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ADVERSE SELECTION IN THE LABOUR MARKET: IMPLICATIONS TOWARDS FIRM DYNAMICS

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Abstract

In this paper we develop a labour market model where both components of worker flows, namely job flows and replacement are addressed. At micro level, firms decide simultaneously about job creation and workers replacement. The main features of the model are asymmetric information about workers productivity and search frictions. Combining these two stochastic dimensions allows to rationalize some facts on firm dynamics, which is not addressed by models using just one of the features mentioned above. As a result we have an integrated framework on labour market which delivers predictions on firm dynamics, worker dynamics and unemployment, all compatible with each other. This makes the model an useful device to evaluate implications of policy shocks on several dimensions of the labor market.

KEY WORDS: replacement, firm dynamics, unemployment
JEL CODES: J63, J64, J21

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1 introduction

One stylised fact about worker flows is the relevance of it's two components: workers replacement and job flows (job creation and job destruction). This is shown in empirical papers pointing that job flows reach high magnitudes and are substantially outnumbered by worker flows[1].

However replacement and job creation are treated in separated studies, analysing distinct aspects of the labour market. While job creation appears in papers focusing on unemployment determination based on search friction, replacement is analysed in models of asymmetric information to rationalize some empirical regularities on worker dynamics.

In this paper we develop a labour market model where firms decide simultaneously about job creation and workers replacement. We basically add search frictions to a particular framework of asymmetric information in the labour market, which deals with adverse selection [2].

In doing so we are able to extend the set of predictions beyond the dimensions treated separated by these two frameworks, which are unemployment and worker dynamics. Our extended framework delivers predictions also in a new dimension, namely, firm dynamics. Moreover these new predictions are compatible with some of the main empirical regularities pointed by the literature on firm dynamics.

The labour market represented in our model evolves in the following way. Initially firms post an optimal number of vacancies. The labour force size and composition will vary across firms due to the stochastic environment where hiring takes place. Firms then decide if they replace any of it's employees and if it will open any new job position. Replaced workers will integrate the job seekers pool, together with unemployed workers and those coming from firms that face adverse productivity shocks and have to shut down. Search frictions prevents firms to chase only high productive workers for their open vacancies, and so replaced workers may find another job.

Firms' subsequent decisions on replacement and job creation depend on initial labour force size and composition, leading to testable predictions exploring performance path dependence with respect to these initial conditions.

Two alternative wage determination procedures fit in the model. One is based on a restrictive assumption of posted wages, while the other generalizes wage determination through a bargain process, in which posted wages fits as

[1]See for instance: Hamermesh et al. (1996), Davis and Haltiwanger (1998), Albaek and Sorensen (1998), Abowd et al. (1999), Burgess et al. (2000).

[2]Models of asymmetric information can be splitted according to the variability of worker's productivity across firms. The assumption of constant productivity across firms leads to the adverse selection configuration in the labour market.

a particular case.

The model developed in this paper has direct connection with two branches in the literature. The first is composed by models on adverse selection in the labour market such as Greenwald (1986), Gibbons and Katz (1991) and Canziani and Petrongolo (2001). Our approach to model replacement decisions, based on the revelation of worker's productivity, is very similar to the one used by these papers to model lay-off decisions. One important difference comes with the introduction of search friction, which simplifies the wage determination process and allows the analysis of a more elaborated employment decision, which introduces the firm dynamics dimension.

The second branch refers to a specific class of matching models of unemployment, where firms decide about it's labour force size. Bertola and Caballero (1994), Bertola and Garibaldi (2001) and Garibaldi (2006) are the main references in this class of models. Our approach to model job creation is very similar to the one used by these papers. Our contribution to this literature is to show that the introduction of the simplest form of heterogeneity had driven us to a larger set of interesting predictions, including a new component of unemployment flow.

The nature of firm's decision process and the stylised facts on firm dynamics predicted by our model connects it with the active exploitation framework of Ericson and Pakes (1995). As in their model firms takes a risky action to change their performance after learning about a previous result. In our framework replacement can be seen as the risky action, since firm may either loose some profit, if it does not fill all the vacancies open due to replacement, or increase it getting a higher share of type 1 workers.

Finally, it worths mention that Moscarini (2005) followed a similar strategy, combining models on imperfect information on workers productivity with matching models. He also delivers predictions on worker dynamics and unemployment. However his model differs from ours in two dimensions. First, the information problem in his framework is not characterized as adverse selection since low productive type workers in one firm can become high productive in another firm. This implies that his model does not predicts any additional welfare loss for any particular group of displaced workers. Second, he does not incorporate firm's decision on labour force size, which makes his model silent about firm dynamics.

The outline for the rest of the paper is the following. The benchmark framework is described in the next two section, where first we introduce the model set-up and then analyse the equilibrium. The fourth section is devoted to discuss the model predictions. The wage bargain version is exposed in the fifth section, before a final section summarizing the main contributions.

2 Benchmark framework

2.1 Timing and information assumptions

- Timing

  Time is discrete with only two periods: t_1 and t_2. Decisions are taken only at the beginning of each time period. Any new information becomes available at the end of the first period.

- Information about worker quality

  There are two types of workers defined according to the productivity level: high and low. Employers information about workers quality in the beginning of the first period is restricted to the share of high type workers in the population (α^*).

  The true quality level of the worker is revealed to the current employer at the end of the first period.

  For new matches in the second period, firms verify workers previous state (unemployed, employed by surviving firm, employed by extinct firm) only at the moment that they meet each other.

2.2 Labour supply

- workers population

  Fixed population for each type of worker denoted by L^1 and L^0 respectively.

- workers decision process

  They may only be employed earning wage w or unemployed earning benefits b.

  Only unemployed workers can search for job. They receive, at most, one offer per period with probability q_t. In case of receiving an offer, (s)he decides whether to accept it or not.

