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Temporary Jobs and Labor Turnover

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Abstract

This paper provides a simple model which explains the choice between permanent and temporary jobs. This model, which incorporates important features of actual employment protection legislations neglected by the economic literature so far, reproduces the main stylized facts about entries into permanent and temporary jobs observed in Continental European countries. We find that job protection has very small effects on total employment but induces large substitution of temporary jobs for permanent jobs which significantly reduces aggregate production.

Key words: Temporary jobs, Employment protection legislation.

JEL classification: J63, J64, J68.

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1 Introduction

It is recurrently argued that the dramatic spread of temporary jobs in Continental European countries is the consequence of the combination of stringent legal constraints on the termination of permanent jobs and of weak constraints on the creation of temporary jobs.[1] Strikingly, however, very little is known about the creation of temporary and permanent jobs, inasmuch as very few contributions have analyzed the choice between these two types of job. There are also very few explanations of the duration of temporary jobs.

Our paper contributes to filling this gap. It provides a model which explains the duration of temporary jobs and the choice between temporary and permanent jobs. This model reproduces important stylized facts that previous models were unable to explain. In particular, for countries with stringent job protection, the model fits the large share of temporary contracts in employment inflows, the huge amount of creation of temporary contracts of very short duration, and the large contribution of inflows into temporary jobs to fluctuations in employment inflows overall. The model sheds new light on the consequences of employment protection. It shows that the stringency of legal constraints on the termination of permanent jobs has very little effect on total employment, but does induce a large-scale substitution of temporary jobs for permanent jobs which significantly reduces aggregate production.

One of the main originalities of our approach is to account for important features of employment protection legislations which have been neglected by the literature so far. In most countries, it is costly to dismiss temporary workers before the date of termination of the contract stipulated when the job starts. More precisely, in the 'French type' regulation, that prevails in Belgium, France, Greece, Italy and Germany, temporary contracts cannot be terminated before their expiration date,[2] whereas in the 'Spanish type' regulation, which covers Spain and Portugal, the rule for dismissals before the expiration date of temporary contracts is the same as for permanent contracts.[3] Hence, for a given employment spell, it is generally at least as costly to terminate a temporary contract before its expiration date as it is to terminate a reg-

[1] See Boeri (2011) for a synthesis.

[2] There are obviously exceptions to this general rule, for instance for misbehavior on the part of one of the parties. The legislations are described in appendix A. For a given employment spell, it appears that it is generally at least as costly to terminate a temporary contract before its date of termination as to terminate a regular contract.

[3] Henceforth, we focus on regulation of the French type. We show in Cahuc, Charlot and Malherbet (2012) that the Spanish type yields the same outcome as the French type in the context of our model.

ular contract. In the previous literature, it is generally assumed that it is costly to terminate permanent contracts, whereas temporary contracts can be terminated at no cost at any time. This assumption, made for the sake of technical simplicity, is at odds with many actual regulations. It implies that employers prefer temporary jobs, which can be destroyed at no cost, to permanent jobs, which are costly to destroy, thus making it difficult to explain the choice between permanent and temporary jobs. Our more realistic approach assumes that temporary contracts cannot be terminated before their expiration date.

We consider a job search and matching model where firms hire workers to exploit production opportunities of different expected durations. Some production opportunities are expected to end (i.e. to become unproductive) quickly, others are expected to last longer. This assumption takes into account the heterogeneity of expected durations of production opportunities which is an important feature of modern economies. For instance, firms can get orders for their products for periods of several days, several months or several years, and it is not certain that these orders will be renewed. In the model, jobs can be either permanent or temporary. Permanent employees are protected by dismissal costs. Temporary jobs can be destroyed at zero cost at their expiration date, which is chosen at the instant when workers are hired. But employers have to keep and pay their employees until the date of termination of temporary jobs. These assumptions about employment legislation, which are framed to match the main features of Continental European labor regulations, do not induce Pareto optimal allocations. However, permanent workers protected by firing costs may give moral and political support to such regulations.[4]

When firing costs are sufficiently small, we find that all production opportunities are exploited with permanent jobs. When firing costs are relatively large, permanent jobs are chosen to exploit production opportunities expected to endure for a long time, while temporary jobs are used for production opportunities with short expected durations. In this framework, higher firing costs increase the share of entries into temporary jobs.

We show that our model matches the main stylized facts concerning entries into permanent and temporary jobs in Continental European countries. Moreover, simulation exercises show that the durations of temporary jobs are much shorter than the durations of production opportunities. Therefore, higher firing costs, by increasing the share of temporary jobs, induce

[4]See Saint-Paul (1996, 2002).

a strong excess of labor turnover on production opportunities with relatively short durations. This excess of labor turnover is detrimental to temporary workers whose expected job duration becomes shorter when the employment protection of permanent jobs becomes more stringent. In this context, heightened protection for permanent jobs will have very small negative effects on aggregate employment. However, this small aggregate impact is the net consequence of two large counteracting effects: a strong decrease in the number of permanent jobs and a strong increase in the number of temporary jobs. This large reallocation of jobs, which conforms to empirical evidence,[5] decreases aggregate production, because the production (net of labor turnover costs) of temporary jobs is much smaller than that of permanent jobs. All in all, our model shows that protection of permanent jobs has very small effects on aggregate employment, but induces employment composition effects that significantly reduce aggregate production. Changes in aggregate production are five times larger than changes in aggregate employment.

Our paper is related to at least three strands of the literature.

First, we introduce heterogeneity of idiosyncratic productivity shock arrival rates into the job search model. This allows us to explain empirical evidence which indicates that the expected duration of production opportunities is a major motive for using temporary jobs when the destruction of permanent jobs is costly. Indeed, it turns out that the share of temporary contracts is higher in industries with higher labor turnover in countries with stringent job protection (Bassanini and Garnero, 2013). Drager and Marx (2012) find, using a large firm-level data set from 20 countries, that workload fluctuations strongly increase the probability of hiring temporary workers in rigid labor markets, but that no such effect is observed in flexible labor markets. Strikingly, we are not aware of any model that explains such facts. Our model sheds light on the impact of temporary contracts from a perspective different from the one in which temporary contracts are viewed as a way of screening workers before they are promoted into permanent jobs.[6] Actually, in all countries, permanent contracts comprise probationary periods, with no firing cost and very short notice, which are used to screen workers into permanent jobs. The maximum mandatory duration of probationary periods is around several months,

[5] See among others Autor (2003), Kahn (2010), Centeno and Novo (2011), Cappellari et al. (2012), Hijzen et al. (2013).

[6] See Bucher (2010), Faccini (2014), Kahn (2010), Nagypal (2002), Portugal and Varejão (2009).

depending on countries, industries and skills.[7] To the extent that temporary jobs cannot be terminated before their expiration date, it can only be profitable to screen workers by means of temporary contracts if the duration of the probationary period is too short, at least shorter than that of temporary contracts.[8] Accordingly, the view that temporary contracts are used to screen workers can be useful to explain the spread of temporary jobs lasting longer than the probationary period of permanent jobs. But this approach cannot explain the huge amount of creation of temporary contracts of very short spell, much shorter than that of probationary periods.[9] For instance, in France, the average duration of temporary jobs is about one month and a half, while the probationary periods last at least two months and can go to eight months.[10]

Second, we complement the literature on the impact of employment protection legislation[11] by explaining the choice between permanent and temporary jobs. Most of this literature does not explain this choice.[12] Usually, in this literature, temporary jobs, which can be destroyed at zero cost, are preferred to permanent jobs, which are costly to destroy, and it is either assumed that all new jobs are temporary, or that the regulation forces firms to create permanent jobs. As far as we know, four papers explain the choice between temporary and permanent jobs in a dynamic setting.[13] Berton and Garibaldi (2012) propose a matching model with directed search and exogenous wages in which firms are willing to open permanent jobs when their job filling rate is faster than that of temporary jobs. The model features a sorting of firms and workers

[7] See: http://www.ilo.org/dyn/eplex/termmain.home?p_lang=uk.

[8] In general, the probationary period of temporary jobs is much shorter than that of permanent jobs. Furthermore, when a temporary job is transformed into a permanent job, the duration of the temporary job has to be subtracted from the duration of the probationary period of the permanent job.

[9] To the extent that workers can be dismissed at zero cost during probationary periods, at first sight it is more profitable to exploit job opportunities expected not to last long with permanent contracts that are terminated at no cost during the probationary periods, rather than with temporary contracts that cannot be terminated before their date of termination even if the job becomes non profitable. However this type of behavior is illegal. An employer who systematically hires workers under permanent contracts and dismisses them during the probationary period instead of using temporary contracts runs the risk of being prosecuted. Our paper does not account for probationary periods, which are left for future research. We merely assume that permanent workers are protected by firing costs from the start of their contract.

[10] In France, the legal maximum duration of the probationary period for permanent contract goes from 2 months for blue collar workers to 4 months for white collar workers. The probationary period can be renewed once if this is stipulated in the labor contract.

[11] See among others, Lazear (1990), Bentolila and Saint-Paul (1992), Saint-Paul (1996), Ljungqvist (2002), l'Haridon and Malherbet (2009).

[12] See, among others: Blanchard and Landier (2002), Cahuc and Postel-Vinay (2002), Boeri and Garibaldi (2007), Sala, Silva and Toledo (2012), Costain, Jimeno and Thomas (2010), Bentolila et al. (2012), Saint-Paul (1996).

[13] Kahn (2010) provides a static two period model where temporary jobs are used to screen workers.

into permanent and temporary jobs. This model, which provides an endogenous explanation for the coexistence of permanent and temporary contracts, predicts that temporary workers have shorter unemployment durations than permanent workers, which appears to be true in empirical analysis. Caggese and Cunat (2008) consider the optimal dynamic employment policy of a firm that faces capital market imperfections and can hire two types of labor: one that is totally flexible (fixed-term contracts) and one that is subject to firing costs (permanent contracts). They assume that both are perfect substitutes, but that permanent employment is relatively more productive. This implies that a firm without financing constraints would hire permanent workers up to the point where expected firing costs are equal to the productivity gain with respect to temporary workers. Cao, Shao and Silos (2010) provide a matching model where firms find it optimal to offer high-quality matches a permanent contract because temporary workers continue to search on the job while permanent workers do not. Finally, Alonso-Borrego, Galdon-Sanchez and Fernandez-Villaverde (2011) assume that permanent and temporary jobs have different firing costs and hiring costs. In these papers, the duration of temporary jobs is exogenous and it is assumed that firms can dismiss workers before the date of termination of temporary contracts. We use an alternative approach, consistent with actual employment protection legislations of Continental European countries, where the duration of temporary jobs is chosen by employers and workers and where workers cannot be dismissed before the date of termination of temporary contracts or where the rule for dismissals is the same for temporary and permanent contracts .

Third, some papers explain why short-term contracts and long-term contracts may coexist in the absence of employment protection legislation. This issue is particularly relevant to understanding the emergence of temporary contracts in labor markets where there is little difference between the termination costs of temporary and permanent contracts, as in some Anglo-Saxon countries. Smith (2007) has provided a stock-flow matching model where it can be optimal to hire workers of low profitability on a temporary basis in order to be positioned to hire more profitable workers when the stock of job seekers has been sufficiently renewed. This model offers an underlying rationale for why some employment is limited in duration. It also explains the duration of temporary contracts. In our approach, which is complementary, the utilization of temporary contracts does not hinge on a stock-flow matching model but on the heterogeneity of expected production opportunity durations in an environment where there is a legal menu of contracts. Moreover, contrary to Smith, we assume a labor market with free entry. Macho-Stadler, Pérez-Castrillo and Porteiro (2014) provide an alternative explanation where long-term contracts allow the better provision of incentives because firms can credibly transfer payments from earlier to later periods in the life of the workers, and this transfer alleviates the incentive compatibility constraint. In this setup, short-term contracts can emerge in equilibrium because they allow the market to ensure a better matching between agents' abilities and firms' needs.

Our paper is organized as follows. Stylized facts are presented in section 2. A benchmark search and matching model is developed in section 3. Section 4 extends the benchmark model to a more realistic environment and provides simulation exercises that enable us to evaluate the impact of the regulation of job protection on labor turnover, employment and aggregate production. Section 5 states our conclusions.

2 Stylized facts

This section presents three important stylized facts about entries into employment in France and in Spain.[14]

First, most entries into employment are into temporary jobs.[15] Figures 1 and 2 display employment inflows, from unemployment and inactivity, by type of job in France and Spain over the period 2000-2010. These figures show that about 90 percent of entries are into temporary jobs in both countries. These figures do not take into account conversions of temporary jobs into permanent jobs, since they display employment inflows from unemployment and inactivity. In France, about 5.5 percent of temporary jobs are converted into permanent jobs (Le Barbanchon and Malherbet, 2013). This means that about one third of entries into permanent jobs are conversions of temporary jobs, while the other two thirds originate from unemployment and inactivity.[16] In Spain, about 3.5 percent of temporary jobs are transformed into perma-

[14] The choice of France and Spain is motivated by the availability of data (ACOSS and DARES for France, Spanish State Employment Office for Spain). As far as we are aware, other continental European countries have only limited information on entries into employment by type of labor contracts.

[15] In what follows, temporary jobs comprise all fixed-term jobs, including jobs filled through temporary work agencies.

[16] For 100 entries into employment from unemployment and inactivity, there are about 10 entries into permanent jobs and 90 entries into temporary jobs. 5.5% of these temporary jobs are converted into permanent jobs, which amounts to 4.95 percent of the 100 entries.

nent jobs,[17] meaning that about one quarter of entries into permanent jobs are conversions of temporary jobs.

The second stylized fact is that the duration of most temporary jobs is very short. Figure 1 shows that temporary jobs of spells shorter than one month account for two third of entries into employment in France. One month is much shorter than the maximum duration of temporary contracts, which is 24 months. It is also much shorter than the duration of the probationary period of permanent jobs, which is two months for low skilled workers; three months for supervisors and technicians; and four months for managers. The probationary period can be renewed once if expressly provided for under the applicable branch-level collective bargaining agreement. Most collective bargaining agreements provide for probationary periods of between 2 and 3 months for low skilled workers, and between 4 and 6 months for managers, including any renewal. The average probationary period is about 3.75 months (OECD, 2013), while the average duration of temporary jobs is about 1.5 months.

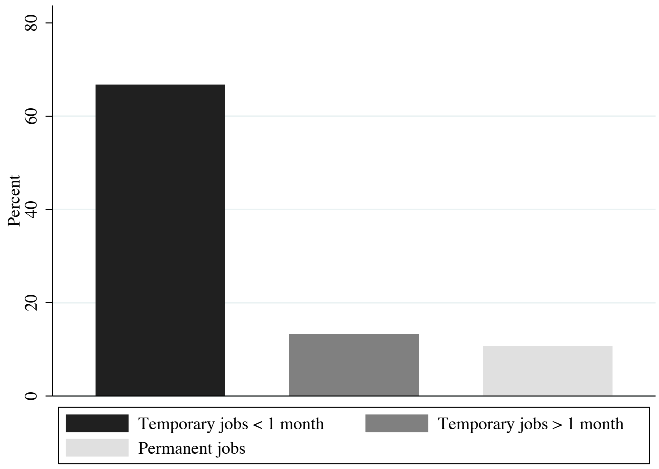

Figure 1: The share of entries into employment according to job type in France over the period 2000-2010. Source: Acoss and DARES, French Ministry of Labor.

