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**Should vocational education be taxed?  
Lessons from a matching model with  
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**March 2011**

**DT-GREQAM**

# Should vocational education be taxed? Lessons from a matching model with generalists and specialists\*

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**Abstract:** Should education become more vocational or more general? We address this question in two steps. We first build and solve a two-sector matching model with generalists and specialists. Generalists pursue jobs in both sectors; however, they come second in job queues. Specialists seek for jobs in a single sector; they come first in job queues. Self-selection in education type vehicles three main externalities: specialists boost job creation in each sector; generalists improve the efficiency of the matching technology; generalists exacerbate firms' coordination problems. We then calibrate the model on the labor market for upper-secondary graduates in OECD countries. In each country, we match the proportion of specialists and unemployment rates by type of education in 2000. Self-selection is always inefficient: taxing vocational education to reduce the proportion of specialists down to the efficient level could reduce unemployment rates (for upper-secondary graduates) by 1.1 to 1.8 percentage points.

**Keywords:** Matching frictions; Education; Efficiency; Calibration

**JEL classification:** I21; J24; J64

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# 1 Introduction

Educational institutions are scrutinized by policy makers. The bottom line of the critiques is that schools are too disconnected from the labor market. Students are considered not to acquire the skills needed by the productive sector; this would explain the failure of the social system to provide young people with jobs and wage earnings. This argument borrows from the widespread perception that skills learnt at school are not directly useful once in the workplace. Providers of education are urged to make their teaching more vocational so as to provide the skills that Governments, firms, and even students expect from employable young workers.

General education does not teach anything valuable in the labor market per se. However, in the learning process, students acquire core skills that are useful everywhere in the economy. In a nutshell, you don't learn math because math.com will hire you. You learn math because math skills are very generic and people with generic skills can occupy more jobs. The argument is in line with Krueger and Kumar (2004) and Lamo, Messina, and Wasmer (2010). Both papers argue that vocationally-oriented schooling systems alter workers' between-sector mobility. This would explain the poor European growth performance at a time where new technologies (and, therefore, new sectors) emerged (Krueger and Kumar); it would also explain the persistence of unemployment after a sectorial shift (Lamo, Messina, and Wasmer).

It is not easy to measure how vocational a given schooling program is. The International Standard Classification of Education cross-classifies education programs by level and type of education, each variable being (supposedly) independent. Table 1 focuses on upper-secondary graduates in 2000. For each country we divide the workforce into people who followed a vocational education—hereafter, the specialists—and people who followed a general education—hereafter, the generalists. Table 1 provides the unemployment rate of each group as well as the overall unemployment rate.

There is substantial heterogeneity in the cross-section of countries. The percentage of specialists is 56% on average and varies from 0% in the US to 95% in Germany; the unemployment rate is 7.7% on average and goes from 1.9% in Luxembourg to 18.1% in the Slovak Republic; the unemployment rate differential between specialists and generalists is 0.9 percentage points on average and varies from -2.8 points in Australia to +5.7 points in the Slovak Republic. Although specialists seem to be more exposed to unemployment than generalists, there are no obvious relationships between the aggregate unemployment rate and proportion of specialists on the one hand, and between the unemployment rate differential and proportion of specialists on the other hand.

Country	spec. proportion	spec. u. rate	gen. u. rate	u. rate
Australia	0.267	0.039	0.067	0.060
Austria	0.885	0.033	0.032	0.033
Belgium	0.247	0.089	0.061	0.068
Czech Republic	0.556	0.090	0.065	0.079
Denmark	0.830	0.041	0.054	0.043
France	0.750	0.087	0.091	0.088
Germany	0.937	0.085	0.031	0.082
Greece	0.206	0.152	0.150	0.151
Hungary	0.514	0.076	0.048	0.062
Ireland	0.451	0.025	0.030	0.028
Italy	0.254	0.090	0.112	0.107
Luxembourg	0.653	0.020	0.018	0.019
Netherlands	0.567	0.022	0.032	0.027
New Zealand	0.728	0.055	0.045	0.052
Poland	0.515	0.192	0.151	0.172
Slovak Republic	0.503	0.210	0.152	0.181
Switzerland	0.866	0.023	0.033	0.024
Turkey	0.346	0.109	0.105	0.106
Mean	0.560	0.080	0.071	0.077

Table 1: Generalists, specialists and unemployment rates in the OECD, 2000. The proportion of specialists is the proportion of people who followed a type B or a type C education among upper-secondary graduates in the workforce. Source: OECD data and authors' calculations.

The comparison of unemployment rates by education type is not very meaningful. Minimizing the unemployment rate is not necessarily a good policy target: specialists may be more widely unemployed, but they may also be more productive. Moreover, the consideration of unemployment rates does not allow us to infer what would happen if a significant number of generalists decided to become specialists. What about equilibrium effects? Finally, unemployment rate differentials partly rely on crowding-out effects. For instance, employers prefer to hire specialists who already know the job rather than generalists who must first of all be trained after recruitment. Crowding-out effects have private value—you benefit from a lower risk of unemployment by becoming a specialist—but no social value—someone must be hired anyway.

This paper makes two contributions. We offer a model of the labor market with generalists and specialists where the proportion of specialists is endogenous. The model

highlights various externalities of opposite signs. We then calibrate the model on the labor market for upper-secondary graduates in 18 OECD countries. The efficient proportion of specialists is lower than the observed proportion.

We introduce a static two-sector model with matching frictions (Section 2). Jobs are costly to create and the supply of vacancies responds to job profitability through a free-entry condition in each sector. The matching place is segmented by sector. Specialists participate in a single matching segment, whereas generalists participate in both segments. Employers prefer specialists to generalists because specialists are more productive. Specialists, therefore, overcrowd generalists in job queues. The aggregate matching technology displays asymmetric cross-type congestion effects: specialists create congestion for all—including themselves—, whereas generalists do not affect the odds of employment for the specialists. In this environment, being a generalist increases the scope of potential occupations but it also reduces output and employment probability in a given sector. Conversely, being a specialist narrows the scope of potential occupations but increases output and employment probability in a given sector. These arguments do not depend on the magnitude of the productivity premium and so remain true in the limit where the productivity premium is zero.

We characterize the equilibrium with an exogenous proportion of specialists. We highlight three effects of such a proportion on the unemployment rate. The first two effects imply that the proportion of specialists boosts job creation in each sector. On the one hand, specialists are more productive than generalists and since the former come first in the job queues, firms post more vacancies per job seeker in each sector. On the other hand, generalists exacerbate employers' coordination problems on the job market: generalists may benefit from multiple job offers, but only one offer is accepted.<sup>1</sup> An increase in the proportion of specialists reduces the problem raised by generalists and so provides incentive to job creation. According to the third effect, an increase in the proportion of specialists reduces matching efficiency because specialists seek jobs in only one sector. The combination of these three effects implies that the proportion of specialists has an ambiguous impact on overall unemployment. Numeric simulations based on a calibration of the French labor market for upper-secondary graduates reveal that the relationship between the unemployment rate and proportion of specialists is U-shaped.

We then endogenize the proportion of specialists (Section 3). We consider two distinct cases. In the first people self-select in type of education. They compare the differential return on becoming a specialist with the differential schooling cost. In the second a benevolent planner chooses the proportion of specialists, accounting for the effects on

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<sup>1</sup>This externality typically arises in matching models with multiple applications (see, e.g., Albrecht, Gautier, and Vroman 2006).

job creation. We compare the resulting allocations and examine the various sources of inefficiency. Ex post rent-sharing implies that people do not internalize the effects discussed above. In addition, there may be increasing returns to specialization, which may lead to multiple equilibria (Proposition 2 provides a sufficient condition leading to the existence of three equilibria). The magnitude of the various externalities depends on the productivity differential between generalists and specialists.