2.3 Labour demand

- Firm's population and production technology

In each period N homogeneous firms are candidates to produce the same good using the following technology, based solely on the employment level of each type of worker[3].

$f(\ell_t^1, \ell_t^0) = \ell_t^1 + \theta \cdot \ell_t^0$

We assume the following ordination for some parameters and product price (p).

$1 > \theta$ and $p \cdot \theta > b$

Throughout t_1 firms may be hit, with exogenous probability (μ), by a negative productivity shock, forcing them to leave the market at the end of this period.

Start-up firms in the second period keep the population unchanged.

- Match technology

  Firms post vacancies and set wages on the spot market [4].

  The probability of a firm filling ℓ_t of its v_t open vacancies is represented by a p.d.f.$\gamma_t(\ell_t|\ell_t \leq v_t)$, which in turn depends on how unemployed workers react to this offer (the probability of accepting the offer). Some restrictions on this distribution will be imposed latter[5].

  There is a search cost paid when vacancies are posted. This cost varies according to the number of vacancies ($c(v_t)$).

  Vacancies in new positions (jc) has a linear extra cost component (c) relative to vacancies previously occupied(rep). This is equivalent to: $c^{rep}(v_t) = c^{jc}(v_t) - c \cdot v_t$.

This last assumption is the only one non shared with any of the papers, mentioned in the introduction, about either adverse selection on labour market or matching models of unemployment.

3 Equilibrium

3.1 Wage determination

Firms will offer constant and homogeneous wage equivalent to the unemployment benefit ($w_t = b$), and any unemployed worker will accept an offer

[3]One can see the following properties for the technology: i)constant marginal productivity for both types of workers (1 for high type and θ for low type), and ii) constant returns to scale.

[4]The assumption on wage setting will be relaxed latter.

[5]$\ell_t = \ell_t^1 + \ell_t^0$.

like this, if (s)he gets one. We want to emphasize that this result holds for the two periods, and not only for the first period as in standard models of adverse selection on the labour market.

This is the traditional result on search models without on-the-job search activities. Diamond (1971) is credited to be the first author to demonstrate this result. As shown in his paper wage offers are insensible to the productivity level of the worker in an environment with search friction and no on-the-job search. In this environment firm has no incentive to set higher wages because there is no competition between them for the workers.

The existence of two types of workers is a relevant departure from traditional search framework. This could change the result mentioned above, since firms might compete for type 1 workers. However we have assumed that, due to search frictions, job seeker workers are a priori indistinguishable to firms before they show-up to accept an offer. Firms then face a similar environment for hiring as in traditional search framework, and hence we share Diamond's result.

This simpler wage determination process will allow us to elaborate on the second period employment decisions of the firms, which is the main element of this paper.

3.2 Employment Policy in the First Period

Firms will choose v to maximize expected profits with respect to the distributions for labour force size and composition, $\gamma(.|v)$ and α respectively. We assume that the random variables attached to these distributions are independent from each other[6]. Formally we have:

$$\max_{v} E_{\alpha}E_{\gamma|v}[\pi(v)] = \max_{v} p \cdot E_{\alpha}E_{\gamma|v}[\ell^1 + \theta \cdot \ell^0 | \ell \leq v] - b \cdot E_{\gamma|v}[\ell | \ell \leq v] - c^{jc}(v)$$

After some manipulation we can re-write firm's expected profit as:[7]

[6]To avoid too much notation, time subscript will be suppressed for the remain of this section.

[7]The first term can be written as:

$$p \cdot E_{\alpha}E_{\gamma|v}[\ell^1 + \theta \cdot \ell^0 | \ell \leq v] = p \cdot E_{\alpha}E_{\gamma|v}[(s^1 + \theta \cdot s^0) \cdot \ell | \ell \leq v] = p \cdot E_{\alpha}[(s^1 + \theta \cdot s^0)] \cdot E_{\gamma|v}[\ell | \ell \leq v]$$

where s^i represents the share of type i worker in firm's labour force. We have used the fact that this variable is independent from ℓ. So

$$E_{\alpha}E_{\gamma|v}[\pi(v)] = \{p \cdot [\alpha^* + \theta \cdot (1 - \alpha^*)] - b\} \cdot E_{\gamma|v}[\ell | \ell \leq v] - c^{jc}(v)$$

where we have used $E_{\alpha}[(s^1 + \theta \cdot s^0)] = [\alpha^* + \theta \cdot (1 - \alpha^*)]$

$$E_\alpha[\pi^{op}|\ell = 1] \cdot E_{\gamma|v}[\ell|\ell \leq v] - c^{jc}(v)$$

Where $E_\alpha[\pi^{op}|\ell = 1]$ represents the expected operational profit using a new worker. The two components can be defined, respectively, as marginal revenue of vacancies and marginal cost.

Optimal value for v will be well defined according to the shapes of $E_{\gamma|v}[\ell|\ell \leq v]$ and $c^{jc}(v)$. This result is easily established if we have a concave shape for the first function and convex shape for the second, or linear form for only one of them. The optimal value would then equate marginal revenue of vacancies with marginal cost.

In the appendix we show what drives the shape of $E_{\gamma|v}[\ell|\ell \leq v]$ and $c^{jc}(v)$, and provide some sufficient conditions for desirable shapes, based on standard assumptions in the literature. In particular it is shown that exponential $\gamma(.)$ implies concavity for $E_{\gamma|v}[\ell|\ell \leq v]$, which in turn allow us to assume either linear or convex shapes for $c^{jc}(v)$[8].

Note that all firms solve the same problem, which means they all post the same number of vacancies (v^*) and offer the same wage. Despite this, firms will differ with respect to two aspects at the end of the first period: i) labour force size, and ii) labour force composition. These are consequences of the stochastic environment in which hirings take place [9].