In Spain, Figure 2 shows that a large share of entries into temporary jobs are on jobs of very short spell, as in France. The share of entries into contracts of short spell in total employment inflows is large. It amounts to 50 percent for spells below one month and to 10 percent for spells between 1 and 2 months. These figures are significantly smaller than in France, suggesting that

[17]Source: Spanish Ministry of Labor and Immigration, Movimiento Laboral registrado, 2012.

these entries are less systematically recorded in Spain than in France. One of the reasons might be that data for France come from registers of all new contracts whereas data for Spain come from social security records in which several consecutive contracts in the same firm might be consolidated as a single employment spell. Nevertheless, available information for Spain does confirm that the spell of the vast majority of temporary contracts is far below the upper limit of 24 months. It is also below the average duration of probationary periods. Until 2012, in Spain, the length of probationary periods could not be longer than 6 months for blue collars or two months for other workers (3 months in firms with less than 25 workers). But collective agreements may reduce the length of probationary periods, and in fact they do reduce the probationary period for blue collars. The average length of the probationary period is about 1.5 months for blue collars.[18]

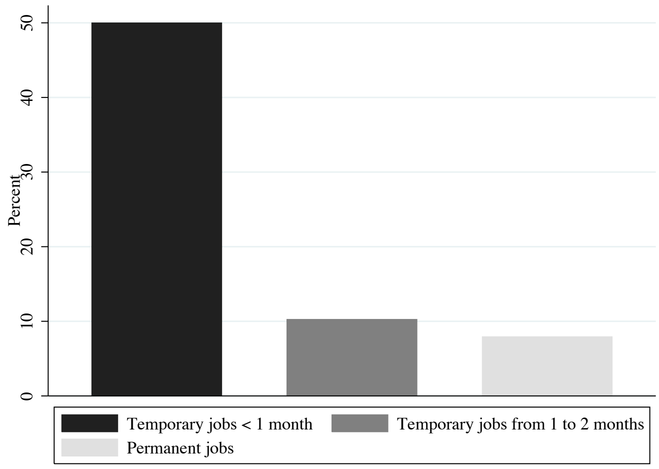

Figure 2: The share of entries into employment according to job type in Spain over the period 2002-2010. Source: Muestra Continua de Vidas Laborales.

All in all, figures 1 and 2 show clearly that the vast majority of entries into temporary employment are on temporary jobs much shorter than the maximum duration of such jobs and shorter than the probationary period of permanent jobs in France and in Spain. Hence, in most cases, it does not appear that temporary jobs are being created to gain more time to screen workers than the probationary period allows. Most temporary jobs are created because the duration of the production opportunities for which these jobs are created is expected to be

[18]Registered collective agreements data set, Ministry of Labor, Spain.

short.

As a consequence of the large share of entries into jobs of short duration, the number of entries into employment is very large in both countries, as shown by table 1. In France, the ratio of annual entries into employment over the stock of jobs is equal to 1.88. In Spain, the ratio is about 1.24. As noted above, this ratio might appear smaller than in France due to the fact that not all entries into employment are reported in Spain.

	France	Spain
Number of jobs (stock)	15.9	12.9
Annual entries into temporary jobs	26.7	14.4
Annual entries into permanent jobs	3.2	1.6
Number of entries/Number of jobs	1.88	1.24

Table 1: Number of jobs and number of entries (in millions) into employment according to the type of contract. Private non agricultural sector. Period 2000q1 2010q2 for France and 2005q1 2010q2 for Spain. Source: ACOSS and Spanish State Employment Office.

The third stylized fact is that the principal part of fluctuations in employment inflows is due to inflows into temporary jobs. In France changes in total employment inflow are mainly driven by temporary jobs, as shown by figure 3 which displays the deviations of the number of entries into employment with respect to the trend. The average gap between the number of entries and its trend is seven times larger for temporary jobs than for permanent jobs. In particular, at the beginning of the recession that started in 2008, we see a strong drop in entries into temporary jobs, much larger than the drop in entries into permanent jobs. Figure 4 shows that employment inflows follow a similar pattern in Spain, where the average gap between the number of entries and its trend is eleven times larger for temporary jobs than for permanent jobs. The collapse of employment inflow in 2008 comes from the drop in entries into temporary jobs. Over the period covered in figure 4, short run fluctuations in employment inflow are mostly driven by temporary jobs.

Let us now provide a model that can explain these three stylized facts.

3 The model

For the sake of clarity, we start by presenting a simple benchmark model that describes the process of job creation when there is a match between an unemployed worker and a vacant job

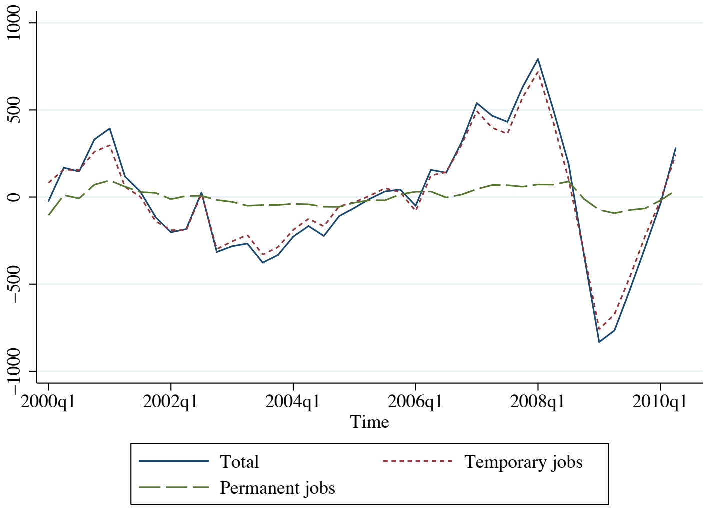

Figure 3: Number of entries into employment per quarter (in thousands) in France in the private non agricultural sector. Deviations with respect to trends (Hodrick and Prescott filter). Source: ACOSS and DARES.

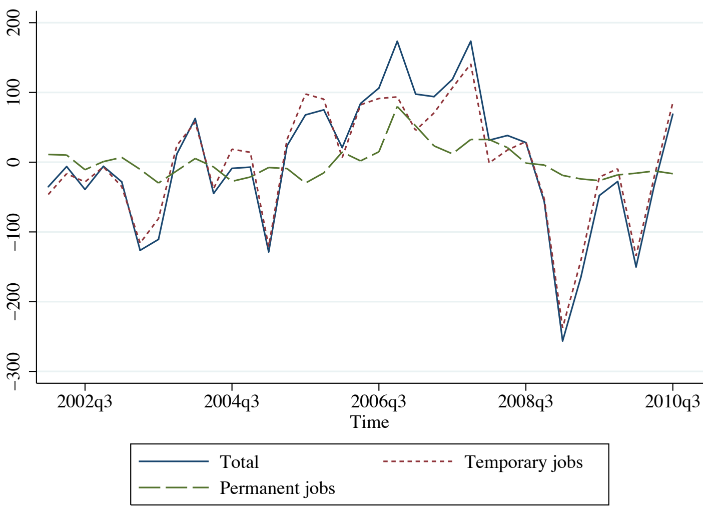

Figure 4: Number of entries into employment per quarter (in thousands) in Spain in the private non agricultural sector. Deviation with respect to trends (Hodrick and Prescott filter). Source: Spanish State Employment Office.

in a context where production opportunities become unproductive at constant Poisson rates. This setup is extended in the next section to include productivity shocks, as in the search and matching framework of Mortensen and Pissarides (1994) which is more relevant for representing the situation of firms that have fluctuations in the demand for their product. The labor market equilibrium is also determined in the next section when we proceed to quantitative exercises.

3.1 The benchmark setup

There is a continuum of infinitely-lived risk-neutral workers and firms, with a common discount rate $r > 0$. Workers are identical and their measure is normalized to 1. Firms are competitive and create jobs to produce a numéraire output, using labor as sole input. All jobs produce the same quantity of output per unit of time, denoted by $y > 0$, but jobs differ by the rate at which they become unproductive, denoted by $\lambda > 0$. When a job is created, its type λ is randomly selected from within $[\lambda_{\min}, +\infty)$, $\lambda_{\min} > 0$, according to a sampling distribution with cumulative distribution function G and density g. The distribution of λ has positive density over all its support and no mass point. Jobs and workers are brought together pairwise through a sequential, random and time consuming search process. Unemployed workers sample job offers sequentially at a rate that will be determined later in the paper.

There are two types of contract: temporary and permanent. Permanent contracts are the 'regular' type of contract. Permanent contracts stipulate a fixed wage that can be renegotiated by mutual agreement only: renegotiations thus occur only if one party can credibly threaten to leave the match for good if the other refuses to renegotiate. Permanent contracts are open-ended: they do not stipulate any pre-determined duration. Permanent jobs can be terminated at any time at cost F, paid by the employer. F is a red-tape cost, not a transfer from the firm to the worker (such as severance pay). Here we consider only red-tape costs, since it is well known that severance payments only change the timing of the payout − a factor which is basically irrelevant in models with risk-neutral agents. There is a (small) cost to write a contract, either temporary or permanent, which is denoted by $c > 0$.

To account for the main features of European regulations, it is assumed that temporary contracts stipulate a wage and a fixed duration. Temporary contracts are neither renegotiable nor renewable. The employer must pay the worker the wage stipulated in the contract until the date of termination, even if the job becomes unproductive before this date. Alternatively, it could be assumed that temporary contracts have an infinite cost of termination before their date of termination and that the wage could be reset every period.[19] At their date of termination,

[19]We thank Guido Menzio (the editor), for suggesting this alternative interpretation.

temporary jobs can be either destroyed at zero cost or transformed into permanent jobs. Then, new permanent contracts can be bargained over.[20]

Temporary jobs allow firms to circumvent the legislated protection of permanent jobs. In most countries there are legal constraints on the utilization of temporary jobs. They take different forms: limits on the maximum duration, on the number of renewals, on the circumstances under which temporary jobs can be used (replacement, seasonal work, or temporary increases in company activity). These constraints are difficult to enforce, and indeed are generally very weakly enforced. A good example is France, where temporary jobs account for 90 percent of job creation, although in principle temporary jobs can be created only for replacement, seasonal work or temporary increases in company activity. In light of this, our model, which neglects most of these legal constraints, except the impossibility to renew temporary contracts, seems to be a reasonable benchmark for analyzing the consequences of job protection in the presence of temporary jobs.[21]

When they meet, workers and employers bargain over a contract that maximizes the surplus of the starting job, which can be either temporary or permanent. A temporary contract is chosen if it yields a higher surplus than a permanent contract. If a temporary contract is selected, the wage profile and the duration of the contract are chosen once for all in the starting contract because it is not permitted to renegotiate the contract.

Let us now define the surplus of permanent and temporary jobs before analyzing the choice between these two types of job.

3.2 Permanent jobs

The surplus of a continuing permanent job with productivity y and shock arrival rate λ, denoted $S_c(\lambda)$, is equal to the sum of the discounted gains of the firm, denoted $J_c(\lambda)$, and of the worker, denoted $W_c(\lambda)$, in case of continuation, minus their discounted gains if the job is destroyed. If the job is destroyed, the firm has to pay the firing costs, F, and gets zero profits from the job.

[20] In the benchmark model, where productivity is equal either to y or to zero, it is assumed that firing costs are sufficiently small to ensure that jobs with zero productivity are destroyed. In this setup, there is no wage renegotiation on any type of job since there is no shock that allows any party to have a credible threat with which to trigger renegotiations. Renegotiation can only occur at the date at which the temporary job is transformed into a permanent job, provided that this is the case.

[21] The mandatory limit on the duration of temporary contracts and on the number of renewals are analyzed in Cahuc et al. (2012).

The worker becomes unemployed and he gets discounted gains denoted by U. Therefore,

$$S_c(\lambda) = J_c(\lambda) + F + W_c(\lambda) - U.$$

When productivity drops from y to zero, the job is destroyed if its surplus becomes negative. This is the case if firing costs are sufficiently small, i.e. if $F < U$. Otherwise, the continuing job with zero productivity that pays the wage w forever, so that $rJ_c(\lambda) = -w$ and $rW_c(\lambda) = w$, generates a surplus equal to $F - U > 0$. Henceforth, we assume that $F < U$ to ensure that unproductive jobs are destroyed.

When a worker and a firm are brought together to start a permanent job, there are no firing costs if they do not agree to sign a contract. Let $J_p(\lambda)$ denote the value to a firm of starting permanent jobs with shock arrival rate λ, and $W_p(\lambda)$ the value to the worker. The surplus of starting permanent jobs with shock arrival rate λ is

$$S_p(\lambda) = J_p(\lambda) + W_p(\lambda) - U. \tag{1}$$

The value to a firm of starting permanent jobs with shock arrival rate λ can be written as

$$J_p(\lambda) = \int_0^{\infty} \left[\int_0^{\tau} [y - w(\lambda)]\, e^{-rt}\mathrm{d}t - Fe^{-r\tau} \right] \lambda e^{-\lambda\tau}\mathrm{d}\tau - c. \tag{2}$$

In this equation, the first term inside brackets, $\int_0^{\tau} [y - w(\lambda)]\, e^{-rt}\mathrm{d}t$, stands for the discounted sum of expected profits, equal to the difference between y, the production, and $w(\lambda)$, the wage, multiplied by the term e^{-rt}, which stands for the discount factor. Profits are expected until some random date τ, at which the job becomes unproductive and is destroyed at cost F. At date τ, since the job has been destroyed, its value is equal to zero. The term $\lambda e^{-\lambda\tau}$ corresponds to the density of the Poisson process governing productivity shocks. The last term, c, is the cost to write the contract.

Similarly, the value to a worker of starting a permanent job with shock arrival rate λ can be written as

$$W_p(\lambda) = \int_0^{\infty} \left[\int_0^{\tau} w(\lambda) e^{-rt}\mathrm{d}t + Ue^{-r\tau} \right] \lambda e^{-\lambda\tau}\mathrm{d}\tau. \tag{3}$$

where U denotes the value of unemployment to the worker. The first term, $\int_0^{\tau} w(\lambda)e^{-rt}\mathrm{d}t$, stands for the present value of the wages expected by the worker until date τ, while the second term, $Ue^{-r\tau}$, stands for the present value to the worker of searching for a new job in case of separation, an event that occurs at the random date τ.

Using (2) and (3) and rearranging, the surplus $S_p(\lambda)$, defined by equation (1), can also be written as

$$S_p(\lambda) = \frac{y - rU - \lambda F}{r + \lambda} - c. \tag{4}$$

The properties of the surplus $S_p(\lambda)$ are summarized as follows:

Properties of $S_p(\lambda)$: *function* $S_p(\lambda)$ *is continuous and decreasing in* λ. *It decreases from* $\frac{y}{r} - U - c > 0$ *to* $-c - F < 0$, *so that there exists a unique threshold value*

$$\lambda_p = \frac{y - r(U + c)}{F + c}, \tag{5}$$

such that $S_p(\lambda_p) = 0$ *and* $S_p(\lambda) > 0$ *if and only if* $\lambda < \lambda_p$.

Proof. See appendix B.1. □

3.3 Temporary jobs

The surplus of a temporary job is defined in two stages. We start by defining the expression of the surplus when the duration of the temporary job is given. Then, the expression of the surplus for the optimal duration of the job is derived.

3.3.1 Surplus of temporary jobs when their duration is given

The value to a firm of starting temporary jobs with shock arrival rate λ, and duration Δ, $J_t(\lambda, \Delta)$, can be written as

$$J_t(\lambda, \Delta) = \int_0^{\Delta} \left[y e^{-\lambda \tau} - w(\lambda, \Delta) \right] e^{-r\tau} \mathrm{d}\tau + \max \left[J_p(\lambda), 0 \right] e^{-(r+\lambda)\Delta} - c. \tag{6}$$

The first term, $\int_0^{\Delta} \left[y e^{-\lambda \tau} - w(\lambda, \Delta) \right] e^{-r\tau} \mathrm{d}\tau$, stands for the discounted sum of expected profits over the duration of the job. In this expression, the level of production y is multiplied by the survival function $e^{-\lambda\tau}$ because the production drops to zero at rate λ. The wage $w(\lambda, \Delta)$ is not multiplied by the survival function because the employer has to keep and pay the employee until the date of termination of the contract. The second term, $\max \left[J_p(\lambda), 0 \right] e^{-(r+\lambda)\Delta}$, is the present value of the option for the firm linked to the possibility of transforming the temporary job into a permanent job at the date of termination of the temporary contract. The present value of this option decreases with the duration of the contract because time is discounted at rate r and because the probability that the job is productive at the date of termination of the contract decreases with the spell of the contract. The last term is the cost of writing the contract.

Similarly, the value to a worker of starting temporary jobs with shock arrival rate λ, and duration Δ, $W_t(\lambda, \Delta)$, can be written as

$$W_t(\lambda, \Delta) = \int_0^{\Delta} [w(\lambda, \Delta) - rU]\, e^{-r\tau} \mathrm{d}\tau + \max [W_p(\lambda), U]\, e^{-(r+\lambda)\Delta} + U(1 - e^{-(r+\lambda)\Delta}). \tag{7}$$

In this expression, the first term, $\int_0^{\Delta} [w(\lambda, \Delta) - rU]\, e^{-r\tau} \mathrm{d}\tau$, stands for the discounted sum of expected gains over the duration of the job's present value. The second term, $\max [W_p(\lambda), U]\, e^{-(r+\lambda)\Delta}$, is the present value of the option linked to the possibility of transforming the temporary job into a permanent job at the date of termination of the temporary contract. The last term, $U(1 - e^{-(r+\lambda)\Delta})$, reflects the worker's outside options.