We finally calibrate our model on the labor market for upper-secondary graduates in OECD countries (Section 4). We specify a matching technology and, for each country, we calibrate the model to reproduce the proportion of specialists and unemployment rates for each group as given in Table 1. We consider two distinct values of the productivity premium: 0 and 20%. These values provide extreme bounds to wage differentials across education types among upper-secondary graduates.

It turns out that self-selection is always inefficient. In each country, too many people become specialists. Reducing the proportion of specialists to its efficient level can produce significant employment gains: the unemployment rate would be reduced by 1.8 points—when the productivity premium is zero—to 1.1 points—when the productivity premium is 20%—on average. The Pigouvian tax on vocational education amounts to between 0.5% and 5% of worker output when the productivity premium is zero. This roughly corresponds to between 20% and 100% of the yearly earnings of a secondary educated. In France for instance, the tax is 2.5% and thus represents half the yearly wage.

We also perform a similar analysis for tertiary graduates. The results are qualitatively unchanged: the society would fare better if fewer people became specialists. However, the magnitude of inefficiency is not large and so the actual allocation is close to the efficient allocation. In addition, the proportion of specialists is too low in one or even two countries (Austria and Switzerland).

The trade-off between specialized and general skills has already been put forward in matching models. Wasmer (2006) examines the case of on-the-job training; Mukoyama and Sahin (2006) and Decreuse and Granier (2009) focus on education. For this trade-off to make sense workers with specialized skills must have an advantage in some dimension. Otherwise, people would have no reason to invest in specialized skills. This is why Wasmer (2006) and Decreuse and Granier (2009) also assume that specialized skills are more productive than general skills. This assumption is compatible with the view whereby specialized skills are more productive but also more risky (see, e.g., Grossman and Shapiro 1982; and Acemoglu and Shimer 2000). Another interpretation is the following. People with general skills start with a productivity disadvantage. However, they learn faster than specialists and eventually become more productive. Unfortunately, learning takes time and so a large part of the benefits due to learning will not be captured by the current but

rather by the subsequent employers. From the perspective of the first employer, therefore, a generalist is viewed as less productive than a specialist.

We shed light on a complementary margin of the trade-off between general and specialized skills. Generalists have access to a wider range of offers than specialists but employers prefer to hire specialists. In other words, generalists participate in several job queues at a time and specialists participate in a single queue where they can use the fast line. Of course, there must be a reason why employers prefer the specialists. Specialists, therefore, enjoy a productivity premium over generalists in our model. However, the mechanisms we emphasize still hold when the productivity premium is zero—a case we consider throughout the paper. In addition, we focus on normative implications, whereas previous papers do not.

This paper refers to the literature that studies the efficiency of educational investments when the labor market is frictional. Moen (1999) examines a model in which education improves one’s skills as well as one’s ranking in the job queue. The latter effect resembles our matching technology where specialists crowd out generalists in each sector. Laing, Palivos, and Wang (1995) and Burdett and Smith (2002) provide models in which the number of jobs increases with the magnitude of educational investment. In our model, similarly, the sectorial ratio of vacancy to unemployed increases with the proportion of specialists. In the multi-dimensional skill model of Charlot, Decreuse, and Granier (2005), workers invest in education not only to improve their chance of being employed, but also to raise their outside opportunities during wage negotiation. This latter return to education is not matched by a social gain and workers overinvest in education.<sup>2</sup> What is new in our approach is that the various externalities we put forward do not apply to the human capital investment level but, rather, to the divide of investment between specialized and general skills.

The idea whereby the provision of general skills is insufficient echoes a number of contributions in the literature on training investments. Stevens (1994) introduces the notion of transferable skills. These skills can only be used in a proportion of the different available jobs. Stevens argues that there is an underprovision of transferable skills by employers. Acemoglu (1997) provides a search model in which part of the gains from general training are captured by future employers. He also concludes that there is underinvestment in general training. Smits (2007) promotes a different view. She distinguishes industry-specific skills from generic skills (that have a higher value elsewhere in the economy). Workers want more generic skills than is socially optimal, while firms prefer industry-specific skills.

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<sup>2</sup>Models of educational investment with search frictions also feature externalities that cannot be related with externalities reported here. For instance, Charlot and Decreuse (2005, 2010) focus on composition externalities created by the self-selection in education of heterogeneous agents.

## 2 Model with exogenous proportion of specialists

### 2.1 Environment

The model is static. There are two productive sectors indexed by  $j = 1, 2$ . They both produce a final good. Both goods are sold in competitive markets; they are perfectly substitutable in individual preferences.

There is a continuum of individuals whose size is normalized to unity. All persons start nonemployed and need to find a job. People differ in type: they are either specialists (indexed by  $s$ ) or generalists (indexed by  $g$ ). Specialists can work in a single sector, whereas generalists can work in both. Once employed, type- $i$  agents produce  $y_i$ , with  $i = g, s$ . Let  $y_g = y$  and  $y_s = (1 + \rho)y$ , where  $\rho \geq 0$  is the skill-specific premium. The proportion of specialists is  $x \in [0, 1]$ , while the generalist proportion is  $1 - x$ . Specialists are equally shared between the two sectors.

There is a continuum of firms in each sector. Each firm is endowed with one job, which can be either active or inactive. Active jobs cost  $c$  and need to be filled before production starts. Inactive jobs cost nothing. The mass number of active jobs in each sector is  $n_j$ .

Active jobs and job seekers search for each other. Once a worker is hired, he starts producing and output is split between the worker and the firm. Let  $\beta \in (0, 1)$  denote the worker's share. Output sharing implies that firms prefer to hire specialists because firms obtain more profits with such workers. We also assume that  $(1 - \beta)y > c$ ; this condition ensures that firms create a non-trivial number of jobs when the workforce is entirely composed of generalists—that is,  $x = 0$ .

The key innovation of the model relies on the matching side. Hiring for the various types of workers usually depends on a matching technology whose inputs are the different numbers of job seekers and vacancies. The matching technology features congestion effects: expanding individuals or jobs reduces the matching odds for individuals or jobs of the same type. The crucial point is whether the matching technology displays cross-type congestion effects. When the search place is perfectly segmented by worker and job type, workers or jobs of a given type do not create congestion effects on workers or jobs of the other type. When search is random, cross-type effects are symmetric: at given number of jobs, an increase in the number of workers of a given type reduces the matching probability for both types. Workers are equally likely to get a job and the number of recruitments accruing to a given type of worker is proportional to their share among the job seekers.

We make three assumptions. First, the matching place is segmented by sector. Second, specialists participate in a single market segment, whereas generalists participate in both at no extra cost. Third, cross-type congestion effects are asymmetric: specialists crowd out generalists in each sector.

Market segmentation means that a worker seeking a sector-1 job does not create congestion effects for workers seeking a sector-2 job. In sector  $j$ , the number of meetings  $M_j$  between unemployed and vacancies obeys the following meeting technology:

$$M_j = m(u_j, n_j), \quad (1)$$

where  $u_j$  and  $n_j$  are, respectively, the number of job seekers and vacancies in sector  $j$ . The number of job seekers is  $u_j = x/2 + 1 - x = 1 - x/2$ ; this number decreases with the proportion of specialists. The technology  $m$  is twice continuously derivable, strictly increasing and strictly concave in each argument, has constant returns to scale, and satisfies the boundary properties  $m(u, 0) = m(0, n) = 0$ ,  $m(u, \infty) = u$  and  $m(\infty, n) = n$  for all  $u, n \geq 0$ . Hereafter  $\theta_j = n_j/u_j = n_j/(1 - x/2)$  is market- $j$  tightness, while  $z = (x/2)/(1 - x/2)$  is the ratio of specialists to generalists in both sectors. The mean probability of receiving an offer from a given sector is  $\mu(\theta) = m(1, \theta)$ ; the mean probability of contacting a worker in a given sector is  $\eta(\theta) = \mu(\theta)/\theta$ . We use  $\alpha(\theta) = \theta\mu'(\theta)/\mu(\theta) \in (0, 1)$  to denote the elasticity of the matching technology with respect to vacancies.

