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# Technical skill bias as a response of firms to unemployment: A matching model with applicant ranking and endogenous skill requirements

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ABSTRACT

This paper considers an economy with heterogeneous workers where identical firms optimally decide on the degree of complexity of jobs. Meetings are depicted by an urn-ball process where firms rank their applicants and pick the best one. We show that a general rise in unemployment induces an increase in the employment shares of high-skilled workers which, in turn, makes firms choose more complex jobs, leading then to a decrease in the output of low-skilled workers. The technical skill bias is therefore related to the usual explanations of unemployment. Next, we state that a decentralized equilibrium is efficient in terms of job complexity but inefficient in terms of job creation when firms internalize the usual congestion effect. We then extend the analysis to a dynamic model.



## 1. Introduction

One salient feature of the past several decades is the increase in wage inequality. This phenomenon is particularly marked in the United States where the college premium (the wages of college graduates relative to the wages of high-school graduates) increased by over 25% between 1979 and 1995 (Acemoglu, 2002). The change in the wage structure was associated with a general rise in unemployment as well as a decrease in the employment share of low-skilled workers (Autor et al., 1998).

According to many authors, the (relative) poverty of unskilled workers stems from an exogenous bias in technology, see for instance Nickell (2004). A new technological revolution would have made high (low) skilled workers become more (less) productive in their jobs.

The purpose of this paper is to show that this technical skill bias can be viewed as an optimizing response of firms to unemployment. Low wages and low employment shares of low-skilled workers as well as more complex jobs would directly result from a general rise in unemployment.

Our analysis is based on a matching model of the labor market with endogenous skill requirements and applicant ranking.

This model has two main features. First, although workers are vertically differentiated, there is a single labor market and the hiring process is described by an extension of the urn-ball model (Petrongolo and Pissarides, 2001) where firms rank their applicants and pick the best one. As a consequence, unemployment rates depend on the workers' ability. The higher the ability of a worker, the lower the unemployment rate is. Second, a job can be more or less complex; its degree of complexity being a firms' choice variable. The output of a filled job then depends on two variables which are the ability of the worker and the degree of complexity. Intuitively, we assume that an increase in the degree of complexity of jobs raises the output of high-skilled workers and lowers that of low-skilled ones.

In the first part of the paper, we take the tightness of the labor market (hence the average rate of unemployment) as a given variable, and we study its effects on the dispersion of employment shares and on the degree of complexity of jobs. We state that a decrease in market tightness (which is associated with an increase in general unemployment) lowers the employment shares of low-skilled workers and raises the employment shares of high-skilled ones. As the number of applicants per vacant job increases, firms can recruit higher-ability workers. This gives them an incentive to offer more complex jobs, *i.e.* jobs which

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better suit high-skilled workers. In addition, the increase in job complexity lowers the productivity of low-skilled workers, leading then to a decrease in their relative wages. Conversely, when the market becomes tighter, firms have to switch to lower-ability workers, thus choosing less complex jobs. In other words, the bias in the technical change can be seen as a rational response of firms to a general rise in unemployment.

In the second part of the paper, market tightness is made endogenous by assuming free entry and we study the welfare properties of a decentralized equilibrium. In terms of job complexity, a decentralized equilibrium appears to be always efficient. The reason for this is that firms maximize the expected output of jobs. This is exactly what a social planner should do. We also show that job creation tends to be too high. This result does not depend on firms' technological choices. It comes from the ranking of applicants which creates a new externality: an increase in job creation makes firms hire lower-ability workers, lowering then the average output.

Concerning the average unemployment rate, the comparative statics of the model are the same as the basic matching model (Pissarides, 2000). So, *in fine*, job complexity is related to the usual explanations of unemployment.

Recently, other search models with *ex ante* heterogeneous jobs and workers have been proposed (see Teulings and Gautier, 2004 for a brief presentation of this literature). In those models, the complexity of the jobs (or their specialization when workers are horizontally differentiated as in Marimon and Zilibotti (1999) or Gavrel and Lebon (2008)) is exogenous. In addition, contrary to ours, models with vertical differentiation often assume that the market is segmented in as many sub-markets as skill levels, see Mortensen and Pissarides (1999) or the literature about optimal taxation with equilibrium unemployment (Hungerbühler et al., 2006). On the other hand, in Acemoglu (1999), Shimer and Smith (2000), Albrecht and Vroman (2002), Gautier (2002) and Blázquez and Jansen (2008), the labor market is not segmented and heterogeneous workers form a common pool of applicants; but, contrary to our setting, firms' search is random. In our opinion, the assumptions of segmentation or random search are too strong as they tend to ignore a very intuitive reason for the dispersion of unemployment rates: the simple fact that firms prefer to hire the best workers.