3.3 Unemployment and aggregation in the first period

The number of unemployed workers during the first period will be:

$$U_1 = L - N \cdot E_{\gamma|v^*}[\ell|\ell \leq v^*]$$

The expression above clearly states an effect of the probability of filling vacancies ($\gamma|v(.)$) on unemployment (U). However one could argue in favor of a feedback from the later to the former variable, where higher number of unemployed workers should be associated with a higher probability of filling vacancies. The remaining of this section is dedicated to clarify this relation.

The ratio of aggregate number of matches over aggregate number of firms posting vacancies is the average number of workers that each firm meet when

[8]The literature on matching model of unemployment where firms decide about labour force size,mentioned in the introduction assumes convex cost and constant "probability intensity of the matching event for the marginal vacancy" (Bertola and Garibaldi (2001) page 339). This last assumption sounds to me like uniform $\gamma(.)$, which also satisfy the conditions described in the appendix.

[9]Another dimension in which firms will differ, at this stage, is productivity, as an obvious consequence of the heterogeneities pointed before. After all, firm's i productivity can be written as $(s_i^1 + \theta \cdot s_i^0)$.

it posts vacancies. This should correspond to the expected value of $\gamma|v^*(.)$. Under the assumption of an exponential γ with parameter λ, we can write this expected value as:

$$E_{\gamma|v^*}[\ell|\ell leqv^*]\} = h(\lambda)$$

Then λ would be identified through the following equation:

$$h(\lambda) = \frac{m(U^b, N^v)}{N^v}$$

where $m(U^b, N^v)$ represents an aggregate matching function, a widely used shortcut in models of the labour market to link the aggregate numbers of job seekers (U^b) and number of firms posting vacancies (N^v), in one hand, to total number of matches, in the other hand[10].

I have denoted job seekers by U^b as opposed to U to remark the difference between, the pool of job seekers right before matches take place, and unemployment. For instance, the number of job seekers for the first wave of matches correspond to all the labour force, while unemployment in the first period was already defined as something else. That is, $U_1^b = L \neq U_1$. Generally we have, $U_t = U_t^b - m(U_t^b, N_t^v)$ [11].

The link proposed above requires that firms know the function $m(.)$ and also it's inputs level. Knowledge on $m(.)$ is imposed as an assumption, while inputs level are known to be L and N, respectively, in the first period[12].

3.4 Employment policy in the second period

Employment policy for start-up firms in the second period is described by the same problem analyzed for the first period. The results then also replicate the ones described above (keeping in mind that some parameters change their values).

Surviving firms decide, at the interim between first and second period, about the dispense of each type of labour and whether to hire or not new workers, having been informed about first period labour force size and composition. Moreover they also define the share of replacement in both, dispenses and hirings.

[10]See Petrongolo and Pissarides (2001) for more details about the use of matching functions on labour market models.

[11]Standard models using match functions are defined in continuous time as opposed to our discrete time formulation. In these models U_t^b corresponds to U_t.

[12]Another standard procedure in models using match functions is to use number of vacancies as the relevant input as opposed to the number of firms posting vacancies. The distinction is irrelevant for them since firms is defined as a unique job position.

The apparent huge number of elements in the firm's set of possible actions, are in fact reduced to few elements if we notice the following:

- Any dispense of workers which is not related to a replacement process is discharged since both types are profitable [13].

- Firms will never replace any of their high type worker, since no new worker can be more profitable than that.

- If firms decide to replace r workers, than any new worker will only be allocated for a new position if these r positions have already been filled.

The three observations above allows to write the firm's expected profit in t_2 as:[14]

$$E_\alpha E_{\gamma|v}[\pi_i(r,v)] = E_\alpha[\pi^{op}|\ell = 1] \cdot E_{\gamma|v}[\ell|\ell \leq v] - c^{jc}(v) \\ +p \cdot (\ell_i^1 + \theta \cdot \ell_i^0) - b \cdot (\ell_i^1 + \ell_i^0) - [(p \cdot \theta - b - c) \cdot r]$$

The first two terms are exactly the same that we had in the first period, referring vacancy posting decision. The remaining two terms corresponds to the operational profit provided by the first period employees, and the loss in this profit if the firm decides to replace any of these employees.

Firms would then have to maximize expected profits not only with respect to v, but also with respect to r[15]. This could bring additional complication to the analysis of the firm's optimal choice at t_2.

However we can avoid this additional complication using another result, shown below and proved in the appendix:

- Only firms that try to replace all it's low type workers may become interested in opening new positions.

This result needs the assumption that $(p \cdot \theta - b) < c$. It can be stated as the following relation between r, ℓ^0, and v:
$r = \min\{v, \ell^0\}$

[13]This comes from he fact that $1 > \theta > w = b$

[14]We have just rearranged the following expression

$$E_\alpha E_{\gamma|v}[\pi_i(v)] = E_\alpha[\pi^{op}|\ell = 1] \cdot E_{\gamma|v}[\ell|\ell \leq v] - [c^{rep}(r) + c^{jc}(v) - c^{jc}(r)] \\ +p \cdot (\ell_i^1 + \theta \cdot \ell_i^0) - b \cdot (\ell_i^1 + \ell_i^0) - [(p \cdot \theta - b) \cdot r]$$

using the fact that $[c^{rep}(r) + c^{jc}(v) - c^{jc}(r)] = c^{jc}(v) - c \cdot r$

[15]Formally, firm would solve the following problem: $\max_{r,v} E_\alpha E_{\gamma|v}[\pi_i(r,v)]$

This can be used to simplify firm's expected profit at t_2:

$$\max_v E_\alpha E_{\gamma|v}[\pi(v)] = E_\alpha[\pi^{op}|\ell = 1] \cdot E_{\gamma|v}[\ell|\ell \leq v] - c^{jc}(v)$$
$$-(p \cdot \theta - b - c) \cdot \min\{v, \ell^0\} + p \cdot (\ell^1 + \theta \cdot \ell^0) - b \cdot (\ell^1 + \ell^0)$$

Hence the firm solves a maximization problem similar to the one described for t_1, in the sense that the only choice is relative to v[16].