By definition, the surplus of starting temporary jobs with shock arrival rate λ and duration Δ, $S_t(\lambda, \Delta)$, is defined as follows

$$S_t(\lambda, \Delta) = J_t(\lambda, \Delta) + W_t(\lambda, \Delta) - U, \tag{8}$$

which, using (6) and (7), and assuming that $J_t(\lambda, \Delta) > 0$ and $W_t(\lambda, \Delta) > U$ (which will be true in equilibrium), can be written as

$$S_t(\lambda, \Delta) = \int_0^{\Delta} \left(ye^{-\lambda\tau} - rU\right) e^{-r\tau} \mathrm{d}\tau + \max [S_p(\lambda), 0]\, e^{-(r+\lambda)\Delta} - c. \tag{9}$$

3.3.2 Optimal duration of temporary jobs

The optimal duration of temporary jobs maximizes the surplus of starting temporary jobs. Therefore, the optimal duration of a temporary job with shock arrival rate λ is defined by the first order condition[22]

$$ye^{-\lambda\Delta} - rU - (r + \lambda)\, e^{-\lambda\Delta} \max [S_p(\lambda), 0] = 0. \tag{10}$$

[22] The second order condition is always fulfilled. When $S_p(\lambda) \leq 0$, the second order condition is $-\lambda ye^{-\lambda\Delta} < 0$. When $S_p(\lambda) > 0$, the derivative of the first order condition with respect to Δ is

$$-\lambda ye^{-\lambda\Delta} + e^{-\lambda\Delta} (r + \lambda)\, \lambda S_p(\lambda),$$

which is equal to (using the first order condition): $-\lambda rU < 0$.

In this expression, the term $ye^{-\lambda\Delta}$ stands for the marginal gain of an increase in the duration of the job. This gain decreases with the duration of the job because the survival probability of production opportunities decreases with the job spell. It goes to zero when the duration goes to infinite. The marginal cost is equal to the sum of the two other terms. The first term, rU, is the flow of value that the employee can get if the job is terminated. The second term is the option value linked to the possibility of transforming the temporary job into a permanent job. The marginal cost decreases with the duration of the job and has a strictly positive lower bound, equal to rU.

The first order condition yields, together with equation (4), the optimal duration as a function of λ, denoted by

$$\Delta(\lambda) = \begin{cases} \frac{1}{\lambda}\ln\left(\frac{rU+\lambda F+(r+\lambda)c}{rU}\right) & \text{if } \lambda \leq \lambda_p \\ \frac{1}{\lambda}\ln\left(\frac{y}{rU}\right) & \text{if } \lambda \geq \lambda_p \end{cases} \tag{11}$$

The properties of the optimal duration $\Delta(\lambda)$ can be summarized as follows:

Properties of optimal duration $\Delta(\lambda)$: *function* $\Delta(\lambda)$ *is continuous, with a kink at* $\lambda = \lambda_p$. *It is monotonically decreasing, and goes from infinite, when the shock arrival goes to zero, to zero when the shock arrival rate goes to infinite.*

Proof. See appendix B.2. □

The optimal duration of temporary contracts is displayed in figure 5. Function $\Delta(\lambda)$ is decreasing with the shock arrival rate λ, and has a kink at $\lambda = \lambda_p$ because temporary jobs are transformed into permanent jobs only if the shock arrival rate is below the reservation value λ_p. Otherwise, the surplus yielded by the creation of permanent jobs is negative, which implies that it is worth neither creating permanent jobs nor transforming temporary jobs into permanent jobs. Note that equation (11) shows that the possibility of transforming temporary jobs into permanent jobs induces firms to shorten the duration of temporary jobs. If it were not possible to transform temporary jobs into permanent jobs, the duration of temporary jobs would be equal to $\ln\left(\frac{y}{rU}\right)/\lambda$ for all λ.[23] Note as well that the expression (11) implies that the actual duration of a temporary job differs from the expected duration of job opportunities, equal to

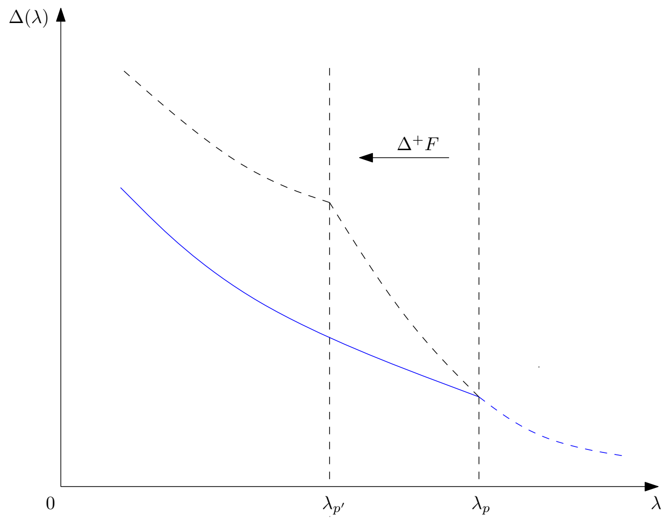

Figure 5: The relation between the shock arrival rate λ and the optimal duration of temporary jobs $\Delta(\lambda)$ for two different values of the firing costs, F (continuous line) and F' (dotted line), with $F' > F$. λ_p is the threshold value for F and $\lambda_{p'}$ is the threshold value for F'. The two curves overlap above λ_p.

$1/\lambda$.[24] Figure 5 also shows that increases in firing costs raise the optimal duration of temporary jobs because they reduce the surplus of permanent jobs and thus the incentive to transform temporary jobs into permanent jobs. Higher firing costs also imply a lower threshold value of λ below which temporary jobs are transformed into permanent jobs. In other words, when firing costs are higher, temporary jobs have longer spells and are less frequently transformed into permanent jobs. The optimal duration of temporary jobs also depends on productivity. Increases in productivity raise the duration of temporary jobs which are not transformed into permanent jobs. Therefore, increases in productivity reduce labor turnover.

Having studied the properties of the optimal duration $\Delta(\lambda)$, we may now examine the properties of the surplus of a temporary contract $S_t(\lambda) = \max_\Delta S_t(\lambda, \Delta)$, which can be summarized as follows:

Properties of $S_t(\lambda)$: *function* $S_t(\lambda)$ *is continuous and decreasing in* λ. *It monotonically decreases from* $\frac{y}{r} - U - c > 0$ *to* $-c$. *Thus, when* $c > 0$, *there exists a unique threshold*

[23]When $\lambda < \lambda_p$, $S_p(\lambda) > 0$ and the expression (4) imply that $y > rU + \lambda F + (r + \lambda)c$, and thus that $\frac{y}{rU} > \frac{rU+\lambda F+(r+\lambda)c}{rU}$.

[24]Of course, we rely on the assumption that the job type λ remains constant over an employment spell. This point is further discussed in section 4.4.3.

value λ_t *such that* $S_t(\lambda_t) = 0$, *and* $S_t(\lambda) > 0$ *if and only if* $\lambda < \lambda_t$.

Proof. see Appendix B.3. □

With these features in mind, it is now possible to study the choice between temporary and permanent contracts.

3.4 Choice between temporary and permanent contracts

When a job is created, firms and workers choose the type of contract that provides the highest surplus. The choice between the two types of contract when $F > 0$ is described in the following proposition:

Proposition 1. *Choice between temporary and permanent contracts*

Let us define $\lambda_s = \{\lambda | S_t(\lambda) = S_p(\lambda)\}$, $\lambda_p = \{\lambda | S_p(\lambda) = 0\}$, $\lambda_t = \{\lambda | S_t(\lambda) = 0\}$. *Then:*

Case 1. *When* $c = 0$, *it is optimal to create temporary jobs for all* $\lambda > 0$.

Case 2. *When* $S_t(\lambda_p) < 0$, *there exists a unique value* $\lambda_p > 0$ *such that it is optimal to create permanent jobs for* $\lambda < \lambda_p$ *and no job otherwise.*

Case 3. *When* $S_t(\lambda_p) > 0$ *there exist unique values* $\lambda_t > \lambda_p > \lambda_s > 0$ *such that it is optimal to create permanent jobs for* $\lambda < \lambda_s$, *temporary jobs for* $\lambda \in [\lambda_s, \lambda_t]$ *and no job for* $\lambda \geq \lambda_t$.

Proof. See appendix B.4. □

There is a trade-off between temporary contracts in which the cost of a productivity shock is an inability to separate for some subsequent period of time, and permanent contracts in which the cost of a negative productivity shock is F. Accordingly, as claimed in proposition 1, depending on the arrival rate of shocks and on the other parameters that determine the value of jobs, it can be optimal to create either temporary or permanent jobs. All in all, proposition 1 has a straightforward interpretation.

First, case 1 states that only temporary contracts are created when the cost to write contracts is equal to zero, because it is always preferable to hire workers on temporary jobs, possibly for very short periods of time, and then to transform temporary jobs into permanent jobs rather than directly hiring workers on permanent jobs.[25] This means that there is no trade-off between permanent jobs and temporary jobs if there are no costs to write contracts. The trade-off would also disappear if it were possible to write a single contract that stipulated a contingent transformation of temporary contract into permanent contract at the instant when the worker is hired. It is likely that such contracts are not observed in the real world because they are too costly to verify.

When writing contracts is costly, cases 2 and 3 state that permanent jobs are preferred to temporary jobs when the firing costs and the shock arrival rate are low.

In case 2, where the surplus of temporary jobs is negative at the maximum value of the shock arrival rate for which it is worth creating permanent jobs, permanent contracts are always more profitable than temporary contracts. Indeed, if $S_t(\lambda_p) < 0$, the surplus of temporary jobs is negative when $\lambda > \lambda_p$ (remind that $S_t'(\lambda) < 0$), where λ_p is the maximum value of the shock arrival rate for which is is worth creating permanent jobs. Therefore, it is not worth creating temporary jobs when $\lambda > \lambda_p$. Moreover, when $\lambda < \lambda_p$, it turns out that the surplus of temporary jobs is smaller than that of permanent jobs, as shown in appendix. The situation corresponding to case 2 arises when firing costs are small enough to ensure that it is preferable to create permanent jobs rather than temporary jobs whatever the value of the shock arrival rate.

The situation that arises in case 3, where the surplus of temporary jobs is positive at the maximum value of the shock arrival rate for which is worth creating permanent jobs, is illustrated by figure 6. This figure displays the surplus of permanent jobs and the surplus of temporary jobs for all possible values of the shock arrival rate λ, assuming that F is sufficiently large.[26] In this situation, it is optimal to create permanent jobs for values of $\lambda \in [\lambda_{min}, \lambda_s]$ as the arrival rate of productivity shocks is sufficiently small. For larger values of λ, i.e. when λ falls within $[\lambda_s, \lambda_t]$, it becomes optimal to create temporary jobs because the surplus of temporary jobs becomes larger than that of permanent jobs. When $\lambda > \lambda_t$, the arrival rate of productivity shocks is so high that it is never worth creating jobs, either permanent or temporary.[27]

It is worth noting that our model implies that temporary jobs pay lower wages than per-

[25] Formally, it can be verified that $S_p(\lambda) < S_t(\lambda)$ when $c = 0$, as shown in appendix B.4.

[26] Note that by assumption $F < U$. We checked in simulations exercises that case 3 can arise for empirically relevant values of the parameters when this assumption is fulfilled.

[27] Remark that $\lambda_t \to \infty$ when the cost of writing a contract goes to zero. When $c = 0$, proposition 1 holds true except that there is no upper bound on the values of λ for which it is profitable to create temporary jobs.

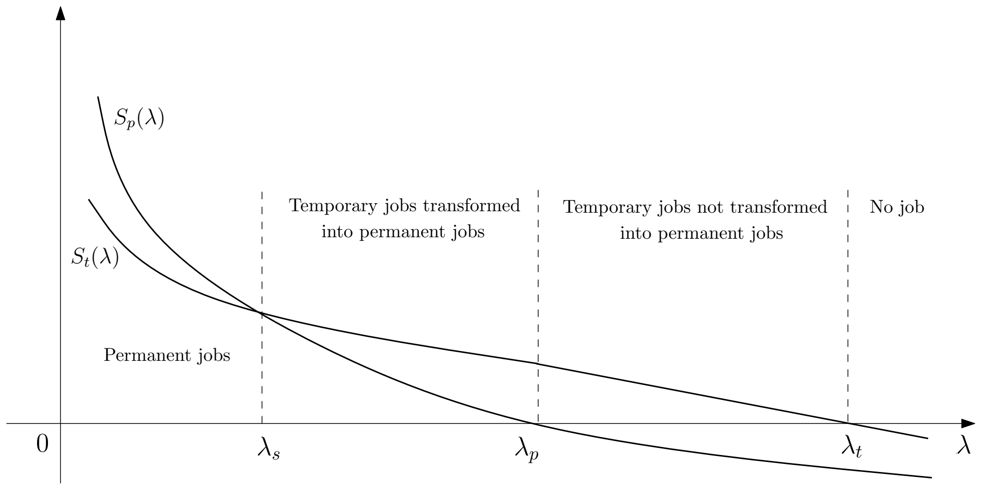

Figure 6: The relation between the shock arrival rate and the type of job creation.

manent jobs even when their productivity is the same. There are two reasons for this property, consistent with empirical evidence.[28] First, the duration of temporary jobs is shorter than that of permanent jobs. This induces a lower average surplus for temporary jobs as shown by figure 6. Second, the impossibility of terminating temporary contracts before their date of termination implies that there are situations where employers pay positive wages to unproductive temporary workers. This reduces their entry wage which is not renegotiated.

4 Quantitative evaluation

We now turn to the quantitative evaluation of the model in order to show that it is compatible with the stylized facts highlighted in section 2. Then we study the impact of job protection on the main variables of interest, *i.e.* job inflows, aggregate employment and production. So far we have restricted ourselves to rather simplistic production and destruction processes where output is constant and job destruction is exogenous. Moreover, labor market equilibrium has not yet been defined. To make our numerical exercise more relevant, we now generalize to a richer stochastic environment and consider an extension of the benchmark model where it is assumed that productivity shocks do not strike productivity down to zero once for all, but

[28]Empirical evidence shows that temporary workers get lower wages than permanent workers controlling for a large cluster of observable characteristics. For instance, Booth et al. (2002) find that temporary workers in Britain earn less than permanent workers (men 8.9 percent and women 6 percent less). Hagen (2002) finds an even larger gap, about 23 percent in Germany, controlling for selection on unobservable characteristics.

imply a new value of the productivity drawn from a stationary distribution, as in the model of Mortensen and Pissarides (1994). We proceed to the analysis at market equilibrium in this framework.

For this purpose, let us now assume that the production of an employee is a random variable with distribution $H(y)$ which has upper support y_u and no mass point. The productivity of each employee changes at Poisson rate λ. When productivity changes, there is a draw from the fixed distribution $H(y)$. For the sake of simplicity, it is assumed that the productivity of new matches is equal to the upper support of the distribution, as in Mortensen and Pissarides (1994). In what follows, we show that the model with productivity shocks can be solved in a similar way to the benchmark model. We then turn to the calibration exercise.

4.1 Permanent jobs

Permanent jobs can start either from new matches or from transformations of temporary jobs. In either situation, the value to the firm of a starting permanent job with shock arrival rate λ and productivity y, denoted by $J_p(y,\lambda)$, satisfies the Bellman equation

$$J_p(y,\lambda) = \int_0^{\infty} \left[\int_0^{\tau} [y - w(y,\lambda)]\, e^{-rt}\mathrm{d}t + e^{-r\tau} \int_{-\infty}^{y_u} \max\left[J_c(x,\lambda), -F\right] \mathrm{d}H(x) \right] \lambda e^{-\lambda\tau}\mathrm{d}\tau - c, \tag{12}$$

where $J_c(x,\lambda)$ denotes the value to the firm of a continuing permanent job with shock arrival rate λ and productivity x. The first term inside brackets, $\int_0^{\tau} [y - w(y,\lambda)]\, e^{-rt}\mathrm{d}t$, stands for the discounted sum of expected profits until date τ at which time a productivity shock hits the job, with $w(y,\lambda)$ denoting the wage. Then, from date τ, the value of the job is $\int_{-\infty}^{y_u} \max\left[J_c(x,\lambda), -F\right]\mathrm{d}H(x)$, as it can either be continued at the new productivity level x, or be destroyed at cost F.