In each sector job offers are not equally shared between the job seekers: specialists overcrowd generalists in the job queues. The number of meetings for the specialists is

$$M_{js} = m(x/2, n_j). \quad (2)$$

Generalists obtain the following residual number of meetings:

$$M_{jg} = m(1 - x/2, n_j) - m(x/2, n_j). \quad (3)$$

Let  $\mu_{js}$  be the probability that a specialist in sector  $j$  receives a job offer. We have

$$\mu_{js} = \frac{M_{js}}{x/2} = m(1, \theta_j/z) = \mu(\theta_j/z). \quad (4)$$

Similarly, the probability that a generalist receives a job offer from sector  $j$  is

$$\mu_{jg} = \frac{M_{jg}}{1 - x} = \frac{\mu(\theta_j) - z\mu(\theta_j/z)}{1 - z}. \quad (5)$$

**Lemma** PROPERTIES OF OFFER PROBABILITIES

*The offer probabilities  $\mu_{js} \equiv \mu_s(\theta_j, z)$  and  $\mu_{jg} \equiv \mu_g(\theta_j, z)$  are such that:*

- (i) both  $\mu_{js}$  and  $\mu_{jg}$  increase with market tightness  $\theta_j$ ;
- (ii) both  $\mu_{js}$  and  $\mu_{jg}$  decrease with the sector-specific proportion of specialists  $z$ .

**Proof** Part (i). The function  $\mu$  is strictly increasing and  $\mu_{js}$  increases with  $\theta_j$ . The derivative of  $\mu_{jg}$  with respect to  $\theta_j$  has the sign of  $\mu'(\theta_j) - \mu'(\theta_j/z)$ . This sign is positive because the function  $\mu$  is strictly concave and  $z$  is lower than 1.

Part (ii). The function  $\mu$  is strictly increasing and so  $\mu_{js}$  decreases with  $z$ . The derivative of  $\mu_{jg}$  with respect to  $z$  yields

$$\begin{aligned}\frac{\partial \mu_{jg}}{\partial z} &= \frac{-\mu(\theta/z) + (1-z)\frac{\theta}{z}\mu'(\theta/z) + \mu(\theta)}{(1-z)^2} \\ &= g(z)(1-z)^{-2}.\end{aligned}$$

However,  $g(1) = 0$  and

$$g'(z) = -\frac{\theta}{z^2}(1-z)\mu''(\theta/z) > 0.$$

Therefore,  $g(z) < g(1) = 0$  and  $\mu_{gz} < 0$  for all  $z < 1$ .

An increase in market tightness benefits both groups of workers. This is not only true for the specialists who do not suffer from job competition by the generalists, but also for the generalists who obtain the residual number of offers. Similarly, an increase in proportion of specialists negatively affects job offers for both groups. Job competition expands for specialists, whereas generalists move back in the job queues.

In each sector the meeting technology reproduces the salient features of the directed search model with worker heterogeneity when all workers search for similar jobs (see, e.g., the separating equilibrium in Shi 2002). Unlike such a model, job offers do not always lead to employment relationships in our setting because generalists seek jobs in two sectors.

Specialists receive one job offer at most. Meeting and matching probabilities coincide as a result and

$$p_{js} = \mu_{js} = \mu(\theta_j/z). \quad (6)$$

Generalists may receive two offers, one from each sector. Their matching probability is

$$p_g = \mu_{1g} + \mu_{2g} - \mu_{1g}\mu_{2g}. \quad (7)$$

From the firms' perspective, the probability of recruiting a specialist is

$$\eta_{js} = \frac{M_{js}}{n_j} = \frac{m(1, \theta_j/z)}{\theta_j/z} = \eta(\theta_j/z). \quad (8)$$

If a generalist receives two offers, then he must choose between them. When offers are the same (which will be the case), he flips a coin with 50-50 probability. The probability of recruiting a generalist is

$$\begin{aligned}\eta_{jg} &= \frac{M_{jg}}{n_j} (1 - \mu_{-jg}/2) \\ &= [\eta(\theta_j) - \eta(\theta_j/z)] (1 - \mu_{-jg}/2).\end{aligned} \quad (9)$$

Worker's expected utility  $U_j^i$  depends on worker's type  $i$  and sector of occupation  $j$ . The firm's expected profit  $\Pi^j$  is sector-specific. We have

$$U_j^i = p_{ji}\beta y_i, \quad (10)$$

$$\Pi^j = -c + \eta_{js}(1 - \beta)y_s + \eta_{jg}(1 - \beta)y. \quad (11)$$

Free entry implies  $\Pi^1 = \Pi^2 = 0$ . The following equations obtain:

$$c = [\eta_{js}(1 + \rho) + \eta_{jg}](1 - \beta)y \quad (12)$$

for  $j = 1, 2$ . The free-entry condition determines sector-specific tightness as a function of the proportion of specialists  $x$  and the other sector tightness  $\theta_{-j}$ .

Before we solve the model we briefly comment two assumptions. First, the model is static. This has pros and cons. On the plus side, the proportion of specialists *among unemployed workers* does not depend on tightness. Generalists and specialists have heterogeneous employment probabilities and so the employment probability differential between a generalist and a specialist depends on tightness (in a non-trivial way). Changes in tightness, therefore, modify the employment probability differential, and, by construction, the proportion of each group among the unemployed. Taking this argument into account would complicate the resolution without adding much in return. On the minus side, unemployment only depends on the matching probability. In a dynamic framework, unemployment exposure would depend on matching probability *and* job loss probability. It is likely that education type determines not only matching odds, but also the job-keeping probability. In the same vein, education type may also affect job-to-job transitions.

Second, we assume output sharing. This can result from bilateral Nash bargaining over match surplus. In this case,  $\beta$  is workers' bargaining power. However, generalists may receive two offers. We implicitly assume that generalists must choose an offer before the wage contract is signed. Firm owners may well make promises, but there are no commitment mechanisms that ensure the wage promise holds. Ex post rent-sharing results. We could consider alternative wage rules. Wage bargaining could take place between three parties. Bertrand competition could result when there are two offers. Both cases would imply that generalists should be able to command higher wage to output ratios than specialists.

## 2.2 Equilibrium

A *symmetric equilibrium* is a positive number  $\hat{\theta}$  that solves the following equation:

$$\frac{c}{(1 - \beta)y} = \eta(\theta/z)(1 + \rho) + (\eta(\theta) - \eta(\theta/z)) \left[ 1 - \frac{\mu(\theta) - z\mu(\theta/z)}{1 - z} / 2 \right]. \quad (\text{FE})$$

Hereafter, we only focus on symmetric equilibria. Therefore,  $\mu_{jg} = \mu_g$ ,  $\mu_{js} = \mu_s$ ,  $\eta_{jg} = \eta_g$ , and  $\eta_{js} = \eta_s$ .

**Proposition 1** PROPERTIES OF AN EQUILIBRIUM WITH EXOGENOUS EDUCATION

Let  $x \in (0, 1)$ . The following statements hold:

- (i) There exists a unique equilibrium with exogenous education;
- (ii) Equilibrium tightness  $\hat{\theta}$  increases with  $y$ ,  $\rho$ , and  $1 - \beta$ ; it also increases with proportion of specialists  $x$ .