We can use the same sufficient conditions as before to guarantee a well defined solution for this problem. However one aspect of the solution for the second period differs from the one for the first period. The optimal value of v now varies across firms. In the appendix we show the derivations necessary to the following result:

$$v_i^* = \begin{cases} \overline{\ell^0}, & \ell_i^0 > \overline{\ell^0} \\ \ell_i^0, & \underline{\ell^0} < \ell_i^0 < \overline{\ell^0} \\ \underline{\ell^0}, & \ell_i^0 < \underline{\ell^0} \end{cases}$$

where $\underline{\ell^0}$ corresponds to the optimal value of v in the first period, and $\overline{\ell^0}$ corresponds to the optimal value of v, in the following hypothetical problem:

$$\max_v E_\alpha[\pi^{op}|\ell = 1] \cdot E_{\gamma|v}[\ell|\ell \leq v] - c^{jc}(v) - (p \cdot \theta - b - c) \cdot v$$

Moreover allocations of the vacancies among replacement and job creation will also vary across firms. To see this note that the allocation for replacement comes from a comparison between v_i^* and ℓ_i^0. As both components varies across firms, so will do the vacancies allocated for replacement. The same holds for the vacancies allocated for job creation which is just the complement to the total vacancies. These components of v_i^* are defined below:

$$r_i^* = \begin{cases} v_i^*, & \ell_i^0 > \underline{\ell^0} \\ \ell^0, & \ell_i^0 < \underline{\ell^0} \end{cases}$$

$$jc_i^* = \begin{cases} 0, & \ell_i^0 > \underline{\ell^0} \\ v_i^* - \ell^0, & \ell_i^0 < \underline{\ell^0} \end{cases}$$

3.5 Unemployment and aggregation in the second period

Job seekers between first and second periods (U_2^b) can be defined as:

[16]It means that the problem stated in the previous footnote was simplified to $\max_v E_\alpha E_{\gamma|v}[\pi(v)]$.

$$U_2^b = U_1 + \mu \cdot N \cdot E_{\gamma|v^*}[\ell|\ell \leq v^*] + \int r(\ell^0) \cdot \psi(\ell^0)\, d\ell^0$$

The first term correspond to those individuals who could not find a job in the first period and will try again. The last two terms correspond to unemployment inflow, or people who did work in the first period but were displaced. The second term corresponds to those displaced due to job destruction while the last term represents those workers that firms decided to replace. In the last term, $\psi(.)$ denotes the first period cross-section distribution of type 0 employed workers.

In order to get second period unemployment level, it is necessary to subtract the unemployment outflow, which correspond to new matches $(m(U_2^b, N_2^v))$. Using the fact that new matches can be always decomposed in those used to replacement process (m^r), and those used to fill newly created job positions, we can define unemployment in the second period as:

$$U_2 = U_1 + \left\{\mu \cdot N \cdot E_{\gamma|v^*}[\ell|\ell \leq v^*] - \int m^{jc}(\ell^0)\, d\ell^0\right\} + \left\{\int [r(\ell^0) \cdot \psi(\ell^0) - m^r(\ell^0)]\, d\ell^0\right\}$$

The right hand side in the expression above has three components. The first is previous unemployment and the second is the difference between job destruction and job creation. Usually we have unemployment dynamics defined based only in these two elements. But in our model there is a third element, due to the interaction of search friction and asymmetric information, which corresponds to non filled vacancies which were part of a replacement process.

It worths noting that theoretical studies on unemployment dynamics are based on models that were shown to underestimate unemployment volatility, or it's sensitivity to productivity shocks[17]. We conjecture that the inclusion of this new component on unemployment dynamics can improve these predictions, but this is a topic beyond the scope of this paper.

Concerning the aggregation issue, the problem is similar to the one in the beginning of the first period, although slightly more complicated. Now the condition that equates average new matches at micro and macro level is the following:

$$E_\psi\{E_{\gamma|v}[\ell|\ell \leq v]\} = \frac{m(U^b, N^v)}{N^v}$$

[17]See Hall (2006) for a recent survey on this literature.

The complication comes in the left hand side, due to the fact that at this stage firms post different number of vacancies, according to their level of type 0 workers, as previously defined.

But we can use the same logic to identify λ writing

$$E_{\psi}\{E_{\gamma|v}[\ell|\ell \leq v]\} = g(\lambda)$$

and then:

$$g(\lambda) = \frac{m(U_2^b, N_2^v)}{N_2^v}$$

We have previously stated an assumption on the knowledge of $m(.)$. So identification of λ will depend on the knowledge of the inputs level of the matching function. By construction $N^v = N$, so the only issue to be checked is knowledge on U_2^b. Since v^* is known for all firms, we can say that the knowledge of $\gamma|v(.)$ leads to the knowledge of U_2^b.

4 Model predictions

As mentioned in the introduction, our extended framework of adverse selection encompasses several predictions in a new dimension for these models, namely firm dynamics. However, in the wage setting formulation, this gain comes at the expense of loosing the predictions on wage dynamics. But we still have some predictions on worker dynamics which will be commented below before we describe the predictions on firm dynamics.

4.1 Workers dynamics

Concerning worker dynamics the model shares two predictions with standard models of adverse selection. One about probability of separation, and another about the prejudice of being replaced for worker's future welfare. They can be stated as the following.

1. negative correlation between probability of separation and job tenure (negative hazard rates).

2. workers separated due to replacement will tend to visit the unemployment state more often than those separated due to job destruction.