Similarly, the value to the worker of being employed on a starting permanent job with shock arrival rate λ and productivity y, denoted by $W_p(y,\lambda)$, satisfies

$$W_p(y,\lambda) = \int_0^{\infty} \left[\int_0^{\tau} w(y,\lambda) e^{-rt}\mathrm{d}t + e^{-r\tau} \int_{-\infty}^{y_u} \max\left[W_c(x,\lambda), U\right] \mathrm{d}H(x) \right] \lambda e^{-\lambda\tau}\mathrm{d}\tau, \tag{13}$$

where $W_c(x,\lambda)$ denotes the expected utility to the worker of a continuing permanent job with shock arrival rate λ and productivity x. The first term inside brackets, $\int_0^{\tau} w(y,\lambda) e^{-rt}\mathrm{d}t$, stands for the discounted sum of wages paid to the worker until date τ. At some random date τ, the job can be hit by a productivity shock, yielding $\int_{-\infty}^{y_u} \max[W_c(x,\lambda), U]\mathrm{d}H(x)$, since it can either be continued with the new productivity level x, or can be destroyed, in which case the worker becomes unemployed.

The surplus of a starting permanent job with shock arrival rate λ and productivity y, denoted by $S_p(y,\lambda)$ can be defined as

$$S_p(y,\lambda) = J_p(y,\lambda) + W_p(y,\lambda) - U. \tag{14}$$

Firing costs are paid when a continuing permanent job is destroyed, but not when the employer and the employee destroy a starting job because they cannot achieve an initial agreement. The cost c to sign a contract is paid when the job starts, but not when the job is continued. Accordingly, firing costs and the cost to sign a contract create a difference between the surplus of a starting permanent contract, $S_p(y,\lambda)$, and that of a continuing permanent contract $S_c(y,\lambda)$. The surplus of a continuing permanent contract is equal to

$$S_c(y,\lambda) = S_p(y,\lambda) + F + c. \tag{15}$$

Using this expression and equations, (12), (13) and (14), we get

$$rS_c(y,\lambda) = y - r(U-F) + \lambda\left(\int_{-\infty}^{y_u} \max[S_c(x,\lambda), 0]\,\mathrm{d}H(x) - S_c(y,\lambda)\right). \tag{16}$$

Continuing permanent jobs are destroyed when their surplus becomes negative. Since $S_c(y,\lambda)$ increases with y, jobs are destroyed if their productivity drops below the reservation value, denoted by $R(\lambda)$, such that $S_c(R,\lambda) = 0$. This reservation productivity satisfies

$$R(\lambda) = r(U-F) - \lambda \int_{R(\lambda)}^{y_u} \frac{y - R(\lambda)}{r+\lambda}\mathrm{d}H(y). \tag{17}$$

This equation implies that $R(\lambda)$ is a decreasing function of λ.

The creation of permanent jobs can arise from entries of unemployed workers into employment or from transformations of temporary jobs into permanent jobs. In both cases, permanent jobs are created if their productivity is above the threshold denoted by $T(\lambda)$, such that $S_p(T,\lambda) = 0$. This threshold satisfies

$$T(\lambda) = R(\lambda) + (r+\lambda)(F+c). \tag{18}$$

4.2 Temporary jobs

The value to the firm of starting temporary jobs with shock arrival rate λ and duration Δ, $J_t(\lambda, \Delta)$, can be written as:

$$\begin{aligned} J_t(\lambda, \Delta) &= \int_0^\Delta \left[e^{-\lambda\tau} y_u + \left(1 - e^{-\lambda\tau}\right) \int_{-\infty}^{y_u} y \mathrm{d}H(y) - w(\lambda, \Delta) \right] e^{-r\tau} \mathrm{d}\tau \qquad (19) \\ &+ e^{-(r+\lambda)\Delta} \max\left[J_p\left(y_u, \lambda\right), 0\right] + e^{-r\Delta}\left(1 - e^{-\lambda\Delta}\right) \int_{-\infty}^{y_u} \max\left[J_p\left(y, \lambda\right), 0\right] \mathrm{d}H(y) - c. \end{aligned}$$

The integral of the first row stands for the present value of the instantaneous profits obtained over the duration of the temporary contract. The terms of the second row correspond to the present value of the gains expected at the date of termination of the temporary contract minus the cost to write the contract.

The value to the worker of being employed on a starting temporary job with shock arrival rate λ and duration Δ, $W_t(\lambda, \Delta)$, can be written as

$$\begin{aligned} W_t(\lambda, \Delta) &= \int_0^\Delta w(\lambda, \Delta) e^{-r\tau} d\tau + e^{-(r+\lambda)\Delta} \max\left[W_p\left(y_u, \lambda\right), U\right] \qquad (20) \\ &+ e^{-r\Delta}\left(1 - e^{-\lambda\Delta}\right) \int_{-\infty}^{y_u} \max\left[W_p\left(y, \lambda\right), U\right] \mathrm{d}H(y). \end{aligned}$$

The first term corresponds to the present value of wages obtained over the duration of the temporary contract. The second and third terms correspond to the present value of the worker's expected gains at the date of termination of the temporary contract.

The surplus of starting permanent jobs with shock arrival rate λ, can then be written as

$$S_t(\lambda, \Delta) = J_t(\lambda, \Delta) + W_t(\lambda, \Delta) - U, \qquad (21)$$

which implies, using (19) and (20), that the surplus of starting temporary jobs with shock arrival rate λ and duration Δ can be written as

$$\begin{aligned} S_t(\lambda, \Delta) &= \int_0^\Delta \left(e^{-\lambda\tau} y_u + \left(1 - e^{-\lambda\tau}\right) \int_{-\infty}^{y_u} y \mathrm{d}H(y) - rU \right) e^{-r\tau} \mathrm{d}\tau + \qquad (22) \\ & e^{-(r+\lambda)\Delta} \max\left[S_p(y_u, \lambda), 0\right] + e^{-r\Delta}\left(1 - e^{-\lambda\Delta}\right) \int_{-\infty}^{y_u} \max\left[S_p(y, \lambda), 0\right] \mathrm{d}H(y) - c. \end{aligned}$$

The integral of the first row stands for the present value of the instantaneous surpluses obtained over the duration of the temporary contract. The terms of the second row correspond to the present value of the gains expected at the date of termination of the temporary contract minus the cost to write the contract.

4.2.1 Optimal duration of temporary contracts

Once the value of starting jobs is known, it is possible to determine the optimal duration of temporary contracts and shed light on the choice between temporary and permanent contracts.

The optimal duration of temporary contracts is the value of Δ, denoted by $\Delta(\lambda)$, which maximizes $S_t(\lambda, \Delta)$. We get (see appendix C)

$$\Delta(\lambda) = \begin{cases} \frac{1}{\lambda} \ln \left(\frac{y_u - \bar{y} - (r+\lambda)[S_p(y_u,\lambda) - \chi]}{rU - \bar{y} + r\chi} \right) & \text{if } \lambda \leq \lambda_p \\ \frac{1}{\lambda} \ln \left(\frac{y_u - \bar{y}}{rU - \bar{y}} \right) & \text{if } \lambda \geq \lambda_p \end{cases} \tag{23}$$

where $\bar{y} = \int_{-\infty}^{y_u} y \mathrm{d}H(y)$, $\chi = \int_{T(\lambda)}^{y_u} S_p(y, \lambda) \mathrm{d}H(y)$, and λ_p is defined by the condition $S_p(y_u, \lambda_p) = 0$.

This expression of the optimal duration of temporary contracts is similar to that obtained in the benchmark model (see equation (11)). The optimal duration is continuous, decreases with the shock arrival rate λ and increases with the productivity of starting jobs. It goes to zero when the shock arrival rate λ becomes very large, and has a kink at λ_p.

4.2.2 Choice between temporary and permanent contracts

The choice between the creation of temporary and permanent jobs is determined by the comparison of the values of the surplus of starting jobs. As in the benchmark model, (Proposition 1, case 3), there are values of the parameters such that temporary jobs are preferred to permanent jobs if the shock arrival rate is above a threshold denoted by λ_s, which satisfies $S_p(y_u, \lambda_s) = S_t(\lambda_s)$ (see appendix D). Below this threshold, permanent jobs are created. There also exists an upper finite value of the shock arrival rate, λ_t, such that $S_t(\lambda_t) \equiv \max_\Delta S_t(\lambda_t, \Delta) = 0$, above which no job is created. Temporary jobs with shock arrival rate λ falling in the interval $[\lambda_s, \lambda_t]$ are transformed into permanent jobs only if their productivity is above the reservation value $T(\lambda)$. Otherwise, they are destroyed.

4.3 Labor market equilibrium

Let us now describe the process of job creation, the matching between workers and jobs, and the bargaining between workers and employers in order to determine the labor market equilibrium.

Firms must invest $\kappa > 0$ to find a production opportunity. κ is a sunk cost. As described above, all production opportunities start with the same level of productivity y_u. Then they are hit by shocks at Poisson rates λ that differ across jobs. Firms draw production opportunities from the distribution $G(\lambda)$ just after the sunk cost κ has been paid. When a production opportunity is found, a job vacancy can be created. The value of a type-λ vacant job (*i.e.* with shock arrival rate λ) is denoted by $V(\lambda)$. Free entry implies that the expected value of vacant jobs is equal to the investment cost

$$\kappa = \int \max\left[V(\lambda), 0\right] \mathrm{d}G(\lambda). \tag{24}$$

Unemployed workers and job vacancies are brought together through a constant returns to scale matching technology which implies that vacant jobs are filled at rate $q(\theta)$, $q'(\theta) < 0$, where $\theta = v/u$ denotes the labor market tightness, equal to the ratio of vacancies, v, over unemployment u. For the sake of simplicity, it is assumed that the instantaneous cost of vacancies equals zero and that firms must re-invest to find new production opportunities when matches are broken. Moreover, bargaining allows workers to get the share $\beta \in (0, 1)$ of the job surplus. Therefore, the value of type-λ vacant jobs satisfies

$$rV(\lambda) = q(\theta)\left[(1-\beta)S(\lambda) - V(\lambda)\right] \tag{25}$$

where $S(\lambda)$ denotes the surplus of type-λ starting filled jobs. Firms create type-λ vacancies only if their expected value is positive. Since it has been shown above that all (temporary and permanent) job surpluses $S(\lambda)$ decrease with λ and become negative when λ goes to infinite, this implies that type-λ vacant jobs are created only if $\lambda < \lambda_{\text{sup}}$ where λ_{sup} equals either λ_t (see figure 6) if the equilibrium comprises temporary and permanent jobs or λ_p if there are permanent jobs only, which occurs when firing costs are sufficiently small.

The matching technology implies that unemployed workers sample job offers at rate $\theta q(\theta)$. Thus, denoting by z the instantaneous income of unemployed workers, the value of unemployment satisfies

$$rU = z + \theta q(\theta)\beta \int_{\lambda_{\min}}^{\lambda_{\text{sup}}} \frac{S(\lambda)}{G(\lambda_{\text{sup}})} \mathrm{d}G(\lambda).$$

Combining the three previous equations, we get

$$rU = z + \frac{\beta\theta\left[r + q(\theta)\right]}{(1-\beta)\,G(\lambda_{\text{sup}})}\kappa. \tag{26}$$

This equation shows that increases in labor market tightness, which increase the arrival rate of job offers, improve the expected gains of unemployed workers.

Now, let us focus on two types of labor market equilibrium: one where there are only permanent jobs and another where there are permanent and temporary jobs.[29]

4.3.1 Equilibrium with permanent jobs only

When firing costs are sufficiently small, all jobs are permanent because the surplus of permanent jobs is always larger than that of temporary jobs. It is possible to find a system of two equations that defines the equilibrium value of (θ, λ_p). From equations (24) and (25), the free entry condition can be written as

$$\kappa = \frac{q(\theta)(1-\beta)}{r+q(\theta)} \int_{\lambda_{\min}}^{\lambda_p} S_p(y_u, \lambda) \mathrm{d}G(\lambda), \tag{27}$$

where $S_p(y_u, \lambda)$ is defined by equations (15) and (16), and by equation (26) which defines U, as U shows up in the expression of $S_p(y_u, \lambda)$. We get another relation between θ and λ_p using the condition that defines the threshold value of shock arrival rates above which no jobs are created

$$S_p(y_u, \lambda_p) = 0. \tag{28}$$

Equations (27) and (28) define a unique equilibrium value of (θ^*, λ_p^*) provided that the conditions of existence are satisfied, which is assumed. This leads to the following proposition:

Proposition 2. *Equilibrium with permanent contracts only.*

Provided that an equilibrium with permanent jobs only exists, it is unique and defined by a couple (θ^*, λ_p^*) solving equations (27) and (28).

Proof. See appendix E.1. □

Having determined the equilibrium values of (θ^*, λ_p^*), it is then possible to compute rU^* defined by equation (26), and to substitute it into equation (17) to determine the function $R^*(\lambda)$. Then, the equilibrium steady state unemployment rate is computed from the equality of unemployment inflows and outflows. We now turn to the equilibrium with both types of contract.

[29] As shown in Proposition 1 for the benchmark model, an equilibrium with temporary jobs only can exist in our framework. We rule out this possibility for the sake of realism. We also rule out the trivial equilibrium without entries into employment.

4.3.2 Equilibrium with permanent and temporary jobs

When firing costs are sufficiently large, starting jobs can be either temporary, with surplus $S_t(\lambda)$, or permanent, with surplus $S_p(y_u, \lambda)$. The free entry condition becomes

$$\kappa = \frac{q(\theta)(1-\beta)}{r+q(\theta)} \left[\int_{\lambda_{\min}}^{\lambda_s} S_p(y_u, \lambda) \mathrm{d}G(\lambda) + \int_{\lambda_s}^{\lambda_t} S_t(\lambda) \mathrm{d}G(\lambda) \right]. \tag{29}$$

This equation defines a relationship between θ and the thresholds. In turn, the conditions

$$S_t(\lambda_t) = 0, \tag{30}$$

$$S_p(y_u, \lambda_s) = S_t(\lambda_s), \tag{31}$$

$$S_p(y_u, \lambda_p) = 0, \tag{32}$$

define the thresholds as a function of θ, once the relation between rU and θ has been taken into account in the expressions of the surpluses S_t and S_p. Then, equations (30), (31), and (32) together with (29) define a unique equilibrium value of the quadruple $(\lambda_{s,}\lambda_p, \lambda_t, \theta)$, provided that it exists, which is assumed. This leads to the following proposition:

Proposition 3. *Equilibrium with permanent and temporary contracts.*

Provided that an equilibrium with permanent and temporary contracts exists, it is unique and defined by the quadruple $(\lambda_{s,}^*\lambda_p^*, \lambda_t^*, \theta^*)$ *solving equations (29) to (32).*

Proof. See appendix E.2. □

Once the equilibrium values of $(\lambda_{s,}^*\lambda_p^*, \lambda_t^*, \theta^*)$ are known, we can determine rU^* defined by (26), and use equation (17) to get $R^*(\lambda)$. Then, $T^*(\lambda)$ is defined by equation (18). It is then possible to compute the duration of temporary contracts in steady-state, $\Delta^*(\lambda)$, defined by (23). The equilibrium steady state unemployment rate is computed from the equality of unemployment inflows and outflows.

4.4 Simulation exercises

We now calibrate the model to explore its quantitative properties. In particular, we show that the model is able to reproduce the main stylized facts about entries into employment observed in countries like France and Spain where there is stringent employment protection legislation and a large share of temporary jobs, *i.e.*: *(i)* most entries into employment are into temporary jobs; *(ii)* the duration of most temporary jobs is very short; *(iii)* the main part of fluctuations in employment inflows is due to inflows into temporary jobs. The model is first calibrated to match the labor market of the US economy, where firing costs are close to zero. Then, firing costs are increased to evaluate their impact on entries into permanent and temporary jobs.

4.4.1 Calibration

The parameters and targets used in the calibration refer to the US economy, which represents the benchmark economy without firing costs. Admittedly, this assumption is an approximation, to the extent that we neglect the exceptions to the employment-at-will doctrine which induce firms to use some temporary contracts (see *e.g.* Autor, 2003). However, employment protection legislation remains very weak in the US relative to most other OECD countries, and especially to Continental European countries (Venn, 2009).