**Proof** (i) Let  $\phi : \mathbb{R}_+ \times (0, 1) \rightarrow \mathbb{R}$  be such that

$$\phi(\theta, z) = \eta(\theta/z)(1 + \rho) + (\eta(\theta) - \eta(\theta/z)) [1 - \mu_g(\theta, z)/2] - \frac{c}{(1 - \beta)y}. \quad (13)$$

An equilibrium is such that  $\phi(\hat{\theta}, z) = 0$ . The function  $\phi$  is continuously derivable in  $\theta$ . In addition,  $\phi(0, z) = 1 + \rho - c/((1 - \beta)y) > 0$ ,  $\phi(\infty, z) = -c/((1 - \beta)y) < 0$  and

$$\begin{aligned} \phi_\theta(\theta, z) &= \frac{\eta'(\theta/z)}{z} [\rho + \mu_g(\theta, z)/2] + \eta'(\theta) [1 - \mu_g(\theta, z)/2] \\ &\quad - (\eta(\theta) - \eta(\theta/z)) \frac{\partial \mu_g(\theta, z)}{\partial \theta} / 2. \end{aligned} \quad (14)$$

The first two terms are negative because  $\eta$  is strictly decreasing. The Lemma shows that the third term is negative as well. Therefore,  $\phi_\theta(\theta, z) < 0$  and there exists a unique equilibrium.

(ii) The comparative statics with respect to  $1 - \beta$ ,  $y$ , and  $\rho$  immediately follow. As for the proportion of specialists per sector  $z$ , equilibrium tightness  $\hat{\theta} \equiv \hat{\theta}(z, \cdot)$  is such that  $\hat{\theta}(0, \cdot)$  solves

$$\eta(\theta) (1 - \mu(\theta)/2) = \frac{c}{(1 - \beta)y}, \quad (15)$$

whereas  $\hat{\theta}(1, \cdot)$  solves

$$\eta(\theta) (1 + \rho) = \frac{c}{(1 - \beta)y}. \quad (16)$$

In addition,

$$\phi_z(\theta, z) = -\frac{\theta}{z^2} \eta'(\theta/z) (\rho + \mu_g(\theta, z)/2) - (\eta(\theta) - \eta(\theta/z)) \frac{\partial \mu_g(\theta, z)}{\partial z} / 2. \quad (17)$$

The first term is positive because  $\eta$  is decreasing. The Lemma implies that the second term is also positive. Therefore,  $\phi_z(\theta, z) > 0$ . The implicit function theorem implies

$$\hat{\theta}_z(z, \cdot) = -\frac{\phi_z(\theta, z)}{\phi_\theta(\theta, z)} > 0. \quad (18)$$

Since  $dz/dx > 0$ , the proof is closed.

In the usual working of the free-entry condition, congestion increases with tightness, which ensures the existence of a unique equilibrium. This logic also applies here because more jobs in a given sector reduce the matching probability for each. In addition expanding the number of jobs in a particular sector reduces expected profits in the other sector because generalists there have more chances of receiving multiple offers.<sup>3</sup> Both effects lead to a negative impact of sector-specific tightness on job profitability.

The productivity premium  $\rho$  and output amount accruing to firm's owner  $(1 - \beta)y$  make jobs more profitable. The equilibrium number of firms increases as a result.

The proportion of specialists has a positive impact on market tightness. Two effects are involved. First, increasing  $x$  is good for job creation because the odds of matching with a high-productive worker are higher. This effect is all the higher in so far as the productivity differential  $\rho$  is large; it vanishes when  $\rho = 0$ . Second, increasing  $x$  means generalists receive fewer offers. The Lemma shows that  $\mu_g$  decreases with  $x$  because specialists overcrowd generalists in job queues. The number of people who receive multiple offers goes down as a result. The implicit coordination problem is smaller for firms' owners and they create more jobs. The magnitude of this effect does not depend on the productivity premium. The effect, therefore, survives when  $\rho = 0$ .

We finally remark that the function  $\hat{\theta}$  is defined for a non-trivial proportion of specialists  $x \in (0, 1)$ . The function admits well-defined limits and so we denote  $\hat{\theta}(0) = \lim_{x \rightarrow 0} \hat{\theta}(x)$  and  $\hat{\theta}(1) = \lim_{x \rightarrow 1} \hat{\theta}(x)$  in the rest of the paper.

### 2.3 Beveridge curve and proportion of specialists

Let  $u_s$ ,  $u_g$ , and  $u$  denote, respectively, the specialist, generalist, and overall unemployment rates. We have

$$u_s = u_s(\theta, x) = 1 - \mu_s(\theta, x), \quad (19)$$

$$u_g = u_g(\theta, x) = [1 - \mu_g(\theta, z(x))]^2, \quad (20)$$

$$u = u(\theta, x) = x[1 - \mu_s(\theta, z(x))] + (1 - x)[1 - \mu_g(\theta, z(x))]^2. \quad (21)$$

The unemployment rate differential between specialists and generalists may be positive or negative. Specialists benefit from a higher job offer probability in each sector. But generalists pursue jobs on both sectors and receive twice the number of offers they have in a given sector.

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<sup>3</sup>There is a similar effect in the matching model with homogenous workers and multiple applications of Albrecht, Gautier, and Vroman (2006). A new job increases not only congestion in the usual meaning but it also increases the chances that a contacted worker receives another offer.

The overall unemployment rate is the weighted average of group-specific unemployment rates. We have

$$u = 1 - (2 - x) \mu(\theta) + (1 - x) \mu_g(\theta, z(x))^2. \quad (22)$$

Unemployment rate is one minus the employment probability. In each sector,  $1 - x/2$  workers seek for jobs. The mean job offer probability is  $\mu(\theta)$ . The total number of offers received by the unemployed is  $(2 - x) \mu(\theta)$ . These offers do not always lead to employment relationships because generalists may receive two offers—this event occurs with probability  $\mu_g^2$ .

Group-specific unemployment rates as well as the overall unemployment rate respond to changes in tightness and proportion of specialists. Changes in the latter proportion alter the relationship between the unemployment rate and (sector-specific) tightness because generalists receive offers from both sectors. Consequently, the unemployment rate increases with the proportion of specialists at a given vacancy to job seeker ratio. For instance, if the proportion of specialists  $x = 1$ , then the unemployment rate is  $u = 1 - \mu(\theta)$ . If the proportion of specialists is 0, then the unemployment rate is  $u = (1 - \mu(\theta))^2 < 1 - \mu(\theta)$ . The matching process becomes less efficient as the proportion of specialists increases.

[Insert Figure 1]

Figure 1 depicts a kind of Beveridge curve. Unemployment rate lies on the horizontal axis, whereas sector-specific tightness lies on the vertical axis. The curve is decreasing and convex, with  $u(0, x) = 1$  and  $u(\infty, x) = 0$  as usual. Figure 1 also depicts equilibrium tightness  $\theta = \hat{\theta}(x)$ , a straight line. The equilibrium unemployment rate results from the curve intersection, that is  $u = u(\hat{\theta}(x), x)$ . An increase in the proportion of specialists has two effects. On the one hand, it reduces the efficiency of the matching process. The Beveridge curve moves rightward as a result, which tends to increase unemployment. On the other hand, it moves equilibrium tightness up, which tends to reduce the unemployment rate. The overall impact of the proportion of specialists is ambiguous.

## 2.4 Parameterization

Here our purpose is to calibrate the French labor market of upper-secondary graduates in 2000 with a special focus on generalists and specialists. ISCED data organize horizontal differentiation of educational attainments. These data rank educational attainments into six levels (1 to 6) that go from pre-primary schooling to research. At each schooling level, there are three different types of education: from A (general) to C (vocational).