In order to deal with these predictions we need workers facing the risk of separations at least in two separate moments. In our formulation this occur only once, at the end of the first period. However it is easy to see that if we add a third period to the model, the decisions at the end of the second period would mimic those at the end of the first period.

In this extended framework we can see that, at the end of the second period, there will be a higher concentration of type 1 workers among those completing two years of tenure than among those completing one year. This is due to the fact that several type 0 workers were replaced at the end of the first period, but no type 1 worker did so. As type 1 worker has lower probability of separation, the first prediction follows easily.

The second prediction relies in the fact that the composition in the group facing job destruction is better, in the sense that it leans towards type 1 workers, which has a lower probability of separation [18].

Predictions like the second one is rarely related to unemployment in standard models of adverse selection, since most of them assume that labour market clears. The standard models usually state predictions on prejudice for displaced workers in terms of wage loss. The same can be said with respect to predictions comparing workers performance after separation according to the cause of separation (replacement or job destruction). In standard models separations are not distinguished in terms of informational content.

In this sense Gibbons and Katz (1991) has close connections to our framework. They had the insight that firms extinction may hide the information on worker type, and made some predictions on workers performance after separation according to the cause of separation. They also provides an intuitive argument to encompass unemployment in their model. Their argument is based on making firms heterogeneous in terms of technology, such that low type workers will be profitable only for few firms. They deduce then, that these workers will face higher unemployment duration, making unemployment duration higher for displaced workers than for those facing job destruction.

4.2 Firm Dynamics

According to our model the driving force to explain firm dynamics is the initial level of ℓ^0 and how it evolves as firms ages.

Some start-ups have low level of ℓ^0 while others have high levels. The first group creates jobs straight away and decides for smaller rates of replacement. The second group focus hiring efforts in replacement process and does not

[18] In this group you have both types of workers, while among replaced workers there is only type 0. The probability of separations are lower for type 1 workers because separations for this type of workers occurs only through job destruction, while type 0 also face a positive probability of replacement on top of the same risk of job destruction.

create jobs. As a consequence of these optimal policies we have the following distinctions. In one hand the first group improves it's labour force composition in a slower rate than the second. On the other hand this later group tends to decreases it's labour force size, due to search frictions, while the first group increases it's labour force size.

In order to check if data is compatible with the dynamic mechanism described above, we should restate it in terms of observable variables. The independency of the random variables filled vacancies and labour force composition in these vacancies, will be helpful in this sense. This assumption implies that smaller firms will be over represented among firms with low levels of type 0 workers.

So the two groups mentioned above can be defined in terms of initial size. Then we can say that in the second period the two groups tend to become similar to each other both in terms of labour force composition, and size.

It should be emphasized thought that the model predicts the existence of some large start-up firms with small amount of ℓ^0 and vice-versa. Thus the comparison now holds for the average behaviour of these groups.

We can then state the following predictions involving firm's performance (measured as size, productivity, or their variations: job creation, and productivity growth) and other observable characteristics (industry, age, and initial size).

1. For smaller start-ups, size tends to increase with age. For larger start-ups, size tends to decrease at early stages of their life cycle (and eventually starts to increase later).

2. At early stages of their life cycle, smaller start-up firms tend to create more jobs. Job creation becomes less sensible to initial size at later stages of firm's life cycle.

3. homogeneous firms in terms of observable characteristics (industry, size and age) attain distinct performance levels (measured as job creation or productivity levels).

4. Productivity tends to increase as a firm becomes older.

5. At early stages of their life cycle, smaller start-up firms tend to have higher productivity levels.

6. At early stages of their life cycle, smaller start-up firms tend to have lower rates of productivity growth. This rate of growth becomes less sensible to initial size at later stages of firm's life cycle.

4.3 stylised facts on firm dynamics

Some important stylised facts about firm dynamics brought by empirical papers are summarized in three surveys. Caves (1998) and Davis and Haltiwanger (1999) concentrate on findings about employment growth, and Bartelsman and Doms (2000) focus on productivity. All these papers restrict their analysis to results based on longitudinal microdata (either at firm or plant level). The facts connected to our predictions are the following:

1. Smaller firms tend to grow in size while larger firms tend to shrink.
2. Job creation rates tend to increase with size, conditioned on age.
3. Homogeneous firms in terms of observable characteristics (industry, size and age) attain distinct performance levels (measured as job creation, productivity levels).
4. Productivity tends to be persistent.

We now will check whether model predictions stated before are compatible with these facts. The first fact above is compatible with the first prediction.. The third fact is perfect in line with the corresponding prediction. The last prediction is also compatible with the last three predictions.

The second prediction is not sustained by the corresponding fact. In fact The second fact actually contradicts this prediction. This is may be related to selection process governing job destruction, as described by learning models. So it would be interesting to check whether an extended version of the model with endogenous job destruction will cope with this fact.

5 Relaxing the assumption on wage determination

The model is compatible with wage determination based on a bargain scheme. This is the standard procedure for matching models of the labour market. According to this procedure the wage corresponds to the sum of two components: i) the reservation wage (b in our model), and ii) a share (β) of the match rent, which represents worker's bargain power[19].

[19] See Rogerson et al. (2004) for insights on how this solution is obtained.

5.1 First period

So in t_1 wages would correspond to:

$$w^* = \beta \cdot (p \cdot [\alpha + \theta \cdot (1-\alpha)] - b) + b$$

while the expected operational profit of a single worker would correspond to:

$$E_\alpha[\pi^{op}|\ell = 1] = (1-\beta) \cdot (p \cdot [\alpha + \theta \cdot (1-\alpha)] - b)$$

Therefore firm's expected profit would be:

$$E_\alpha E_{\gamma|v}[\pi(v)] = (1-\beta) \cdot \{p \cdot [\alpha + \theta \cdot (1-\alpha)] - b\} \cdot E_{\gamma|v}[\ell|\ell \leq v] - c^{jc}(v)$$

which differs from our benchmark framework only due to the appearance of the term $(1-\beta)$ shifting down the revenue component. So the analysis about optimal employment policy in the first period shown for the case of posted wages, can be replicated for the case of bargained wages.