The values of the parameters are in the range of those chosen in the literature (see *e.g.* Mortensen and Pissarides, 1999, Shimer, 2005, and Mortensen and Nagypal, 2007). We define the time period to be one month, and consequently set the discount rate r to 0.41 percent, which corresponds to a 5 percent annual discount rate. As in Mortensen and Pissarides (1994), the distribution of idiosyncratic shocks is assumed to be uniform in the range $[y_{\min}, 1]$. The income of unemployed workers (the value of leisure), z, is equal to 0.3, a reasonable value that lies below the upper end of the range of income replacement rates in the United States if interpreted entirely as an unemployment benefit (see *e.g.* Shimer, 2005). We follow the literature and assume a Cobb-Douglas matching technology of the form $hv^{\eta}u^{1-\eta}$, where h is a mismatch parameter and η is the elasticity of the matching function with respect to the number of vacancies. We assume η to be equal to 0.5, which falls in the range of the estimates obtained by Petrongolo and Pissarides (2001). Following common practice, we set the bargaining power parameter β to 0.5, a value that internalizes the search externalities in our benchmark specification without firing costs (see *e.g.* Pissarides, 2009). The sampling distribution of type-δ jobs, $\delta = 1/\lambda$, is a log-normal distribution defined over the interval $[0, +\infty)$.

At this stage, we are left with 6 parameters for which data or direct estimates are not available and that remain to be determined: the cost of writing contracts, c; the mismatch/scale parameter of the matching function, h; the two parameters of the cumulative distribution function (cdf) of the sampling log-normal distribution of durations of production opportunities, σ and μ; the bottom value of the uniform productivity distribution, $y_{\min}$; and the investment cost, κ. These parameters gathered in the tuple $(c, h, \sigma, \mu, y_{\min}, \kappa)$ are used to match the targets summarized in the upper part of Table 2. Assuming a flexible economy where $F = 0$, the calibration strategy then consists in solving the equilibrium, as defined by (27) and (28), together with a set of 6 constraints that allows to identify the 6 unknown parameters. These equations cannot be solved sequentially because the system is not decomposable. This set of constraints is made up of: (i) two equations that define the median and the mean value of job tenure in the cross-section; (ii) one equation that defines the average monthly job finding rate; (iii) one equation that defines the steady state equilibrium unemployment rate, computed from labor market flows equilibrium; (iv) one equation that defines the labor market tightness; and finally (v) one equation that defines the minimum expected job tenure. This strategy allows us to jointly determine the tuple $(c, h, \sigma, \mu, y_{\min}, \kappa)$ which is a solution to the system described above. Baseline and calibrated parameters are summarized in the lower part of Table 2. It turns out that the cost of writing a contract is small, equal to about 0.45 percent of the average monthly production of a job (which amounts to 0.99 when $F = 0$), corresponding to 0.8 hours assuming that there are 160 working hours in a month. The shape parameter σ and the scale parameter μ of the log-normal distribution of production opportunities durations imply that the median value and the mean value of the interval of time between subsequent idiosyncratic productivity shocks are equal to 20 months and 31 months respectively.

4.4.2 The economy with firing costs and temporary contracts

Let us now look at the consequences of firing costs. We focus on steady states only. This exercise allows us to illustrate the mechanism of the model and to probe whether it can potentially reproduce the three stylized facts presented above in section 2. Obviously, this exercise is illustrative. It is not meant to reproduce the labor market of a specific country, but more generally to illustrate the consequences of the introduction of firing costs in a labor market with frictions and flexible wages. Dealing with a specific country with strong job protection would require taking into account the influence of minimum wage and/or collective bargaining, factors that often play an important role in countries with strong job protection.

The first fact is that the share of entries into temporary jobs strongly increases with job

Calibration targets		
	Value	Source
Mean job tenure	80 months	CPS (2008)
Median job tenure	48 months	CPS (2008)
Average unemployment rate	6%	Shimer (2005)
Average job finding rate	0.45	Shimer (2005)
Average labor market tightness	1	Shimer (2005)
Minimum expected job tenure	1 day (1/22 month)	Assumption
Calibrated parameters		
Parameter	Notation	Value
Cost of a contract	c	0.0044
Mismatch parameter	h	0.45
$log\ N$ - shape parameter	σ	0.9154
$log\ N$ - scale parameter	μ	3.0340
Minimum match product	$y_{\min}$	-0.1333
Investment cost	κ	1.3190
Baseline parameters		
Bargaining power	β	0.5
Matching elasticity	η	0.5
Discount rate	r	0.41%
Value of leisure	z	0.3
Maximum match product	y_u	1

Table 2: Calibration targets and benchmark parameters values. The median and the mean values of job tenure in the cross section of jobs, equal to 4 years (48 months) and 6.67 years (80 months) respectively, are obtained from the CPS, Displaced Workers, Employee Tenure, and Occupational Mobility Supplement, for the private sector in 2008. The average unemployment rate, monthly job finding, and labor market tightness are set equal to 6 percent, 0.45 and 1 respectively, in line with e.g. Shimer, 2005 or Nagypal and Mortensen, 2007. We assume that the minimum expected job tenure is equal to one day.

protection. Figure 7 shows that the model predicts that firing costs do have a strong impact on the share of entries into temporary jobs. Firms begin to use temporary contracts when firing costs reach about five percent of the average monthly production of an employee. Then, when firing costs increase, the share of entries into temporary jobs rises steadily. It amounts to 85 percent of all entries into employment when firing costs equal about 50 percent of the average monthly production of a job, which is a reasonable order of magnitude given the available estimates.[30] All in all, the model allows us to explain the large share of entries into temporary jobs observed in Continental European countries.

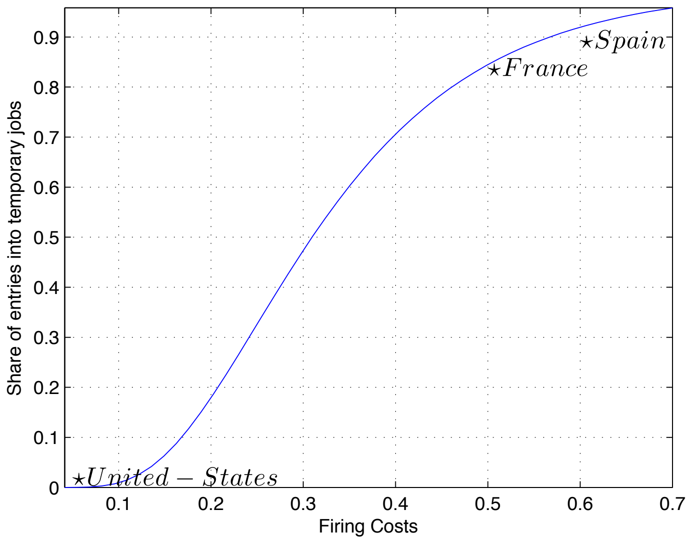

Figure 7: The relation between firing costs (in shares of monthly production of an employee) and the share of entries into temporary jobs in total employment inflows.

The predictions of the model are also in line with the second stylized fact, according to which the average duration of new temporary jobs is very low, about 1.5 months in France. Indeed, the model predicts that the average duration of new temporary jobs is 1.5 months when 90 percent of entries are into temporary jobs.

[30]Kramarz and Michaud (2010) estimate that the termination of the contract of a marginal permanent job amounts to 16 percent of the annual wage for an individual layoff and to 50 percent of the annual wage for a collective layoff in France. Since about 4 out of 6 layoffs are individual layoffs, the average cost is 20 percent of the annual wage, which corresponds to 1.5 months of production if the share of wages in production is 2/3. Assuming that red-tape costs amount to about 1/3 of the total layoff costs, we find that red-tape costs represent about 0.5 month of production. For Spain, we assume as do Bentolila et al. (2012), that firing costs are 20 percent higher than in France, so that they amount to 0.6 month of the average production of jobs.

Figure 8 shows that the model fits the third stylized fact, according to which changes in entries into temporary jobs account for the main share of changes in the total number of entries into employment. This figure represents the relation between changes in productivity, and changes in the number of entries into temporary and permanent jobs. There is an aggregate productivity shock common to all jobs, which implies that the productivity of each job is equal to $p + y$ instead of y previously. The productivity shock is permanent and not anticipated. As can be inferred from the figure which displays the impact of p (on the horizontal axis) on the number of entries (on the vertical axis), productivity shocks induce much larger changes in entries into temporary jobs than into permanent jobs. The rise in entries into temporary jobs following a positive productivity shock is ten times larger than the rise in entries into permanent jobs. This order of magnitude is in line with the facts observed in France and Spain over the period 2000-2010, where the corresponding number lies between 7 and 11, as documented in section 2.

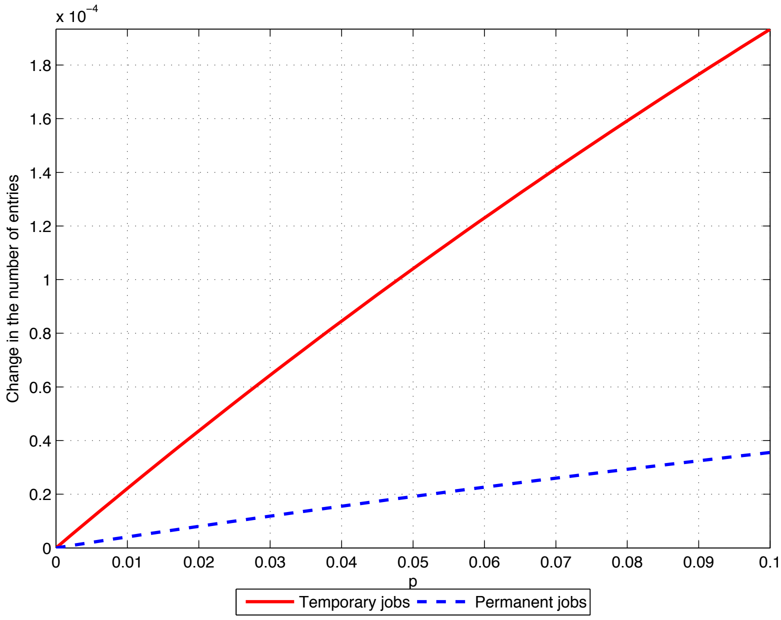

Figure 8: Changes in the number of entries into temporary and permanent employment induced by changes in aggregate productivity.

4.4.3 Job protection and the excess of job turnover

Our model is particularly useful when it comes to evaluating the impact of job protection on job turnover, employment and production.

Job turnover Our model predicts, in line with empirical evidence, that the average duration of new temporary jobs is short, about 1.5 months, when the share of temporary jobs in entries corresponds to that observed in France or Spain. It is interesting to compare this duration with that of jobs that would be used to exploit the same production opportunities (on the same range of type-λ jobs) in the absence of job protection, where all jobs are permanent according to our model. The result is illustrated in figure 9, which shows that the duration of temporary jobs is much shorter than the duration of the permanent jobs which, absent firing costs, would be utilized to exploit the same production opportunities. This figure displays the duration of temporary jobs in the range of shock arrival rates for which temporary jobs are not transformed into permanent jobs. The case where temporary jobs are transformed into permanent jobs is examined below.

For instance, for a value of the average time interval between productivity shocks, δ, equal to 4.5 months, figure 9 shows that the expected duration of permanent jobs is slightly above five months, while the duration of temporary jobs is about five weeks. This difference is indeed quite large, and it increases when productivity shocks are less frequent. The reason is that firms want to avoid situations where they have to pay unproductive workers. This implies that firing costs can induce, through their impact on the creation of temporary jobs, an important excess of job turnover which in turn can induce large production losses.

Obviously, this result hinges on the assumption that the shock arrival rate follows a Poisson process with constant instantaneous probability. Empirical estimates usually find non-monotonous separation rates that begin to increase with tenure and then decrease toward a level that is lower than that observed at the beginning of the employment spell (see e.g. Booth et al., 1999). The relatively high level of separation rates at the beginning of employment spells suggests that the shock arrival rate is higher at the beginning of job spells. This feature should induce employers to shorten the duration of temporary contracts with respect to a situation where the shock arrival rate is constant. Accordingly, it is likely that the assumption of a constant shock arrival rate leads to an underestimation of the discrepancy between the duration

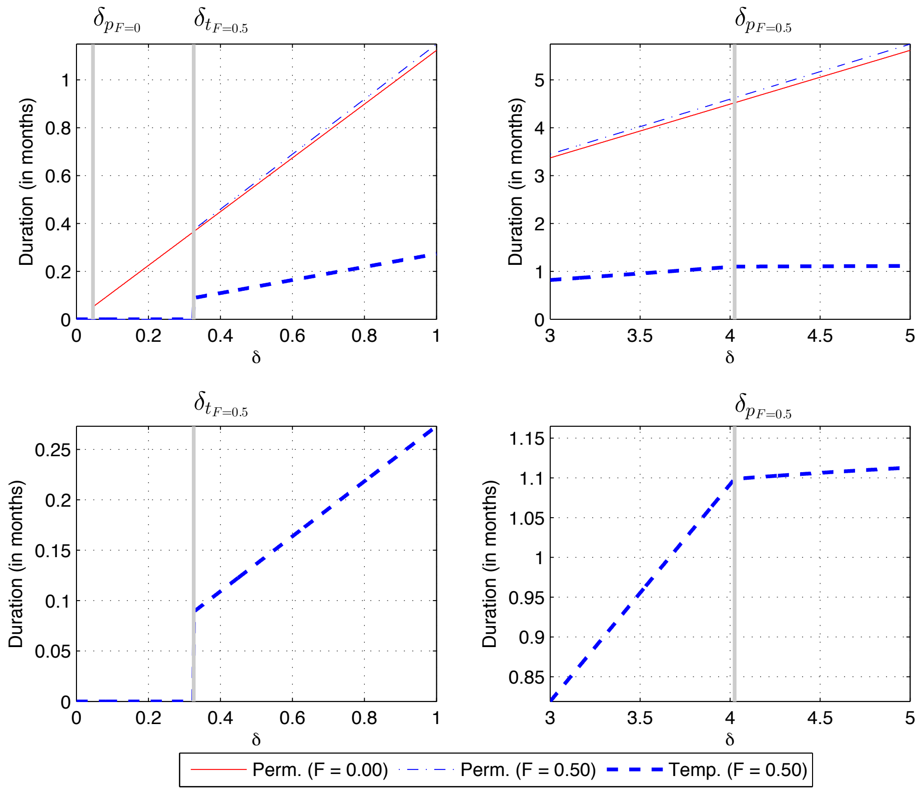

Figure 9: The relation between the average time interval between productivity shocks $\delta = 1/\lambda$ (x-axis) and the expected duration of i) permanent jobs with firing costs (dashed and dotted line), ii) permanent jobs without firing costs (continuous line), iii) temporary jobs (dashed line). Firing costs are expressed in average monthly production of an employee. The two top figures display the duration of both types of jobs. These figures display the duration of temporary jobs in the range of shock arrival rates for which temporary jobs are not transformed into permanent jobs.

of temporary jobs and that of production opportunities.

Figure 10 provides complementary information about the impact of firing costs on jobs and contracts durations. The left hand side panel shows that the mean expected duration of permanent jobs increases with firing costs. The middle panel shows that the duration of temporary contracts also raises with firing costs, as discussed above in Figure 5. The right hand side panel displays the expected duration of jobs starting as temporary jobs including the duration of the job once the contract is turned from temporary to permanent. It appears that the expected duration of temporary jobs is much shorter than that of permanent jobs.