The specialists are upper-secondary educated who followed a vocational program (B or C). The generalists are upper-secondary educated who followed a general program (A). The specialist unemployment rate was about 8.7%, while the generalist unemployment rate was about 9.1%. The proportion of specialists was  $x_0 = 75\%$ . The corresponding proportion of specialists in each sector is  $z_0 = 60\%$ .

We first match the theoretical unemployment rates  $u_s$  and  $u_g$  with the empirical values. We need a matching technology with (at least) a free parameter for this purpose. The matching technology must satisfy all the assumptions listed in Sub-section 2.1. We use a variant of the urn-ball matching technology suggested by Albrecht et al (2004):  $\mu(\theta) = 1 - [1 - (\theta/\lambda)(1 - e^{-\lambda/\theta})]^\lambda$ , with  $\lambda > 0$ .<sup>4</sup> The authors derive this technology from the standard urn-ball model extended to the case of multiple applications. In this setting, parameter  $\lambda$  is the number of applications that each worker makes. By analogy (and by analogy only), parameter  $\lambda$  can be interpreted in our model as the number of applications that job seekers make on a given search market. Specialists, therefore, send  $\lambda$  applications in the only market they participate in, whereas generalists send  $2\lambda$  applications.

We find the values of  $\lambda$  and  $\theta$  such that

$$\begin{aligned} u_s &= 1 - \mu(\theta/z_0, \lambda) = 8.7\%, \\ u_g &= [1 - (\mu(\theta, \lambda) - z_0\mu(\theta/z_0, \lambda)) / (1 - z_0)]^2 = 9.1\%, \end{aligned}$$

where the dependence vis-à-vis  $\lambda$  has been made explicit. We denote the solutions  $\bar{\lambda}$  and  $\bar{\theta}$ .

In a second step we derive tightness from the working of the model with exogenous education. We now specify the rest of the parameters. Output  $y$  is normalized to unity. The productivity differential  $\rho = 0$ . This figure allows us to show that the working of the model does not depend on the fact that specialists are more productive than generalists. What matters *is* that specialists overcrowd generalists in job queues. The figure  $\rho = 0$  is somewhat arbitrary and so we will consider alternative values below. Workers' output share is  $\beta = 0.5$ .

We use the free-entry condition and compute the value of the job creation cost  $c$  such that  $\hat{\theta}(0.6) = \bar{\theta}$ . We have

$$\frac{\bar{c}}{(1 - \beta)y} = \eta(\bar{\theta}/z_0, \bar{\lambda})(1 + \rho) + (\eta(\bar{\theta}, \bar{\lambda}) - \eta(\bar{\theta}/z_0, \bar{\lambda})) [1 - \mu_g(\bar{\theta}, z_0, \bar{\lambda})/2]. \quad (\text{FE})$$

Table 2 summarizes the parameter set.

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<sup>4</sup>The Cobb–Douglas technology suffers from two drawbacks. On the one hand, it does not satisfy all the assumptions listed in Sub-section 2.1. In particular matching probabilities may exceed one. On the other hand, the calibration exercise would require a particular elasticity of the matching technology in each country to be set. Changes in scale parameters for instance would not allow us to simultaneously match the specialist and generalist unemployment rates.

$y$	$\rho$	$\beta$	$x_0$	$z_0$	$\lambda$	$c$
1.0	0.0	0.5	75%	60%	1.73	20.7%

Table 2: Parameters of the baseline simulation. Parameters  $y$ ,  $\rho$ ,  $\beta$  are arbitrarily fixed;  $x_0$  and  $z_0$  are observed;  $\lambda$  and  $c$  are chosen to match the unemployment rates of both education groups.

The panel of Figures 2 depicts the equilibrium relationships between the specialist, generalist, and global unemployment rates on the one hand, and the productivity differential  $\rho$  and the proportion of specialists  $x$  on the other hand. Figure 2a compares the various unemployment rates when the proportion of specialists varies from 0 to 100%. The generalist unemployment rate  $u_g$  is about 9% and varies very little with the proportion of specialists. The direct negative impact of the proportion of specialists on the job offer probability is actually compensated by the positive effect of such a proportion on market tightness. The specialist unemployment rate is much more volatile and strongly increases with the proportion of specialists. This pattern reflects increased congestion for the specialist at given tightness. The global unemployment rate is U-shaped. The positive effect of  $x$  on tightness dominates at low values of the proportion of specialists; it is dominated at higher values by the decline in matching efficiency. Figure 2a implies that strong employment gains can result from a decrease in proportion of specialists. Starting from 75% and decreasing to 40% leads to a reduction in unemployment rate from 8.8% to about 6%.

[Insert Panel of Figures 2]

Figures 2b to 2d separately focus on each unemployment rate and examine their sensitivity to the productivity differential. The specialist unemployment rate increases with the proportion of specialists whatever the value of  $\rho$ . The generalist unemployment rate may increase or decrease with the proportion of specialists depending on the productivity differential. When the productivity differential is low, tightness does not significantly increase with the proportion of specialists, while generalists move back in job queues. Conversely, the rise in tightness is stronger when the productivity differential is large, and the generalist unemployment rate decreases with the proportion of specialists. The relationship between the overall unemployment rate and the proportion of specialists is always U-shaped. This statement also holds when the productivity differential is zero. Generalists still deteriorate tightness in this case as they exacerbate firms' coordination problems.

### 3 Endogenous proportion of specialists

We endogenize the proportion of specialists  $x$ . Individuals are ex ante homogenous and *must* enter a schooling program prior to searching for a job. Specialized skills cost  $\chi_s$ , whereas general skills cost  $\chi_g$ . Such costs may differ for various reasons. Cost heterogeneity may reflect underlying differences in education effort. Specialized programs may involve a set of skills that were little used beforehand. Conversely, general programs may be more abstract. They may also be due to differences in non-monetary gains associated with each type of education. For instance, a general education may provide non-productive skills like access to culture—in this case  $\chi_g < 0$ . Social norms may favor one type of education versus another, irrespective of economic returns.<sup>5</sup>

We introduce such costs for the purpose of calibration. The working of the model does not require differential schooling costs: a non-trivial proportion of specialists can result as long as the productivity premium accruing to specialists is not too large. However, matching the model with actual data as displayed by Table 1 leaves us with a simple problem. On average, generalists are less exposed to unemployment than specialists; but the specialist unemployment rate is lower than the generalist one in a few countries. In such countries, specialists have higher chances of employment *and* they are paid better. The only way to derive the actual proportion of specialists as an equilibrium outcome of our model is to specify a positive differential schooling cost of becoming a specialist.<sup>6</sup> In addition, we calibrate the model with a small number of parameters. The differential schooling cost will be one of the only free parameters.<sup>7</sup>

We consider two cases. First, we assume that individuals self-select in education on the basis of the differential return to becoming a specialist and the corresponding differential cost. Second, we assume that the Government sets the proportion of specialists. The Government’s goal is to maximize social welfare. This case allows us to characterize the degree and the direction of inefficiency when people select themselves.

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<sup>5</sup>People cannot choose nonparticipation. We implicitly assume that the return to nonparticipation is lower than the return to participation net of schooling cost—whatever the type of education.

<sup>6</sup>This property is due to the assumption whereby the wage is a fixed proportion of output, which, in turn, implies that specialists receive higher wages. A different wage setting could allow generalists to be paid more.

<sup>7</sup>When the specialist unemployment rate is larger than the generalist one, we can consider an alternative calibration strategy: compute the productivity premium such that the observed allocation is the decentralized allocation of the model without schooling cost differential. It turns out that the predicted allocation with no productivity premium is very close to this configuration.