5.2 Second period: new set-up

Wages will vary at the beginning of t_2, depending on the information that firms have about their employees. This is due to the fact that there are three possible values for the match rent: i) one for workers known to be of type 1 (necessarily a continuing worker), ii) one for workers known to be of type 0 (either a continuing worker or a new one replaced by a surviving firm), and iii) one for workers whose type is still unknown (either unemployed or coming from an extinct firm).

The possible wage values would correspond, respectively, to:

$$w^1 = \beta \cdot (p - b) + b$$

$$w^0 = \beta \cdot (p \cdot \theta - b) + b$$

$$w^u = \beta \cdot (p \cdot \alpha^u - b) + b$$

where $\alpha^u = \frac{\alpha \cdot (U_1 + \mu \cdot E_1)}{U_2^b - R}$

We will describe below whether this new set-up will have any impact in firm's and worker's optimal decisions.

5.3 Second period: firm's optimal decision

We can show that surviving firm's optimal employment policy in the second period will be very similar to the one derived for the case of posted wages.

First we argue that the first three items used to simplify the expected profit expression holds true for this version of the model. The first and the third items are trivial, while the second item is not so obvious anymore. As wages increases for type 1 worker, we should check if he is still more profitable than a new worker. So, not replacing a type 1 worker is optimal if $(1-\beta)\cdot(p-b) > (1-\beta)\cdot[p\cdot(s^1+\theta\cdot s^0)-b]$, which is true since previous assumptions guarantees that $1 > (s^1+\theta\cdot s^0)$. The fourth item also holds, as shown in the appendix, under a less restrictive condition, which turns to be $(1-\beta)\cdot(p\cdot\theta-b) < c$.

Therefore we can write expected profit in the second period as:

$$\max_v E_\alpha E_{\gamma|v}[\pi(v)] = E_\alpha[\pi^{op}|\ell=1]\cdot E_{\gamma|v}[\ell|\ell\leq v] - c^{jc}(v)$$
$$+(1-\beta)\cdot[p\cdot(\ell^1+\theta\cdot\ell^0) - b\cdot(\ell^1+\ell^0)] - [(1-\beta)\cdot(p\cdot\theta-b)-c]\cdot\min\{v,\ell^0\}$$

which is similar to the one derived for the benchmark model, differing only with respect to pre multiplicative term $(1-\beta)$. Therefore the solution for the number of vacancies, replacements and job creation follow the same structure as in the benchmark model. Only the values will not be the same.

As in the wage setting framework, employment policy for start-up firms in the second period is described by a simpler problem where their expected profit function is restricted to the first part of the one described above for surviving firms.

5.4 Second period: worker's optimal decision

In this new set-up type 0 workers may prefer to quit since his wage is reduced to levels below the wage for new matches. So we have to compare type 0 worker utility when (s)he remain employed in his current job position with the one when (s)he quits and tries a new match. The latter can be expressed as[20]:

$$E[w^{0,q}] = \frac{m(U^b(q),N^v)}{U^b(q)}\cdot\beta\cdot\{p\cdot[\alpha^q+\theta\cdot(1-\alpha^q)]-b\}+b$$

Where $U^b(q)$ denotes the number of job seekers if type 0 decides to quit, and α^q the respective share of type 1 worker among them.

[20]The expression above is based on $E[w^{0,q}] = \frac{m(U^b_t,N^v_t)}{U^b_t}\cdot w^* + \left\{1-\frac{m(U^b_t,N^v_t)}{U^b_t}\right\}\cdot b$

So quit becomes an optimal choice if:

$$\frac{m(U^b(q), N^v)}{U^b(q)} \cdot \beta \cdot \{p \cdot [\alpha^q + \theta \cdot (1 - \alpha^q)] - b\} > (p \cdot \theta - b)$$

which may hold under certain circumstances related to $m(.)$ and μ.

However even if it is the case that type 0 workers decide to quit, this would have little consequences for our results. This would affect only the firms where $\ell_i^0 > \overline{\ell^0}$ at the end of the first period. They are the only firms who do not replace all type 0 workers. So, if quit is not optimal, some type 0 workers would remain employed, as opposed to when quit is optimal. Anyway this change is irrelevant in the sense that all predictions valid for this version of the model are independent of the quit decision of type 0 workers.

5.5 Predictions

Concerning firm dynamics it is easy to see that previous predictions remain valid. Since expected profit function has the same form, decision rules will have the same structure based on ℓ^0, which in turn lead to the same dynamics.

Concerning worker dynamics previous predictions also remain valid. This is due to the fact that replacement is restricted to type 0 workers. However a new prediction, described below, arises in this framework with bargained wages.

- average wage increases with tenure.

This new prediction results from the fact the wages are proportional to rents. As rents increases once the worker's type is revealed as type 1, so does the wages of these workers, which are over represented among workers who stay in the same job in the second period.

6 Summary and conclusions

In this paper we develop a labour market model where both components of worker flows, namely job flows and replacement are addressed. At micro level, firms decide simultaneously about job creation and workers replacement. In doing so we build an integrated framework on labour market which delivers predictions on firm dynamics, worker dynamics and unemployment, all compatible with each other. This makes the model an useful device to evaluate implications of policy shocks on several dimensions of the labor market.

The main features of the model are asymmetric information about workers productivity and search frictions. When hiring workers firms don't know whether there will be enough people to fill the open vacancies, and once a new worker comes in, they don't know his productivity level.

