the value of production was slightly higher, but there was no difference on the impact of firing restrictions on total output, which led us to assess our assumption as innocuous for our purpose.

Similarly, the aggregate welfare function is the weighted sum of utility of the different workers in steady state, knowing that the utility of worker depends on the idiosyncratic component of productivity. Following the identical argument of before, in equilibrium there are $u$ unemployed worker, $u\theta q(\theta)$ workers in the first period of employment enjoying the utility at the upper support of the price distribution $\bar{x}$, $(1 - u - u\theta q(\theta))$ old workers. Among these, a fraction $\lambda$ faced a productivity shock and enjoys the utility between $\bar{x}$ and $R$, whereas the complement $(1 - \lambda)$ maintained the same utility of the previous period and, in particular, a fraction $u\theta q(\theta)$ entered two period ago and enjoys the utility at $\bar{x}$, whereas the others ($1 - u\theta q(\theta)$) entered more than two period ago and so forth. As the total production, in (32) we maintain the assumption that all workers older than two periods faced a productivity shock. Therefore, the aggregate welfare function is

$$AWF = u\, rU + u\, \theta q(\theta)\, rW(\bar{x}) + \big(1 - u - u\, \theta q(\theta)\big)\big\{\lambda\, rW\big(E(x \mid x \geq R)\big) +$$
$$1 - \lambda\, u\, \theta q \theta\, rW x + 1 - u\, \theta q \theta\, rW E x \;\; x \geq R$$

which after some easy algebra gives us (32). ■

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