### 3.1 Self-selection in education type

The equilibrium proportion of specialists is determined by comparing the net returns to each type of skills. A worker invests in general skills if  $U^s - \chi_s < U^g - \chi_g$ . Conversely, he becomes a specialist if  $U^s - \chi_s > U^g - \chi_g$ . If  $U^s - \chi_s = U^g - \chi_g$ , then he is indifferent vis-à-vis the two types of skills and flips a coin.

The differential return  $\Delta U = U^s - U^g$  is

$$\Delta U \equiv \Delta U(\theta, x) = \mu(\theta/z) \beta (1 + \rho) y - \left[ 1 - \left( 1 - \frac{\mu(\theta) - z\mu(\theta/z)}{1-z} \right)^2 \right] \beta y. \quad (23)$$

A marginal change in market tightness has the following effect:

$$\frac{\partial(\Delta U)}{\partial \theta} = \beta (1 + \rho) y \underbrace{\frac{\mu'(\theta/z)}{z}}_{>0} - \frac{2}{1-z} (\mu'(\theta) - \mu'(\theta/z)) \underbrace{(1 - \mu_g(\theta, z))}_{<0} \beta y. \quad (24)$$

Both the return to becoming a specialist and the return to becoming a generalist increase with the rise in tightness. Since  $\Delta U = 0$  when  $\theta = 0$  and  $\Delta U = \beta \rho y$  when  $\theta$  approaches infinity, the positive effect tends to dominate the negative one. However, at given tightness, the global effect is ambiguous.

In the non-frictional case—that is,  $\theta$  tends to infinity—a specialist is sure to find a job. Why would someone become a generalist when the wage is lower? This reasoning suggests that matching frictions provide incentive to acquire general rather than specialized skills. In another setting where each person allocates educational investment between adaptability and specialized skills, Deceuse and Granier (2009) also argue that matching frictions direct skill investment towards general skills; they are in line with Rosen (1983) who explains that the incentives to specialization are closely related to skill use: “the return to investment in a particular skill is increasing in its subsequent rate of utilization”.

It turns out that the non-frictional case provides only a partial explanation. When tightness is finite, being a specialist is also attractive. If the chance of being offered a job is very small in each sector, then being put in front of the job queue becomes very important—even more than participating in several queues at a time. From this perspective, matching frictions provide incentive to become a specialist. This effect arises only in our setting where the matching technology displays cross-type asymmetric congestion effects.

A marginal change in sector-specific proportion of specialists  $z$  has the following effect:

$$\frac{\partial(\Delta U)}{\partial z} = - \underbrace{\frac{\alpha(\theta/z) \mu(\theta/z)}{z^2}}_{<0} \beta (1 + \rho) y + \frac{2(1 - \alpha(\theta/z)) \mu(\theta/z)}{(1-z)^2} \underbrace{(1 - \mu_g(\theta, z))}_{>0} \beta y. \quad (25)$$

Both returns are negatively impacted. On the one hand, more specialists means increased congestion for them. This is a stabilizer effect: increasing the proportion of specialists

tends to reduce the differential return to becoming a specialist. On the other hand, having more specialists means there are fewer jobs per generalist job seeker. This is a multiplier effect because this effect tends to increase the differential return to becoming a specialist.

There are no reasons to believe that the stabilizer effect should dominate the multiplier effect. The magnitude of such effects depends on  $\theta$ . Consider for instance the limit cases where  $z$  is zero and when  $z$  is one. If  $z$  is zero, then we have

$$\Delta U(\theta, 0) = \beta(1 + \rho)y - [1 - (1 - \mu(\theta))^2] \beta y > 0. \quad (26)$$

If  $z$  is one, then we have

$$\Delta U(\theta, 1) = \beta\mu(\theta)(1 + \rho)y - [1 - (1 - (1 - \alpha(\theta))\mu(\theta))^2] \beta y. \quad (27)$$

Taking the difference, we obtain

$$\Delta U(\theta, 1) - \Delta U(\theta, 0) = \beta y [\mu(1 + \rho + 2\alpha(1 - \mu) + \alpha^2\mu) - (1 + \rho)], \quad (28)$$

with  $\mu = \mu(\theta)$  and  $\alpha = \alpha(\theta)$ . When  $\mu$  is small, the difference is negative and the stabilizer effect dominates as the intuition suggests. However, when  $\mu$  is large, the difference is positive, and the multiplier effect dominates.

In this discussion we separately consider changes in  $\theta$  and  $z$ . A change in  $z$  also affects market tightness. In turn, the change in market tightness modifies the differential return to becoming a specialist. We now examine these equilibrium considerations.

### 3.2 Equilibrium with self-selection in education type

A *symmetric equilibrium with self-selection in education type* is a vector  $(\theta^*, z^*)$  that satisfies

$$\frac{c}{(1 - \beta)y} = \eta(\theta^*/z^*)(1 + \rho) + (\eta(\theta^*) - \eta(\theta^*/z^*)) [1 - \mu_g(\theta^*, z^*)/2], \quad (\text{FE})$$

$$\mu(\theta^*/z^*)(1 + \rho) - [1 - (1 - \mu_g(\theta^*, z^*))^2] \begin{cases} \leq \Delta\chi/(\beta y) & \text{if } z^* = 0 \\ = \Delta\chi/(\beta y) & \text{if } z^* \in (0, 1) \\ \geq \Delta\chi/(\beta y) & \text{if } z^* = 1 \end{cases}, \quad (\text{OS})$$

where  $\Delta\chi \equiv \chi_s - \chi_g$ .

An *interior equilibrium* is a symmetric equilibrium with self-selection in which  $z^* \in (0, 1)$ .

#### **Proposition 2** PROPERTIES OF EQUILIBRIUM WITH SELF-SELECTION

*A. Assume that  $\Delta U(\hat{\theta}(0), 0) > \Delta\chi/(\beta y) > \Delta U(\hat{\theta}(1), 1)$ . The following statements hold:*

(i) there exists an interior equilibrium with

$$\Delta U_\theta \left( \hat{\theta}(z^*), z^* \right) \hat{\theta}'(z^*) < -\Delta U_z \left( \hat{\theta}(z^*), z^* \right); \text{ and} \quad (29)$$

(ii)  $dz^*/d\Delta\chi < 0$  and  $d\theta^*/d\Delta\chi > 0$ ,  $dz^*/d\rho \lesseqgtr 0$  and  $d\theta^*/d\rho > 0$ ,  $dz^*/d\rho \lesseqgtr 0$  and  $d\theta^*/dc < 0$ .

B. Assume that  $\Delta U(\hat{\theta}(0), 0) < \Delta\chi/(\beta y) < \Delta U(\hat{\theta}(1), 1)$ . The following statement holds:

(iii) there are at least three equilibria  $(0, z^*, 1)$  with  $z^* \in (0, 1)$  and

$$\Delta U_\theta \left( \hat{\theta}(z^*), z^* \right) \hat{\theta}'(z^*) > -\Delta U_z \left( \hat{\theta}(z^*), z^* \right). \quad (30)$$

**Proof** Part (i). In the proof of Proposition 1 we characterize the implicit function  $\hat{\theta} \equiv \hat{\theta}(z, \rho, c)$  defined by the free-entry condition (FE). The equilibrium, therefore, is such that

$$\begin{aligned} \Delta U \left( \hat{\theta}(z^*), z^* \right) &\leq \Delta\chi \text{ if } z^* = 0, \\ \Delta U \left( \hat{\theta}(z^*), z^* \right) &= \Delta\chi \text{ if } z^* \in (0, 1), \\ \Delta U \left( \hat{\theta}(z^*), z^* \right) &\geq \Delta\chi \text{ if } z^* = 1. \end{aligned}$$

The result follows from the fact that  $\Delta U$  is differentiable with respect to  $z$ .