Combining these two stochastic dimensions, using a simple aggregation device, allows to integrate predictions on the effect of adverse selection on workers dynamics with predictions on it's effects on unemployment flows. Moreover, in combining these two frameworks we have to detail further firm's employment policy, which in turn allow some predictions on firm dynamics.

Concerning unemployment dynamics, we have presented a new component of unemployment inflow, which results from the interaction of replacement and search frictions. This can be explored in future research on unemployment dynamics, such as the current debate on the sensibility of unemployment flows to productivity shocks.

Concerning firm dynamics, the model predicts some stylized facts regarding some correlations of performance variables with characteristics such as size and age. These predictions are also addressed by the framework of active exploitation, which is not a coincidence once we note the similarity of the driven force leading to firms dynamics in both frameworks.

Desirable extensions of our framework would deal with endogenous job destruction and/or on-the-job search. Similarity with the active learning framework suggests that the model may also be compatible with imperfect competition in the product market.

Appendices

A Studying the shape of $E_{\gamma|v}[\ell|\ell \leq v]$

We analyze below the curvature of $E_{\gamma|v}[\ell|\ell \leq v]$, which in turn is used to access the existence and uniqueness of an optimal solution for firm's hiring policy.

Using the result derived above, we have:

$$E_{\gamma|v}[\ell|\ell \leq v] = \frac{\int_0^v \ell \cdot \gamma(\ell)\, d\ell}{\Gamma(v)}$$

In what follows we will study the sign of the first two derivatives of the expected value above with respect to v.

$$\frac{dE_{\gamma|v}[\ell|\ell \leq v]}{dv} = \frac{v \cdot \gamma(v)}{\Gamma(v)} + \int_0^v \ell \cdot \gamma(\ell)\, d\ell \cdot \frac{-\gamma(v)}{[\Gamma(v)]^2}$$

this can be easily rearranged as:

$$\frac{dE_{\gamma|v}[\ell|\ell \leq v]}{dv} = \frac{\gamma(v)}{\Gamma(v)} \cdot \{v - E_{\gamma|v}[\ell|\ell \leq v]\}$$

The positive sign for the derivative defined above is guaranteed by the fact that for any random variable, with non-degenerate density functions, it's expected value when right truncated is always lower than the truncation value.

For the second derivative we have:

$$\frac{d^2E_{\gamma|v}[\ell|\ell \leq v]}{dv} = \left\{\frac{\gamma'(v)}{\Gamma(v)} - \left[\frac{\gamma(v)}{\Gamma(v)}\right]^2\right\} \cdot \{v - E_{\gamma|v}[\ell|\ell \leq v]\} + \frac{\gamma(v)}{\Gamma(v)} \cdot \left\{1 - \frac{dE_{\gamma|v}[\ell|\ell \leq v]}{dv}\right\}$$

The first part, $\left\{\frac{\gamma'(v)}{\Gamma(v)} - \left[\frac{\gamma(v)}{\Gamma(v)}\right]^2\right\} \cdot \{v - E_{\gamma|v}[\ell|\ell \leq v]\}$, have a negative sign for any monotonic non-increasing $\gamma(.)$. The last part, $frac\gamma(v)\Gamma(v) \cdot \left\{1 - \frac{dE_{\gamma|v}[\ell|\ell \leq v]}{dv}\right\}$, also have a negative sign if $1 > \frac{dE_{\gamma|v}[\ell|\ell \leq v]}{dv}$.

The second condition is attended by log concave density functions. Several densities fit in this class, as for example exponential, uniform, beta, gamma, normal, laplace, extreme value (type 1), Weibull[21].

As it is straightforward to see that exponential and uniform always attend, the condition for the first component, we will then stick to them for the sake of convenience.

B The relation between r, ℓ^0, and v at t_2

- benchmark model (posted wages)

  Consider a firm at t_2 who is deciding marginally about opening one extra vacancy either as part of a replacement process or for job creation purpose. We will compare the marginal gain associated to replacement $(E_\alpha E_{\gamma|v=1}[\pi^{rep}(1)])$ with the one associated to job creation $(E_\alpha E_{\gamma|v=1}[\pi^{jc}(1)])$.

  The gain associated to replacement is:

$$E_\alpha E_{\gamma|v=1}[\pi^{rep}(1)] = E_\alpha[\pi^{op}|\ell = 1] \cdot E_{\gamma|v=1}[\ell|v = 1] - c^{rep}(1) - (p \cdot \theta - b)$$

  while the one associated to job creation is:

[21]See Gibbons.Katz:91 and references therein.

$$E_\alpha E_{\gamma|v=1}[\pi^{jc}(1)] = E_\alpha[\pi^{op}|\ell = 1] \cdot E_{\gamma|v=1}[\ell|v = 1] - c^{jc}(1)$$

One can see that: $(p{\cdot}p{\cdot}\theta - b) < c \Rightarrow E_\alpha E_{\gamma|v=1}[\pi^{rep}(1)] > E_\alpha E_{\gamma|v=1}[\pi^{jc}(1)]$

- model with wage bargain

  The gain associated to replacement is:

$$E_\alpha E_{\gamma|v=1}[\pi^{rep'}(1)] = E_\alpha[\pi^{op'}|\ell = 1]{\cdot}E_{\gamma|v=1}[\ell|v = 1] - c^{rep}(1) - [p{\cdot}\theta - b - \beta{\cdot}(p{\cdot}\theta - b)$$

  while the one associated to job creation is:

$$E_\alpha E_{\gamma|v=1}[\pi^{jc'}(1)] = E_\alpha[\pi^{op'}|\ell = 1] \cdot E_{\gamma|v=1}[\ell|v = 1] - c^{jc}(1)$$

  One can see that: $(1 - \beta) \cdot (p \cdot \theta - b) < c \Rightarrow E_\alpha E_{\gamma|v=1}[\pi^{rep'}(1)] > E_\alpha E_{\gamma|v=1}[\pi^{jc'}(1)]$