All in all, firing costs increase the expected duration of all types of jobs but raise the share of

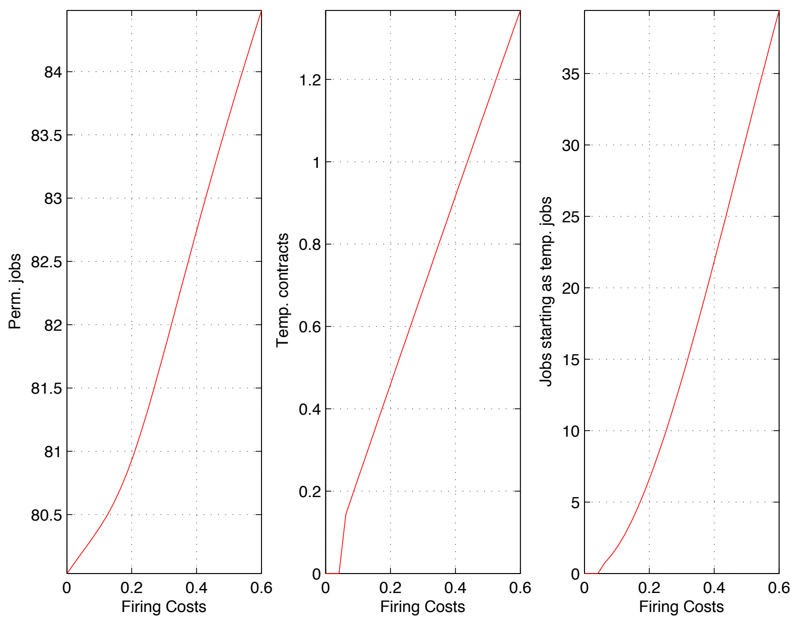

Figure 10: Mean job duration (in months) and firing costs (in share of monthly production of an employee). Left hand side panel: mean expected duration of permanent jobs. Middle panel: mean duration of temporary contracts. Right hand side bottom panel: mean expected duration of jobs starting as temporary jobs (including the duration of the job once the contract is turned from temporary to permanent).

temporary jobs. This implies that higher firing costs can reduce the duration of jobs created to exploit production opportunities with short duration, because they are more often temporary. Obviously, higher firing costs always increase the duration of permanent jobs created to exploit production opportunities with long expected duration. As shown by figure 11, which represents the density of job durations, these counteracting effects of firing costs imply that higher firing costs increase the dispersion of job durations. When firing costs are higher, there are more jobs with long durations. But there are also more jobs with short durations, because there are more temporary jobs.

It turns out that these two counteracting effects have a total positive impact on the average job duration in our model. The average job duration can be computed in two different ways. We can compute either the average duration of the stock of existing jobs (*i.e.* the cross-section of jobs) or the average expected duration of new jobs created. As shown by figure 12, increases in firing costs raise the average duration of the stock of jobs (left hand side panel) and of new jobs (right hand side panel). The effects are nevertheless small: increasing dismissal costs from

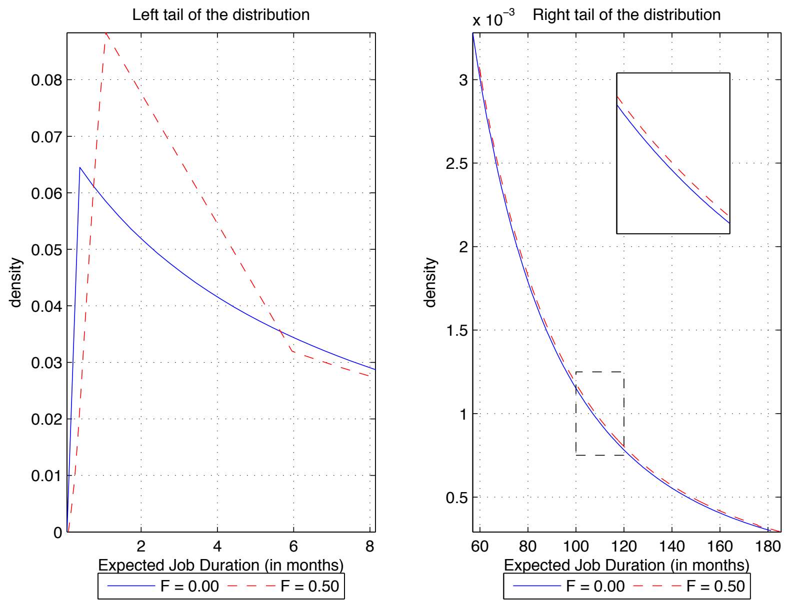

Figure 11: The density of expected job durations (in months) of new jobs for different values of firing costs (in share of monthly production of an employee).

the level observed in the US (equal to zero in the calibration) to that observed in a Continental European country like France (equal to about 50 percent of the average monthly production of jobs), raises the average duration of the stock of jobs by 1.7 percent and the average expected duration of the new jobs by 4.5 percent. This small impact is the net outcome of the two counteracting effects of firing costs on job durations.

Employment and production Let us now analyze the impact of job protection on aggregate production, defined as the sum of production of filled jobs, minus the cost of vacant jobs and the cost of writing contracts. Firing costs are not included in lost output in the benchmark computation.

Employment protection increases the duration of permanent jobs, the duration of temporary jobs (as shown above, figure 5) and the share of temporary jobs. All these effects reduce the average productivity. When job protection becomes more stringent, the average productivity of permanent jobs drops because firms retain permanent jobs with lower productivity. This is the standard labor-hoarding phenomenon. The same phenomenon occurs for temporary jobs, which become less productive on average because firms choose to increase their duration. This

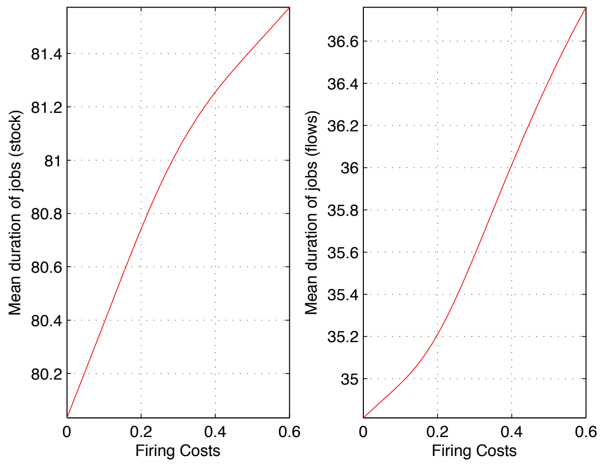

Figure 12: Mean job duration (in months) and firing costs (in share of monthly production of an employee). Left hand side panel: Mean duration of the stock of jobs in cross-section. Right hand side panel: Mean expected duration of new jobs.

implies that firms keep more often unproductive temporary jobs that cannot be destroyed before their termination date. The average productivity of temporary jobs is smaller than that of permanent jobs in our context.[31] Therefore, the increase in the share of temporary jobs also reduces productivity. We find that all these effects imply that the impact of employment protection on aggregate production is much larger than on aggregate employment.

According to our simulation exercises, aggregate production is 0.3 percent lower in the economy with firing costs equal to 50 percent of the average monthly production of jobs than it is in the economy without job protection. Employment is 0.06 percent lower. When firing costs are included in lost output, production drops by 1.6 percent. This shows that changes in production are much larger than changes in employment.

Table 3, which displays the impact of an increase in firing costs from 50 percent to 60 percent of the monthly average production of jobs, corresponding to the French and the Spanish situations respectively, sheds more light on this issue. The three bottom rows show that job protection induces a strong decrease in the number of permanent jobs which is almost compen-

[31] Note that this is always true in the benchmark model where the average productivity of a permanent job is equal to y while that of a temporary job with shock arrival rate λ is equal to y if the temporary job is transformed into a permanent job and to $\frac{1}{\Delta(\lambda)}\int_0^{\Delta(\lambda)} ye^{-\lambda t}\mathrm{d}t = \frac{1-e^{-\lambda\Delta(\lambda)}}{\lambda\Delta(\lambda)}y < y$ if the temporary job is not transformed. Simulations show that the average productivity of temporary jobs is smaller than that of permanent jobs in the model with productivity shocks for empirically relevant values of the parameters.

sated by the increase in the number of temporary jobs, so that the net impact of job protection on total employment is very small, equal to 0.019 percent. The variation in total employment is very small compared to the variation in permanent jobs, meaning that job protection entails a strong reallocation of jobs and negligible effects on total employment. This reallocation has important consequences on production. Rows 2 and 3 of table 3 show that job protection decreases the production of permanent jobs and raises the production of temporary jobs. Row 4 and 5 show that the average productivity of permanent and temporary jobs drops when job protection increases. This is the consequence of the labor hoarding phenomenon described above. The drop in productivity of temporary jobs is about 7 times bigger than that of permanent jobs. These effects reduce total production by 0.09 percent, which is 5 times larger than the relative drop in employment. The relative drop in production becomes 17 times larger than the relative drop in employment if firing costs are included in lost output. This large difference between the change in aggregate production and the change in aggregate employment is the consequence of the increase in the share of temporary jobs, which reduces labor productivity and raises labor turnover costs.

Table 3 highlights a key result of our paper. The calibration assumes however that, absent employment protection, the Hosios condition for efficiency is satisfied. Hence, to assess the robustness of our results, we depart from the standard Hosios condition. We first focus on the case where $\beta = 0.5$, which falls in the range of values $[0.4, 0.6]$ recommended by Petrongolo and Pissarides (2001). We also consider the values found in Millard and Mortensen (1997) ($\beta = 0.3$) and Shimer (2005) ($\beta = 0.7$).[32] Results are provided in the last two columns of table 3. It is evident that our results are robust to these alternative parametric specifications.

All in all, our results point to a large degree of substitution between permanent and temporary jobs. These results are in line with empirical papers which show that job protection has strong effects on the composition of jobs. Centeno and Novo (2012) find that a reform that increased the employment protection of open-ended contracts in Portugal induced an increase in the share of temporary contracts consistent with a high degree of substitution between open-ended and fixed-term contracts. Cappellari et al. (2012) find similar results for Italy. Furthermore, Hijzen et al. (2013) show that these substitution effects induce significant drops in labor productivity.

[32]See Pissarides (2009) for further discussion on this point.

		$\beta = \eta = 0.5$	$\beta = 0.7$	$\beta = 0.3$
Variation in aggregate production	ΔY	-0.0808	-0.0969	-0.0740
Variation in temp. jobs production	ΔY_s	0.3499	0.3453	0.3430
Variation in perm. jobs production	ΔY_p	-0.4307	-0.4422	-0.4170
Variation in temp. jobs productivity	$\Delta \overline{Y_s}$	-0.3040	-0.3824	-0.2576
Variation in perm. jobs productivity	$\Delta \overline{Y_p}$	-0.0431	-0.0720	-0.0314
Variation in the number of jobs	$\Delta(1-u)$	-0.0177	-0.0206	-0.0131
Variation in the number of temp. jobs	Δs	0.6544	0.6085	0.6718
Variation in the number of perm. jobs	Δp	-0.6721	-0.6292	-0.6849

Table 3: Decomposition of the impact of an increase in F from 0.50 to 0.60 on production and employment. At F=0.50, employment is equal to 93.94 and aggregate production to 89.70.

5 Conclusion

By taking into account the situation in which temporary contracts cannot be destroyed at zero cost before their date of termination we have been able to explain not only the choice between temporary and permanent contracts but also the duration of temporary contracts in a search and matching model of the labor market. This model reproduces some important stylized facts about temporary jobs observed in Continental European countries. Our framework shows that job protection of permanent jobs has a negligible impact on total employment but does entail a strong substitution of temporary jobs for permanent jobs, which decreases total production much more than it decreases employment. All in all, this model is useful for explaining and understanding the consequences of the huge creation of temporary jobs observed in Continental European countries characterized by stringent job protection legislations.

This model could be enriched in different ways. In particular, it neglects on-the-job search, a factor which may contribute to explaining the drop in entries into temporary jobs during downturns, when there are fewer voluntary quits associated with job-to-job shifts. It might also prove useful for analyzing the consequence of risk aversion. Another extension might be to consider a framework where the distribution G of durations of production opportunities can change over time.

APPENDIX

A Termination of temporary contracts

This appendix describes the legal rules for the termination of temporary contracts for 7 OECD countries. Other rules governing the conditions of creation, the maximal duration and the renewal of temporary jobs are described in detail in the ILO Employment protection legislation database[33] and in the OECD indicator of job protection.[34] We describe here the total dismissal costs, including severance payments, but our calibration exercises take into account "red tape" costs only. In general, a reasonable approximation of red-tape costs is that they are identical, within each country, for all dismissals, whether on permanent jobs or on temporary jobs before the date of termination stipulated in the contract.

Belgium: In principle regular dismissals (of the kind available in the case of an open-ended contract) are not possible for temporary jobs. The contract has to expire. The party which breaks the contract before the date of expiration without serious cause has to provide a severance payment the amount of which is equal to the minimum of the payment due until the date of expiration of the contract, and twice the payment due during the advance notice if the contract was permanent.

France: Regular dismissals (of the kind available in the case of an open-ended contract) are not possible for temporary jobs. The contract has to expire. Employers can only dismiss fixed-term workers if there is a credible "valid reason" which makes the continuation of employment unacceptable, e.g. fraudulent behavior by the employee. Conversely, the employee can quit if he finds an open-ended contract.

Germany: In principle, regular dismissals (of the kind available in the case of an open-ended contract) are not possible for temporary jobs. The contract has to expire. Employers can only dismiss fixed-term workers if there is a credible "valid reason" which makes the continuation of employment unacceptable, e.g. fraudulent behavior by the employee. The temporary contract can stipulate, however, that the contract can be terminated before the expiration date, with the rules that apply for an open-ended contract.

Greece: Employers can only dismiss fixed-term workers if there is a credible "valid reason"

[33]See http://www.ilo.org/dyn/terminate/
[34]See www.oecd.org/employment/protection

which makes the continuation of employment unacceptable, e.g. fraudulent behavior by the employee. If the contract expires and the worker continues to be employed under the same conditions doing similar or the same work, then the worker is considered as being under an open-ended contract with the corresponding rules applying.

Italy: Regular dismissals (of the kind available in the case of an open ended contract) are not possible. The contract has to expire. Employers can only dismiss fixed-term workers if there is a credible "valid reason" which makes the continuation of employment unacceptable, e.g. fraudulent behavior by the employee. Conversely, the employee can quit if he finds an open-ended contract.

Portugal: the rule for individual dismissal is the same for fixed-term and open-ended contracts. Individual dismissals can be carried out solely for disciplinary reasons, which entails a fairly long disciplinary process. Among OECD countries Portugal is the one with the most stringent legislation for individual dismissals. So, in practice employers avoid this route, either waiting for the end of the fixed term contract (typically a one year contract, renewable for up to three years) or paying the corresponding severance pay (a minimum of three months); or, in the case of open-ended contracts, they negotiate a separation and very often pay out the stipulated amount of severance (one month for each year of tenure).

Spain: If the employer wishes to terminate the contract in advance, he would follow exactly the same procedures as a permanent contract and therefore would pay 20 days for an economic dismissal; but workers can go to court and the employer will normally pay at least the penalty rate of 45 days. So, usually, employers wait for expiration, unless the worker has committed a really serious offence (fraud, etc.).

B The properties of functions $S_p(\lambda)$ and $S_t(\lambda)$

This section proves the properties of $S_p(\lambda)$ and $S_t(\lambda) = \max_\Delta S_t(\lambda, \Delta)$ presented in section 3 and provides a proof for proposition 1. We begin by analyzing the properties of $S_p(\lambda)$, then we continue with the properties of $S_t(\lambda)$ and finally we prove proposition 1.

B.1 Analysis of $S_p(\lambda)$

The function

$$S_p(\lambda) = \frac{y - rU - \lambda F}{r + \lambda} - c, \tag{B1}$$

is continuous. It is decreasing as $S_p'(\lambda) = \frac{-y+rU-rF}{(r+\lambda)^2} \leq 0$. It decreases from $S_p(0) = \frac{y}{r} - U - c > 0$ to $\lim_{\lambda\to+\infty} S_p(\lambda) = -c - F < 0$. Thus, there exists a unique threshold value $\lambda_p = \frac{y-rU-rc}{F+c}$ such that $S_p(\lambda_p) \gtreqless 0$ if and only if $\lambda \lesseqgtr \lambda_p$, as indicated in section 3.