Part (ii). We know that  $z^*$  is implicitly defined by  $\Delta U(\hat{\theta}(z^*, c, \rho), z^*, \rho) = \Delta\chi$ , while  $\theta^* = \hat{\theta}(z^*, c, \rho)$ . Inequality (29) implies that either  $\Delta U_\theta < 0$  or  $\Delta U_\theta \geq 0$  and  $\Delta U_z < 0$ . Consider any parameter  $p \in (\Delta\chi, c, \rho)$ . The implicit function theorem implies

$$\frac{dz^*}{dp} = -\frac{\Delta U_\theta(\theta^*, z^*, \rho) \hat{\theta}_p(z^*, c, \rho) + \Delta U_p(\theta^*, z^*, \rho) - d\Delta\chi/dp}{\Delta U_\theta(\theta^*, z^*, \rho) \hat{\theta}_z(z^*, c, \rho) + \Delta U_z(\theta^*, z^*, \rho)}, \quad (31)$$

$$\frac{d\theta^*}{dp} = \hat{\theta}_p(z^*, c, \rho) + \hat{\theta}_z(z^*, c, \rho) \frac{dz^*}{dp}. \quad (32)$$

As  $\hat{\theta}_{\Delta\chi} = 0$  and  $\Delta U_{\Delta\chi} = 0$ ,  $dz^*/d\Delta\chi > 0$ , which implies  $d\theta^*/d\Delta\chi > 0$ . As  $\hat{\theta}_c < 0$  and  $\Delta U_c = 0$ ,  $dz^*/dc$  has the sign of  $-\Delta U_\theta(\hat{\theta}(z^*, c, \rho), z^*, \rho)$ . This sign can be positive or negative as long as inequality (29) holds. Then,

$$\frac{d\theta^*}{dc} = \hat{\theta}_c - \hat{\theta}_z \frac{\Delta U_\theta \hat{\theta}_c}{\Delta U_\theta \hat{\theta}_z + \Delta U_z} = \hat{\theta}_c \frac{\Delta U_z}{\Delta U_\theta \hat{\theta}_z + \Delta U_z}. \quad (33)$$

If  $\Delta U_\theta \geq 0$ , inequality (29) implies  $\Delta U_z < 0$  and  $d\theta^*/dc < 0$ . If  $\Delta U_\theta < 0$ , then  $dz^*/dc > 0$ , and equation (32) implies that  $d\theta^*/dc < 0$ . A similar reasoning leads to  $dz^*/d\rho$  ambiguous, whereas  $d\theta^*/d\rho > 0$ .

Part (iii). The fact that  $z^* = 0$  and  $z^* = 1$  are equilibria follows from the definition of a symmetric equilibrium. From the differentiability of  $\Delta U$ , there exists  $z^* \in (0, 1)$  such that  $\Delta U(\hat{\theta}(z^*), z^*) = \Delta\chi$  and inequality (30) holds.

Part A provides a sufficient condition for the existence of a “stable” equilibrium. This condition states that the differential return to specialization is larger than the differential schooling cost when none get specialized and lower than the differential cost when everyone is a specialist. Consequently, there is at least one non-trivial proportion of specialists such that  $\Delta U = \Delta\chi/(\beta y)$ . Moreover, the interior equilibrium (if unique) or one of the equilibria (if multiple equilibria) is such that the differential return to becoming a specialist decreases with the proportion of specialists in the neighborhood of equilibrium.

Stability can be achieved by two different means. The proportion of specialists exerts two kinds of impacts on the differential return to becoming a specialist. The direct effect  $\Delta U_z$  may either be positive or negative—we discuss this in the previous sub-section. The indirect effect  $\Delta U_{\theta\hat{\theta}_z}$  transits through the change in tightness. The stability condition (29) requires that the sum of the direct and indirect effects is negative.

An increase in the cost of acquiring specialized skills has non-ambiguous effects. The proportion of specialists falls and tightness decreases on each market as a result. This strengthens the direct effect and the proportion of specialists further decreases. This result has a direct implication. Suppose some external information tells the true value of  $x$  in the workforce. Suppose also that we are in the case of part A of Proposition 2—that is,  $\Delta U(\hat{\theta}(0), 0) > \Delta\chi/(\beta y) > \Delta U(\hat{\theta}(1), 1)$ . We can always find the value of  $\Delta\chi$  such that  $x$  is an equilibrium outcome. We use this property in Sub-section 3.4.

The comparative statics with respect to the job creation cost  $c$  and the productivity premium  $\rho$  are ambiguous. Consider an increase in job creation cost  $c$ . In line with Proposition 1, firms create more jobs per seeker and tightness increases. Matching frictions become less severe in each sector. However (as discussed in Sub-section 3.1), matching frictions have no clear-cut effects on the differential return to becoming a specialist. The equilibrium proportion of specialists increases when such a return goes up and decreases when the return goes down. An increase in the productivity premium  $\rho$  leads to similar discussions. Overall, the proportion of specialists is much less likely to decrease since  $\rho$  has a direct positive impact on the differential return to becoming a specialist.

Part B provides a sufficient condition for the existence of multiple equilibria. Such equilibria are the two extreme situations where there are no specialists, everyone becomes a specialist, plus an interior equilibrium. The interior equilibrium is “unstable” as a marginal increase in the proportion of specialists would increase the differential return to becoming a specialist. Multiple equilibria may arise for two reasons. On the one hand, increasing the proportion of specialists at given tightness does not necessarily reduce the

differential return to becoming a specialist. The multiplier effect discussed above may dominate the stabilizer effect. On the other hand, the interaction between job creation and schooling choices implies that there may be increasing social returns to specialization: expanding the proportion of specialists provides incentive to job creation along the lines of Proposition 1. Meanwhile, the rise in tightness promotes specialized skills.<sup>8</sup>

When multiple equilibria result, high-tightness and high-proportion of specialists equilibria coexist with low-tightness and low-proportion of specialists equilibria. Equilibria cannot easily be Pareto-ranked because the proportion of specialists reduces the efficiency of the matching technology. Unemployment, similarly, may be higher or lower in the high-proportion of specialists equilibrium.

### 3.3 Optimal proportion of specialists

We now examine the case where the proportion of specialists is decided by a benevolent planner who maximizes social welfare. However, the planner does not choose the whole allocation. Firms create jobs in each market and so the planner accounts for the impacts of the proportion of specialists on job creation. In other words, the planner suffers not only from the same information imperfections as workers and firm owners do, but he also takes as given the potential inefficiency of job creation decisions. This assumption allows us to focus on the particular externalities conveyed by education type.

The planner's goal is

$$\max_{x \in [0,1]} \Omega = \left\{ x \mu_s (\hat{\theta}(z(x)), z(x)) (1 + \rho) + (1 - x) [1 - (1 - \mu_g (\hat{\theta}(z(x)), z(x)))^2] - x \frac{\Delta \chi}{\beta y} \right\}. \quad (34)$$

Taking the derivative of  $\Omega$  with respect to  $x$  gives

$$\begin{aligned} \frac{d\Omega}{dx} = & \mu_s (1 + \rho) - \left( 1 - (1 - \mu_g)^2 \right) - \frac{\Delta \chi}{\beta y} \\ & + x \left( \frac{\partial \mu_s}{\partial z} + \frac{\partial \mu_s}{\partial \theta} \theta'(z) \right) (1 + \rho) z'(x) + 2(1 - x) (1 - \mu_g) \left( \frac{\partial \mu_g}{\partial z} + \frac{\partial \mu_g}{\partial \theta} \theta'(z) \right) z'(x). \end{aligned} \quad (35)$$

The first line is the private differential return to becoming a specialist  $\Delta U$  (normalized by  $\beta y$ ) net of differential schooling cost. The second line accounts for the various externalities discussed in the paper. Namely, the planner takes into account that changes in the proportion of specialists affect job creation and matching probabilities of both groups.