C Derivation of v_i^*

The firm solves the following problem in the interim between first and second periods:

$$\max_v E_\alpha E_{\gamma|v}[\pi(v)] = p \cdot (\ell^1 + \theta \cdot \ell^0) - b \cdot (\ell^1 + \ell^0) \\ + E_\alpha[\pi^{op}|\ell = 1] \cdot E_{\gamma|v}[\ell|v] - c^{jc}(v) - (p \cdot \theta - b - c) \cdot \min\{v, \ell^0\}$$

First consider the following notation:

$$E_\alpha E_{\gamma|v}[\pi(v)]_A = p \cdot (\ell^1 + \theta \cdot \ell^0) - b \cdot (\ell^1 + \ell^0) \\ + E_\alpha[\pi^{op}|\ell = 1] \cdot E_{\gamma|v}[\ell|v] - c^{jc}(v) - (p \cdot \theta - b - c) \cdot v$$

$$\overline{\phi_U} = \arg\max\{E_\alpha E_{\gamma|v}[\pi(v)]_A\}$$

$$\overline{\phi_R} = \arg\max\{E_\alpha E_{\gamma|v}[\pi(v)]_A\} s.t. v \leq \ell^0$$

$$E_\alpha E_{\gamma|v}[\pi(v)]_B = p \cdot (\ell^1 + \theta \cdot \ell^0) - b \cdot (\ell^1 + \ell^0) \\ + E_\alpha[\pi^{op}|\ell = 1] \cdot E_{\gamma|v}[\ell|v] - c^{jc}(v) - (p \cdot \theta - b - c) \cdot \ell^0$$

$$\underline{\phi_U} = \arg\max\{E_\alpha E_{\gamma|v}[\pi(v)]_B\}$$

$$\underline{\phi_R} = \arg\max\{E_\alpha E_{\gamma|v}[\pi(v)]_B\} s.t. v \geq \ell^0$$

We can use the new notation to redefine the maximization problem as:

$$\arg\max\{E_\alpha E_{\gamma|v}[\pi(v)]\} = \arg\max\{\overline{\phi_R}, \underline{\phi_R}\}$$

The problem is then solved in three steps.

C.1 first step

Note that

if $\ell^0 > \overline{\phi_U}$ then $\overline{\phi_R} = \overline{\phi_U}$ and $\underline{\phi_R} = \ell^0$

This allows to solve the problem for this region since:

$$E_\alpha E_{\gamma|v=\overline{\phi_U}}[\pi(\overline{\phi_U})]_A > E_\alpha E_{\gamma|v=\ell^0}[\pi(\ell^0)]_A = E_\alpha E_{\gamma|v=\ell^0}[\pi(\ell^0)]_B = E_\alpha E_{\gamma|v=\underline{\phi_U}}[\pi(\underline{\phi_U})]_B$$

Therefore we have $v^* = \overline{\phi_U}$ when $\ell^0 > \overline{\phi_U}$

C.2 second step

Note that

if $\ell^0 < \underline{\phi_U}$ then $\overline{\phi_R} = \ell^0$ and $\underline{\phi_R} = \underline{\phi_U}$

This allows to solve the problem for this region since:

$$E_\alpha E_{\gamma|v=\underline{\phi_U}}[\pi(\underline{\phi_U})]_B > E_\alpha E_{\gamma|v=\ell^0}[\pi(\ell^0)]_B = E_\alpha E_{\gamma|v=\ell^0}[\pi(\ell^0)]_A = E_\alpha E_{\gamma|v=\overline{\phi_U}}[\pi(\overline{\phi_U})]_A$$

Therefore we have $v^* = \underline{\phi_U}$ when $\ell^0 < \underline{\phi_U}$

C.3 third step

Now note that

if $\underline{\phi_U} < \ell^0 < \overline{\phi_U}$ then $\overline{\phi_R} = \ell^0$ and $\underline{\phi_R} = \ell^0$

Therefore we have $v^* = \ell^0$ when $\underline{\phi_U} < \ell^0 < \overline{\phi_U}$

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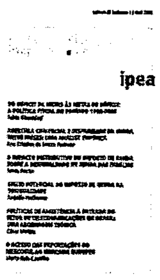

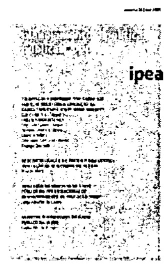

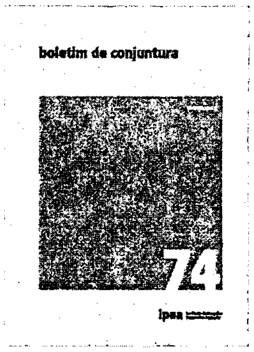

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exemplar avulso
R$ 8,00

Número de Assinaturas |_|_|_|

Total em R$ |_|_|_|,00

BOLETIM DE CONJUNTURA
BC - trimestral

assinatura anual
R$ 60,00 (Brasil)
R$ 85,00 (Exterior)
exemplar avulso
R$ 11,00

Número de Assinaturas |_|_|_|

Total em R$ |_|_|_|,00

TOTAL EM R$
|_|_|_|,00

EXEMPLARES AVULSOS

CÓDIGO	TÍTULO	QUANTIDADE	R$

SUBTOTAL	
CUSTO DO SEDEX*	
TOTAL GERAL	

*envio para outros estados

obs.: antes do encaminhamento do pedido, solicitamos contato prévio para verificação da disponibilidade de estoque e informações sobre a valor do sedex.

SEUS DADOS

nome — setor

endereço — cep

bairro — cidade — estado

telefone 0 xx (   ) — ramal — fax 0 xx (   ) — e-mail

data /   / 200__ — assinatura

Governo Federal

Ministério do Planejamento,
Orçamento e Gestão

ipea