B.2 Properties of the optimal duration $\Delta(\lambda)$

We have:

$$\Delta(\lambda) = \begin{cases} \frac{1}{\lambda} \ln\left(\frac{rU+\lambda F+(r+\lambda)c}{rU}\right) & \text{if } \lambda \leq \lambda_p \\ \frac{1}{\lambda} \ln\left(\frac{y}{rU}\right) & \text{if } \lambda \geq \lambda_p \end{cases} \tag{B2}$$

Function $\Delta(\lambda)$ is continuous and has a kink at λ_p. Let us now show that it is decreasing. This is obvious when $\lambda \geq \lambda_p$. When $\lambda \leq \lambda_p$, we get

$$\begin{aligned} \Delta'(\lambda) &= \frac{1}{\lambda^2} \ln\left(\frac{rU}{rU+\lambda F+(r+\lambda)c}\right) + \frac{1}{\lambda}\left(\frac{F+c}{rU+\lambda F+(r+\lambda)c}\right) \\ &= \frac{1}{\lambda^2}\left[\ln\left(\frac{rU}{rU+\lambda F+(r+\lambda)c}\right) - \left(\frac{rU}{rU+\lambda F+(r+\lambda)c} - 1\right) - \frac{rc}{rU+\lambda F+(r+\lambda)c}\right], \end{aligned}$$

which is negative, because $\ln(x) < x - 1$ for all $x > 0$.

Finally, over the interval $(0, +\infty)$, $\Delta(\lambda)$ goes from $\lim_{\lambda\to 0} \Delta(\lambda) = \lim_{\lambda\to 0} \frac{1}{\lambda} \ln\left(\frac{rU+\lambda F+(r+\lambda)c}{rU}\right) = +\infty$ to $\lim_{\lambda\to+\infty} \Delta(\lambda) = \lim_{\lambda\to+\infty} \frac{1}{\lambda} \ln\left(\frac{y}{rU}\right) = 0$.

B.3 Analysis of $S_t(\lambda)$

- Let us show that $S_t(\lambda)$ is continuous and decreasing with $\lim_{\lambda\to 0} S_t(\lambda) = \frac{y}{r} - U - c > 0$, $\lim_{\lambda\to\infty} S_t(\lambda) = -c$.

- When $\lambda \geq \lambda_p$, we get, from equation (9):

$$S_t'(\lambda) = y\frac{e^{-(r+\lambda)\Delta(\lambda)}\left[(r+\lambda)\Delta(\lambda)+1\right] - 1}{(r+\lambda)^2},$$

  which is negative because $e^{-x} < 1/(x+1)$ when $x > 0$. Equations (9) and (10) allow us to write

$$S_t(\lambda) = y\frac{1 - e^{-(r+\lambda)\Delta(\lambda)}}{r+\lambda} - U\left[1 - e^{-r\Delta(\lambda)}\right] - c.$$

From the definition of $\Delta(\lambda)$ we know that $\lim_{\lambda\to\infty}\Delta(\lambda)=0$ and $e^{-\lambda\Delta(\lambda)}=rU/y$, so that $\lim_{\lambda\to\infty}\frac{1-e^{-(r+\lambda)\Delta(\lambda)}}{r+\lambda}=0$ and $\lim_{\lambda\to\infty}1-e^{-r\Delta(\lambda)}=0$. Therefore, $\lim_{\lambda\to\infty}S_t(\lambda)=-c$.

- When $\lambda<\lambda_p$, we get, from equation (9)

$$S_t'(\lambda)=y\frac{e^{-(r+\lambda)\Delta(\lambda)}\left[(r+\lambda)\Delta(\lambda)+1\right]-1}{(r+\lambda)^2}-e^{-(r+\lambda)\Delta(\lambda)}\left[\Delta(\lambda)S_p(\lambda)-S_p'(\lambda)\right],$$

which is negative, since it has just been shown that the first term $y\frac{e^{-(r+\lambda)\Delta(\lambda)}[(r+\lambda)\Delta(\lambda)+1]-1}{(r+\lambda)^2}$ is negative. Moreover, $S_p(\lambda)>0$ when $\lambda<\lambda_p$, and $S_p'(\lambda)<0$. From the definition of the surplus we get

$$\lim_{\lambda\to 0}S_t(\lambda)=\lim_{\lambda\to 0}S_p(\lambda)=\frac{y}{r}-U-c.$$

- We have established that $S_t(\lambda)$ monotonically decreases from $\frac{y}{r}-U-c$ to $-c$. Thus, there exists a unique threshold λ_t such that $S_t(\lambda_t)=0$. Using the expression of the surplus (9), it follows that λ_t solves the following equation

$$y\frac{1-e^{-(r+\lambda_t)\Delta(\lambda_t)}}{r+\lambda_t}-U(1-e^{-r\Delta(\lambda_t)})-c=0. \tag{B3}$$

B.4 Proof of proposition 1

Case 1. $c=0$. In this case, we can show that it is always preferable to create temporary jobs rather than permanent jobs for all $\lambda>0$. It is convenient to define

$$h(\lambda)\equiv S_t(\lambda)-S_p(\lambda).$$

From (4) and (9), we get

$$h(\lambda)=\int_0^{\Delta}\left(ye^{-\lambda\tau}-rU\right)e^{-r\tau}\mathrm{d}\tau+\max\left[S_p(\lambda),0\right]e^{-(r+\lambda)\Delta}-\frac{y-rU-\lambda F}{r+\lambda}. \tag{B4}$$

- **Case 1a:** $S_p(\lambda)<0$. Let us show that $S_t(\lambda)>0$ for all $\lambda>0$ so that it is always worth creating temporary jobs in that case. Equation (10) allows us to write $y=rUe^{\lambda\Delta(\lambda)}$. Substituting in equation (9), we get:

$$S_t(\lambda)=\frac{y-rUe^{-r\Delta(\lambda)}}{r+\lambda}-U\left(1-e^{-r\Delta(\lambda)}\right).$$

From this expression of $S_t(\lambda)$, it appears that $\lim_{\lambda\to 0}\Delta(\lambda)=\infty$ implies that $\lim_{\lambda\to 0} S_t(\lambda)=\frac{y-rU}{r}>0$ and that $\lim_{\lambda\to\infty}\Delta(\lambda)=0$ implies that $\lim_{\lambda\to\infty} S_t(\lambda)=0$. We get, from equation (9):

$$S_t'(\lambda)=y\frac{e^{-(r+\lambda)\Delta(\lambda)}\left[(r+\lambda)\Delta(\lambda)+1\right]-1}{(r+\lambda)^2},$$

which is negative because $e^{-x}<1/(x+1)$ when $x>0$. Therefore, $S_t(\lambda)$ is decreasing on $(0,+\infty)$ and goes from $\frac{y-rU}{r}>0$ to zero. Hence, $S_t(\lambda)>0$ for all $\lambda>0$, meaning that it is optimal to create temporary jobs when $c=0$ and $S_p(\lambda)<0$.

- **Case 1b:** $S_p(\lambda)>0$. Since $\Delta(\lambda)=\frac{1}{\lambda}\ln\left(\frac{rU+\lambda F}{rU}\right)$ (see equation (11)), (B4) implies that:

$$h(\lambda)=-U(1-e^{-r\Delta(\lambda)})+\frac{rU+\lambda F}{r+\lambda}-\frac{rU}{r+\lambda}e^{-r\Delta(\lambda)}.$$

Using the fact that $\lim_{x\to 0}\log(1+x)=\lim_{x\to 0}x$ and $\lim_{x\to 0}e^{-x}=\lim_{x\to 0}1-x$, we get $\lim_{F\to 0}e^{-r\Delta(\lambda)}=\lim_{F\to 0}(1-\frac{F}{U})$. Therefore:

$$\lim_{F\to 0}h(\lambda)=\lim_{F\to 0}\left[-F+\frac{rU+\lambda F}{r+\lambda}-\frac{rU}{r+\lambda}\left(1-\frac{F}{U}\right)\right]=0.$$

The envelop theorem implies that

$$\frac{\mathrm{d}S_t(\lambda)}{\mathrm{d}F}=\frac{\mathrm{d}S_p(\lambda)}{\mathrm{d}F}e^{-(r+\lambda)\Delta(\lambda)},$$

and therefore, using the expression of $S_p(\lambda)$ (see equation (4)), that

$$\frac{\mathrm{d}h(\lambda)}{\mathrm{d}F}=\frac{\mathrm{d}S_t(\lambda)}{\mathrm{d}F}-\frac{\mathrm{d}S_p(\lambda)}{\mathrm{d}F}=\frac{\lambda\left[1-e^{-(r+\lambda)\Delta(\lambda)}\right]}{r+\lambda}>0$$

Since $\lim_{F\to 0}h(\lambda)=\lim_{F\to 0}S_t(\lambda)-S_p(\lambda)=0$ and $\frac{\mathrm{d}h(\lambda)}{\mathrm{d}F}=\frac{\mathrm{d}S_t(\lambda)}{\mathrm{d}F}-\frac{\mathrm{d}S_p(\lambda)}{\mathrm{d}F}>0$, we have $h(\lambda)>0$ for all $\lambda>0$. Therefore, it is optimal to create temporary jobs when $c=0$ and $S_p(\lambda)>0$, provided that $F>0$.

Cases 2 and 3. $c>0$. We prove that (i) $\exists\lambda|S_t(\lambda)=S_p(\lambda)$; (ii) $\lambda|S_t(\lambda)=S_p(\lambda)$ is unique. We also prove that (iii) when $S_t(\lambda_p)<0$ holds (case 2 of Proposition 1), we have $0<\lambda_t<\lambda_p<\lambda_s$, while (iv) when $S_t(\lambda_p)>0$ holds (case 3), we have $0<\lambda_s<\lambda_p<\lambda_t$, where $\lambda_p=\{\lambda|S_p(\lambda)=0\}$, $\lambda_t=\{\lambda|S_t(\lambda)=0\}$ and $\lambda_s=\{\lambda|S_t(\lambda)=S_p(\lambda)\}$.

Let us first make use of the FOC (10) to substitute the term $\max\left[S_p(\lambda), 0\right] = \frac{y - rUe^{\lambda\Delta(\lambda)}}{r+\lambda}$ in (9). We get that the surplus $S_t(\lambda)$ can be written:

$$S_t(\lambda) = \frac{y}{r+\lambda} - U + \frac{\lambda U e^{-r\Delta(\lambda)}}{r+\lambda} - c.$$

This expression, substracted to that of the surplus $S_p(\lambda)$ given by equation (4), implies that function $h(\lambda)$ is equal to:

$$h(\lambda) = \frac{\lambda F - \lambda U(1 - e^{-r\Delta(\lambda)})}{r+\lambda}. \tag{B5}$$

Let us study the properties of function $h(\lambda)$ defined by (B5) for $\lambda \in [0, +\infty)$ to examine the intercept of $S_t(\lambda)$ and $S_p(\lambda)$.

(i) Let us first prove that $\exists \lambda | S_t(\lambda) = S_p(\lambda)$. Function h is continuous and defined over the interval $[0, +\infty)$, with $\lim\limits_{\lambda\to 0} h(\lambda) = 0^-$ and $\lim\limits_{\lambda\to\infty} h(\lambda) = F \geq 0$. Besides,

$$h'(\lambda) = \frac{-\lambda U r \Delta'(\lambda) e^{-r\Delta(\lambda)}}{r+\lambda} + \frac{r\left(F-U\right)}{\left(r+\lambda\right)^2} + \frac{rUe^{-r\Delta(\lambda)}}{\left(r+\lambda\right)^2}. \tag{B6}$$

The sign of $h'(\lambda)$ is ambiguous as $F < U$. However, $\lim\limits_{\lambda\to 0} h'(\lambda) = \frac{F-U}{r} < 0$, as $\lim\limits_{\lambda\to 0} e^{-r\Delta(\lambda)} = 0$ and $\lim\limits_{\lambda\to 0} \Delta'(\lambda) e^{-r\Delta(\lambda)} = 0$. Therefore, h starts from a negative value close to zero, is first decreasing (negatively valued) and must then be increasing over some range to meet the condition $\lim\limits_{\lambda\to+\infty} h(\lambda) = F > 0$. By continuity, there exists at least one value of λ, such that $h(\lambda) = 0$.

(ii) Let us prove that there exists a unique value of λ, denoted by λ_s such that $h(\lambda_s) = 0$. Using (B5), the definition of λ_s implies $F = U(1 - e^{-r\Delta(\lambda_s)})$. Reinserting in (B6) yields:

$$h'(\lambda_s) = \frac{-\lambda_s U r \Delta'(\lambda_s) e^{-r\Delta(\lambda_s)}}{r+\lambda_s} \geq 0,$$

which establishes uniqueness, as multiple thresholds would imply $h' \leq 0$ for at least one of those thresholds. As a result, we have $h(\lambda) \leq 0$ for $\lambda \leq \lambda_s$ while $h(\lambda) > 0$ for $\lambda > \lambda_s$. Now, we have shown the existence and the uniqueness of $\lambda_s = \{\lambda | S_t(\lambda) = S_p(\lambda)\}$, $\lambda_p = \{\lambda | S_p(\lambda) = 0\}$ (see appendix B.1), and $\lambda_t = \{\lambda | S_t(\lambda) = 0\}$ (see appendix B.3).

(iii) Let us prove the claim of case 1, where $S_t(\lambda_p) < 0$. It is easy to show that $\lambda_p > \lambda_t$: since $S_t(\lambda)$ is decreasing, $S_t(\lambda_p) < 0 = S_t(\lambda_t)$ implies at $\lambda_p > \lambda_t$. Let us show that $\lambda_p < \lambda_s$.

We have established that $h(\lambda) \leq 0$ for $\lambda \leq \lambda_s$ while $h(\lambda) > 0$ for $\lambda > \lambda_s$. $S_t(\lambda_p) < 0$ implies $h(\lambda_p) < 0$ and thus $\lambda_p < \lambda_s$. In this case, temporary contracts cannot be profitably utilized and only permanent contracts are chosen for $\lambda < \lambda_p$ while no contract is profitable for $\lambda > \lambda_p$.

(iv) Let us show that $0 < \lambda_s < \lambda_p < \lambda_t$ when $S_t(\lambda_p) > 0$. Let us first show that $\lambda_s < \lambda_p$ and then that $\lambda_p < \lambda_t$ when $S_t(\lambda_p) > 0$.

Let us prove that $\lambda_s < \lambda_p$. We have established that $h(\lambda) \leq 0$ for $\lambda \leq \lambda_s$ while $h(\lambda) > 0$ for $\lambda > \lambda_s$. Making use of the FOC (10) to substitute $y = rUe^{\lambda\Delta(\lambda)} + (r+\lambda)\max[S_p(\lambda), 0]$ in the equation of the surplus $S_t(\lambda)$ given by (9), we can write:

$$S_t(\lambda) = \max[S_p(\lambda), 0] - c + rU\left(e^{\lambda\Delta(\lambda)}\frac{1-e^{-(r+\lambda)\Delta(\lambda)}}{r+\lambda} - \frac{1-e^{-r\Delta(\lambda)}}{r}\right). \tag{B7}$$

Using the expression above (B7), condition $S_t(\lambda_p) > 0$ is equivalent to:

$$rU\left(e^{\lambda_p\Delta(\lambda_p)}\frac{1-e^{-(r+\lambda_p)\Delta(\lambda_p)}}{r+\lambda_p} - \frac{1-e^{-r\Delta(\lambda_p)}}{r}\right) > c,$$

or, making use of the FOC (10), which implies that in $\lambda = \lambda_p$, $ye^{-\lambda_p\Delta(\lambda_p)} = rU$, it is also equivalent to:

$$y\left(\frac{1-e^{-(r+\lambda_p)\Delta(\lambda_p)}}{r+\lambda_p} - e^{-\lambda_p\Delta(\lambda_p)}\frac{1-e^{-r\Delta(\lambda_p)}}{r}\right) > c.$$

Then, $S_t(\lambda_p) > 0$ implies $h(\lambda_p) > 0 = h(\lambda_s)$. Therefore, we have that $\lambda_p > \lambda_s$ when condition $S_t(\lambda_p) > 0$ is met.

Let us prove that $\lambda_p < \lambda_t$. Since S_t is decreasing in λ, when $S_t(\lambda_p) > 0 = S_t(\lambda_t)$, we have $\lambda_t > \lambda_p$. Therefore, when $S_t(\lambda_p) > 0$, temporary contracts are chosen for $\lambda \in [\lambda_s, \lambda_t]$ while permanent contracts are chosen for $\lambda < \lambda_s$, and there are no jobs above λ_t, as claimed in case 3 of proposition 1.

C Optimal duration of temporary jobs in the model with productivity shocks

The optimal duration of temporary jobs maximizes the surplus of starting temporary jobs. We first consider temporary jobs which are not transformed into permanent jobs because the shock arrival rate is above the threshold value λ_p. Then, the case of temporary jobs that can be transformed into permanent jobs is studied in a second step.