Our contribution is closer in spirit to Acemoglu (1999). In this matching model, search is also random but skill requirements are endogenous. Firms decide on job complexity, hence the output of the workers in their jobs.[1] Like Acemoglu (2002), we understand the behavior of technical change "by recognizing that the developments and use of technology is, at least in part, a response to profit incentives." According to Acemoglu, the strengthening of firms' skill requirements results from the change in skill labor supply; this adaptation also explains the increase in the unemployment rates of all skill groups of the past decades. With skilled workers, firms choose complex technology. With unskilled workers, technical change tends to be "deskilling" as in the nineteenth century. In our contribution, the technical skill bias directly derives from a general rise in unemployment and understanding this phenomenon is equivalent to explaining unemployment. However from a formal point of view, our analysis is similar to Acemoglu (1999).[2] When firms rank their applicants and pick the best candidate, an increase in general unemployment has the same effect as an increase in the supply of skilled workers when search is random.

The paper is organized as follows: The (static) model is exposed in Section 2. Section 3 studies the effects of a market-tightness increase on employment shares and job complexity. Market efficiency and comparative statics are the topic of Section 4. In Section 5, we prove that our main results still hold in a dynamic setting. Section 6 is the conclusion.

## 2. The model

### 2.1. Market structure

We study the effect of a general rise of unemployment on firms' technological choices in the following simplified environment:

We consider a static economy that comprises large numbers of risk-neutral workers and firms.

Workers are vertically differentiated by their ability $z$. Among the population of workers, ability $z$ is distributed according to a continuous distribution, $G(z)$, with support $[0, Z]$. The density of $G(.)$ is denoted by $g(.)$.

On the contrary, firms are *ex ante* identical. In our setting, their technology is endogenous. When entering the labor market, firms irreversibly decide on the degree of complexity of the (unique) job they will offer.

There are frictions in the labor market that stop the instantaneous matching of workers with jobs. The hiring process is depicted by an urn-ball model where workers send a single application[3] and firms select the best candidate they interview.

Wages are determined according to Nash bargaining. Finally, as in most matching models, job creation derives from the assumption of free-entry.

Let us provide a detailed account of these assumptions.

### 2.2. The hiring process

Firms try to fill $V$ vacancies with $N$ workers searching for a job. The ratio $V/N$, referred to as the labor market tightness, is denoted by $\theta$. Applying the usual urn-ball model, we assume that each job seeker draws a single firm at random.[4] In general, firms will have several applicants of different abilities. Firms are assumed to have full knowledge of the sample of their applicants. So, they will pick the best one.

Let $q(z,\theta)$ denote the "probability" (in fact, it is a density) for a firm to hire a worker of ability $z$.

Concerning the matching process, we state the following lemma:

**Lemma 1.** *In an urn-ball model with heterogeneous workers and applicant ranking, the density $q(z,\theta)$ is given by:*

$$q(z,\theta) = \exp\left[-\frac{1-G(z)}{\theta}\right]\frac{g(z)}{\theta} \tag{1}$$

**Proof.** In order to compute the probability of hiring a worker of ability $z$,[5] let us first consider the probability for a firm not to meet any applicant of ability greater than $z$. This probability is given by:

$$\left[1-\frac{1}{V}\right]^{(1-G(z))N}$$

Because there are many firms, the previous expression tends to:

$$\exp\left[-\frac{1-G(z)}{\theta}\right]$$

[1] In Albrecht and Vroman (2002) as in Gautier (2002), the composition of jobs is endogenous, but the output of a skilled worker in a skilled job is exogenous.

[2] In Acemoglu (1998), technology is also endogenous. However, in this paper there are no frictions in the labor market.

[3] This assumption is made for the sake of simplicity. Multiple applications are unlikely to affect the main results.

[4] Albrecht et al. (2003) extend the urn-ball to the case where homogenous job seekers issue multiple applications.

[5] For simplistic reasons, we consider countable sets. However, the results extend to continuums.