C.1 Case 1: $\lambda \geq \lambda_p$

If $\lambda \geq \lambda_p$, the surplus of a temporary job with shock arrival rate λ and duration Δ is:

$$S_t(\lambda, \Delta) = \int_0^{\Delta} \left(e^{-\lambda\tau} y_u + \left(1 - e^{-\lambda\tau}\right) \int_{-\infty}^{y_u} y \mathrm{d}H(y) - rU \right) e^{-r\tau} \mathrm{d}\tau - c.$$

The first order condition, $\partial S_t(\lambda, \Delta)/\partial\Delta = 0$, can be written as:

$$e^{-\lambda\Delta} y_u + \left(1 - e^{-\lambda\Delta}\right) \int_{-\infty}^{y_u} y \mathrm{d}H(y) - rU = 0.$$

The second order condition:

$$-\lambda e^{-\lambda\Delta} \int_{-\infty}^{y_u} (y_u - y) \, \mathrm{d}H(y) < 0,$$

is always satisfied. Then, the optimal duration is:

$$\Delta(\lambda) = \frac{1}{\lambda} \ln \frac{y_u - \int_{-\infty}^{y_u} y \mathrm{d}H(y)}{rU - \int_{-\infty}^{y_u} y \mathrm{d}H(y)},$$

which corresponds to the expression given by equation (23).

C.2 Case 2. $\lambda \leq \lambda_p$

When $\lambda \leq \lambda_p$, the surplus of a permanent job with shock arrival rate λ and duration Δ is:

$$\begin{aligned} S_t(\lambda, \Delta) &= \int_0^{\Delta} \left(e^{-\lambda\tau} y_u + \left(1 - e^{-\lambda\tau}\right) \int_{-\infty}^{y_u} y \mathrm{d}H(y) - rU \right) e^{-r\tau} \mathrm{d}\tau + \\ & \quad e^{-(r+\lambda)\Delta} S_p(y_u, \lambda) + \left(1 - e^{-\lambda\Delta}\right) e^{-r\Delta} \int_{T(\lambda)}^{y_u} S_p(y, \lambda) \mathrm{d}H(y) - c. \end{aligned}$$

where $T(\lambda)$ is defined by equation (18). The first order condition, $\partial S_t(\lambda, \Delta)/\partial\Delta = 0$, can be written as:

$$\begin{aligned} & e^{-\lambda\Delta} y_u + \left(1 - e^{-\lambda\Delta}\right) \int_{-\infty}^{y_u} y \mathrm{d}H(y) - rU - r \int_{T(\lambda)}^{y_u} S_p(y, \lambda) \mathrm{d}H(y) \\ & +(r + \lambda) e^{-\lambda\Delta} \left(S_p(y_u, \lambda) - \int_{T(\lambda)}^{y_u} S_p(y, \lambda) \mathrm{d}H(y) \right) = 0. \end{aligned}$$

The second order condition:

$$-\lambda e^{-\lambda\Delta} \left[\int_{-\infty}^{y_u} (y_u - y) \, \mathrm{d}H(y) - (r + \lambda) \left(S_p(y_u, \lambda) - \int_{T(\lambda)}^{y_u} S_p(y, \lambda) \mathrm{d}H(y) \right) \right] < 0,$$

is always satisfied. Thus, the optimal duration is:

$$\Delta(\lambda) = \frac{1}{\lambda} \ln \frac{y_u - \int_{-\infty}^{y_u} y \mathrm{d}H(y) - (r + \lambda) \left[S_p(y_u, \lambda) - \int_{T(\lambda)}^{y_u} S_p(y, \lambda) \, \mathrm{d}H(y) \right]}{rU - \int_{y_{\min}}^{y_{\max}} y \mathrm{d}H(y) + r \int_{T(\lambda)}^{y_u} S_p(y, \lambda) \, \mathrm{d}H(y),},$$

which corresponds to the expression given equation (23).

D The properties of functions $S_p(y_u, \lambda)$ and $S_t(\lambda)$ in the model with productivity shocks

D.1 Properties of $S_p(y_u, \lambda)$

The surplus of a starting permanent job with productivity y_u and shock arrival rate λ is:

$$S_p(y_u, \lambda) = \frac{y_u - rU - \lambda F}{r + \lambda} - c + \frac{\lambda}{r+\lambda} \int_{R(\lambda)}^{y_u} \frac{x - R(\lambda)}{r + \lambda} \mathrm{d}H(x). \tag{D8}$$

From this expression, it is straightforward to prove, assuming that $y_u - rU > rF$, that S_p is continuous in λ and decreases from:

$$\lim_{\lambda \to 0} S_p(y_u, \lambda) = \frac{y_u}{r} - U - c,$$

to

$$\lim_{\lambda \to +\infty} S_p(y_u, \lambda) = -F - c.$$

D.2 Properties of $S_t(\lambda)$

The surplus of a starting temporary job with shock arrival rate λ and optimal duration $\Delta(\lambda) = \max_\Delta S_t(\lambda, \Delta)$ is, using equation (22):

$$\begin{aligned} S_t(\lambda) \;=\; & \int_0^{\Delta(\lambda)} \left(e^{-\lambda\tau} y_u + \left(1 - e^{-\lambda\tau}\right) \int_{-\infty}^{y_u} y \mathrm{d}H(y) - rU \right) e^{-r\tau} \mathrm{d}\tau + \\ & e^{-(r+\lambda)\Delta(\lambda)} \max\left[S_p(y_u, \lambda), 0\right] + \left(1 - e^{-\lambda\Delta(\lambda)}\right) e^{-r\Delta(\lambda)} \int_{-\infty}^{y_u} \max\left[S_p(y, \lambda), 0\right] \mathrm{d}H(y) - c. \end{aligned} \tag{D9}$$

From this expression, it is easily checked that $S_t(\lambda)$ is continuous and decreasing from $\lim_{\lambda \to 0} S_t(\lambda) = \frac{y_u}{r} - U - c$ to $\lim_{\lambda \to +\infty} S_t(\lambda) = -c$. It turns out that $\lim_{\lambda \to +\infty} S_t(\lambda) = -c$ because equation (23) implies that $\lim_{\lambda \to +\infty} \Delta(\lambda) = 0$ and $\max\left[S_p(y_u, \lambda), 0\right] = 0$ when $\lambda \to +\infty$. Moreover, $\lim_{\lambda \to 0} S_t(\lambda) = \frac{y_u}{r} - U - c$ because equation (23), which implies $\lim_{\lambda \to 0} \Delta(\lambda) = +\infty$, yields, using expression (D9):

$$\lim_{\lambda \to 0} S_t(\lambda) = \frac{y_u}{r} - U - c.$$

D.3 Intercept of S_t and S_p in the model with productivity shocks:

Using the expression (D9) of $S_t(\lambda)$, and keeping in mind that $\lim_{\lambda \to 0} \Delta(\lambda) = +\infty$, we get:

$$\lim_{\lambda \to 0} S_t'(\lambda) = \frac{-y_u + \int_{-\infty}^{y_u} y \mathrm{d}H(y)}{r^2}. \tag{D10}$$

Similarly, using the expression (D8) of $S_p(y_u, \lambda)$, and keeping in mind that $\lim_{\lambda\to 0} R(\lambda) = rU - rF$, we get:

$$\lim_{\lambda\to 0} S_p'(y_u, \lambda) = -\frac{y_u - r(U-F)}{r^2} + \frac{\int_{r(U-F)}^{y_u} [y - r(U-F)] \, \mathrm{d}H(y)}{r^2}. \tag{D11}$$

Using (D10) and (D11) we get:

$$\lim_{\lambda\to 0} S_p'(y_u, \lambda) > \lim_{\lambda\to 0} S_t'(\lambda) \Leftrightarrow \int_{-\infty}^{r(U-F)} [y - r(U-F)] \, \mathrm{d}H(y) < 0,$$

which holds if and only if $U > F$.

Since $\lim_{\lambda\to 0} S_t(\lambda) = \lim_{\lambda\to 0} S_p(y_u, \lambda)$, the fact that $\lim_{\lambda\to 0} S_p'(y_u, \lambda) > \lim_{\lambda\to 0} S_t'(\lambda)$ if and only if $U > F$ implies that there exists a value of $\lambda > 0$ such that $S_p(y_u, \lambda) > S_t(\lambda)$ in the neighborhood of $\lambda = 0$, if and only if $U > F$. Condition $U > F$ is assumed throughout the paper. Then S_p and S_t have at least one positive intercept for positive values of $S_t(\lambda)$ if $S_p(y_u, \lambda_p) = 0 < S_t(\lambda_p)$. This yields a condition similar to condition $S_t(\lambda_p) > 0$ in the benchmark model (Proposition 1). We checked that this intercept is unique in the calibration exercises.

E Labor market equilibrium

E.1 Equilibrium with permanent jobs only

The free entry condition and the condition that defines the threshold value of the shock arrival rate above which no jobs are created are respectively:

$$\kappa = \frac{q(\theta)(1-\beta)}{r + q(\theta)} \int_{\lambda_{\min}}^{\lambda_p} S_p(y_u, \lambda) \mathrm{d}G(\lambda), \tag{E12}$$

$$S_p(y_u, \lambda_p) = 0, \tag{E13}$$

with

$$(r+\lambda) S_p(y_u, \lambda) = y_u - rU - \lambda F + \lambda \int_{R(\lambda)}^{y_u} \frac{y - R(\lambda)}{r + \lambda} \mathrm{d}H(y) - (r+\lambda)\, c, \tag{E14}$$

$$R(\lambda) = r(U-F) - \lambda \int_{R(\lambda)}^{y_u} \frac{y - R(\lambda)}{r+\lambda} \mathrm{d}H(y), \tag{E15}$$

$$rU = z + \frac{\beta\theta\,[r + q(\theta)]}{(1-\beta)\, G(\lambda_p)} \kappa. \tag{E16}$$

Substituting (E16) in (D8) and (E15) implies that the threshold value of shock arrival rates λ_p above which no jobs are created $S_p(y_u, \lambda_p) = 0$, can be restated as $\lambda_p \equiv \lambda_p(\theta)$. Then, the free entry condition, which defines the equilibrium value of θ, can be written as follows:

$$\Gamma(\theta) \equiv \kappa - \frac{q(\theta)(1-\beta)}{r+q(\theta)} \int_{\lambda_{\min}}^{\lambda_p(\theta)} S_p(y_u,\lambda)\mathrm{d}G(\lambda) = 0. \tag{E17}$$

Differentiating (E17) with respect to θ, keeping in mind that $S_p(y_u,\lambda_p)=0$, yields:

$$\Gamma'(\theta) = -(1-\beta)\frac{q'(\theta)r}{[r+q(\theta)]^2} \int_{\lambda_{\min}}^{\lambda_p(\theta)} S_p(y_u,\lambda)\mathrm{d}G(\lambda) - \frac{q(\theta)(1-\beta)}{r+q(\theta)} \int_{\lambda_{\min}}^{\lambda_p(\theta)} \frac{\mathrm{d}S_p(y_u,\lambda)}{\mathrm{d}\theta}\mathrm{d}G(\lambda),$$

where $\frac{\mathrm{d}S_p(y_u,\lambda)}{\mathrm{d}\theta} < 0$ (from equations (D8) and (E16)) so that $\Gamma'(\theta) > 0$. This implies that (E17) defines a unique value of θ provided that the conditions of existence of θ are satisfied.

E.2 Equilibrium with permanent and temporary jobs

The free entry condition and the conditions that define the threshold value of the shock arrival rate above which no temporary jobs are created λ_t, the threshold value of the shock arrival rate above which no permanent job can be profitably created λ_p, and the segmentation threshold between permanent and temporary contracts, λ_s, are respectively:

$$\kappa = \frac{q(\theta)(1-\beta)}{r+q(\theta)} \left[\int_{\lambda_{\min}}^{\lambda_s} S_p(y_u,\lambda)\mathrm{d}G(\lambda) + \int_{\lambda_s}^{\lambda_t} S_t(\lambda)\mathrm{d}G(\lambda) \right], \tag{E18}$$

$$S_p(y_u,\lambda_p) = 0, \tag{E19}$$

$$S_t(\lambda_s) = S_p(y_u,\lambda_s), \tag{E20}$$

$$S_t(\lambda_t) = 0, \tag{E21}$$

where the surplus of a starting permanent contract with productivity y and shock arrival rate λ writes:

$$(r+\lambda)S_p(y,\lambda) = y - rU - \lambda F + \lambda \int_{R(\lambda)}^{y_u} \frac{y-R(\lambda)}{r+\lambda}\mathrm{d}H(y) - (r+\lambda)\,c, \tag{E22}$$

where

$$R(\lambda) = r(U-F) - \lambda \int_{R(\lambda)}^{y_u} \frac{y-R(\lambda)}{r+\lambda}\mathrm{d}H(y), \tag{E23}$$

and

$$rU = z + \frac{\beta\theta\,[r+q(\theta)]}{(1-\beta)\,G(\lambda_t)}\kappa, \tag{E24}$$

while the surplus of a temporary contract with shock arrival rate λ writes:

$$\begin{aligned} S_t(\lambda) &= \frac{1-e^{-(r+\lambda)\Delta(\lambda)}}{r+\lambda} y_u + \frac{\lambda(1-e^{-r\Delta(\lambda)}) + r(e^{-(r+\lambda)\Delta(\lambda)} - e^{-r\Delta(\lambda)})}{r(r+\lambda)} \int y \mathrm{d}H(y) \qquad \text{(E25)} \\ & +e^{-(r+\lambda)\Delta(\lambda)} \max\left[S_p\left(y_u,\lambda\right),0\right] + e^{-r\Delta(\lambda)}\left(1-e^{-\lambda\Delta(\lambda)}\right) \int \max\left[S_p\left(y,\lambda\right),0\right] \mathrm{d}H(y) \\ & -U(1-e^{-r\Delta(\lambda)}) - c, \end{aligned}$$

where $\Delta(\lambda)$ is defined by equation (23).

Substituting (E24) in equations (E22), (E23) and (E25), and making use of (E19), (E20) and (E21) imply that we can restate the thresholds as $\lambda_s \equiv \lambda_s(\theta), \lambda_p \equiv \lambda_p(\theta), \lambda_t \equiv \lambda_t(\theta)$, so that the free entry condition, which defines the equilibrium value of θ, can be written

$$\Gamma(\theta) \equiv \kappa - \frac{q(\theta)(1-\beta)}{r+q(\theta)} \left[\int_{\lambda_{\min}}^{\lambda_s(\theta)} S_p(y_u,\lambda) \mathrm{d}G(\lambda) + \int_{\lambda_s(\theta)}^{\lambda_p(\theta)} S_t(\lambda) \mathrm{d}G(\lambda) + \int_{\lambda_p(\theta)}^{\lambda_t(\theta)} S_t(\lambda) \mathrm{d}G(\lambda) \right] = 0. \qquad \text{(E26)}$$

Differentiating Γ with respect to θ, and keeping in mind that $S_p(y_u, \lambda_s(\theta)) = S_t(\lambda_s(\theta))$ and that $S_t(\lambda_t(\theta)) = 0$, yields:

$$\begin{aligned} \Gamma'(\theta) &= -(1-\beta)\frac{q'(\theta)r}{[r+q(\theta)]^2} \left[\int_{\lambda_{\min}}^{\lambda_s(\theta)} S_p(y_u,\lambda)\mathrm{d}G(\lambda) - \int_{\lambda_s(\theta)}^{\lambda_t(\theta)} S_t(\lambda)\mathrm{d}G(\lambda) \right] \\ & \quad -\frac{q(\theta)(1-\beta)}{r+q(\theta)} \int_{\lambda_{\min}}^{\lambda_s(\theta)} \frac{\mathrm{d}S_p(y_u,\lambda)}{\mathrm{d}\theta}\mathrm{d}G(\lambda) - \int_{\lambda_s(\theta)}^{\lambda_t(\theta)} \frac{\mathrm{d}S_t(\lambda)}{\mathrm{d}\theta}\mathrm{d}G(\lambda), \end{aligned}$$

where $\frac{\mathrm{d}S_p(y_u,\lambda)}{\mathrm{d}\theta} < 0$ (from equations (D8) and (E16)) and $\frac{\mathrm{d}S_t(\lambda)}{\mathrm{d}\theta} \leq 0$ (from equations (D9) and (E16)), so that $\Gamma'(\theta) > 0$. Again, the uniqueness of the equilibrium value of θ follows.

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