It follows that a marginal change in  $x$  can improve welfare in equilibrium with self-

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<sup>8</sup>This mechanism borrows from Acemoglu (1996), Burdett and Smith (2002), and Laing, Palivos, and Wang (1996). All these papers analyze investments in education.

selection. We have

$$\frac{d\Omega}{dx} \Big|_{x=x^*} = x \left( \frac{\partial \mu_s}{\partial z} + \frac{\partial \mu_s}{\partial \theta} \theta'(z) \right) (1 + \rho) z'(x) + 2(1-x)(1-\mu_g) \left( \frac{\partial \mu_g}{\partial z} + \frac{\partial \mu_g}{\partial \theta} \theta'(z) \right) z'(x). \quad (36)$$

The direction of the change is a priori ambiguous.

In the particular case where  $\rho = 0$ , the planner's goal reduces to

$$\max_{x \in [0,1]} \Omega = 1 - u \left( \hat{\theta}(z(x)), z(x) \right) - x \frac{\Delta \chi}{\beta y}. \quad (37)$$

The goal is to maximize employment reduced by the overall differential cost of education  $\Delta \chi$ .

The extent of inefficiency crucially depends on the magnitude of congestion effects displayed by the aggregate matching technology. When workers do not create congestion effects, the decentralized allocation is constrained efficient. To illustrate this argument, suppose that the elasticity  $\alpha$  is arbitrarily small. The probability of receiving an offer is then roughly the same for the specialists and the generalists; let us call it  $m$ . The differential return of becoming a specialist is  $\Delta U = m(1 + \rho)\beta y - [1 - (1 - m)^2]\beta y$ . The derivative of the planner's goal with respect to  $x$  becomes  $d\Omega/dx = (\Delta U - \Delta \chi)/(\beta y)$ . The planner's choice, therefore, coincides with the decentralized allocation: either none ( $\Delta U < \Delta \chi$ ) or everyone becomes a specialist ( $\Delta U > \Delta \chi$ ).

## 4 Are there too many specialists in OECD countries?

We calibrate our model on OECD data at country level. We focus on upper-secondary graduates. We match the actual allocation with the decentralized allocation predicted by our model. We then compare the actual allocation with the efficient allocation. We also perform a similar analysis for tertiary graduates.

Before we proceed to the calibration, we want to highlight the implicit assumptions behind this exercise. We first assume that people who followed a general education and people who followed a vocational education compete for the same jobs. This assumption is in line with the fundamental question we address, that is, whether schooling programs should become more vocational or more general; it is less adapted to the ISCED divide between vocational and general education. For instance, the only way to become a nurse is to follow a nurse training program. Second, we assume that people have more or less the same education level. However, vocational programs tend to be shorter than general programs. We finally neglect worker ex ante heterogeneity and resulting composition effects induced by self-selection in education type. More generally, the characteristics of specialists coincide with the characteristics of generalists in our model.

The calibration strategy is as described in Sub-section 2.4. In each country we find the value of parameter  $\bar{\lambda}$  of the matching technology and the value of market tightness  $\bar{\theta}$  that reproduce the specialist and generalist unemployment rates at observed proportion of specialists  $x_0$ . We then choose the productivity premium  $\rho$  and find the job creation cost  $\bar{c}$  such that  $\hat{\theta}(z_0) = \bar{\theta}$ . We finally select the cost of acquiring specialized skills  $\bar{\Delta}\chi$  such that the (stable) equilibrium proportion of specialists is  $x^* = x_0$ . Formally, we have

$$\bar{\Delta}\chi = \Delta U \left( \hat{\theta}(z_0), z_0 \right). \quad (38)$$

Once the parameter set is found for each country, we compute the efficient allocation. We find the socially optimal proportion of specialists  $x^s$ , the corresponding sectorial proportion of specialists  $z^s$ , and associated unemployment rates  $u_s^s$  and  $u_g^s$ . We finally compute the Pigouvian tax  $t^s$  on vocational education that decentralizes the constrained-efficient allocation:

$$t^s = \Delta U \left( \hat{\theta}(z^s), z^s \right) - \bar{\Delta}\chi. \quad (39)$$

The productivity premium is a key variable because it governs the magnitude of the positive externality associated with the proportion of specialists. In the absence of external country-specific information available for all countries, we consider different values of the productivity premium. We report the whole results for  $\rho = 0$ —that is, there are no wage differentials across education type—and  $\rho = 20\%$ —that is, the wage premium accruing to specialists is 20%. On top of that, we also report the value of the productivity premium (if any) such that the actual allocation is efficient.

## 4.1 Results for upper-secondary graduates

We consider the 18 countries featured by Table 1.

Table A1 in the Appendix gives the values of the calibrated parameters for the different countries and for both values of  $\rho$ . The mean job creation cost amounts to between 13.5% ( $\rho = 0$ ) and 15.1% ( $\rho = 20\%$ ) of output per worker. The values are larger when the productivity premium is 20% because equilibrium tightness must stay the same whereas the workforce is more productive on average. The mean differential schooling cost is -0.5% when  $\rho = 0$  and +8.7% when  $\rho = 20\%$ . Here again, the differential schooling cost is larger when  $\rho = 20\%$  because the equilibrium proportion of specialists must stay the same, whereas specialists receive higher wages. The case  $\rho = 0$  is quasi compatible with a situation where the differential schooling cost is zero, which explains our preference for this parameterization.

Table 3 compares the actual allocation with the efficient allocation when  $\rho = 0$  and when  $\rho = 20\%$ . Self-selection is always inefficient. The private differential return to

becoming a specialist is higher than the social return. Consequently, too many people become specialists. The magnitude of inefficiency decreases with  $\rho$ . When  $\rho = 0$ , the efficient proportion is, on average, 28 percentage points lower than the empirical proportion. When  $\rho = 20\%$ , the difference falls to 18 percentage points.

[Insert Table 3]

Inefficiency results in additional unemployment risk. The unemployment rate is almost always larger in the decentralized economy than in the efficient allocation. Designing a good education policy, therefore, can lead to employment gains. Subsidizing general programs (or, alternatively, taxing vocational programs) can reduce the global unemployment rate by 1.1 percentage points ( $\rho = 20\%$ ) to 1.8 percentage points ( $\rho = 0$ ) on average.

The people who remain specialists would be the winners of such policies towards general education. Table 3 displays small changes for the generalists, whereas the specialist unemployment rate would be massively reduced. German specialists for instance would see their unemployment rate fall from 8.5% to 3.5–5%. By contrast, the generalist unemployment rate would not change.

The magnitude of inefficiency can be measured by the Pigouvian tax on vocational education. This tax varies between 0.5% and 5% of output per worker when  $\rho = 0$ . What do these figures mean? In our static model output per worker represents output over one's lifetime. Let us assume that people work 40 years and that they discount time at 5% yearly rate. The present value of the future flows of output at labor market entry is roughly 20 times the yearly flow. The Pigouvian fee therefore amounts to between 0.1 year and one year of output. The individual wage is half total output. The tax amounts to between 0.2 and two years of yearly earnings. This tax is paid over the number of years spent in vocational education.

Table 3 also provides the threshold  $\rho$  such that the actual allocation is efficient. The threshold productivity differential varies between 22.5% in the Netherlands and 140% in Greece. It does not exist in four countries, which means that the proportion of specialists is always too high in these countries.<sup>9</sup> These values are not empirically credible because they imply enormous wage differentials across education type. They also imply very large schooling cost differentials (not reported here).

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<sup>9</sup>Increasing the productivity premium expands the magnitude of the positive externality associated with the proportion of specialists. However, it also reduces the chances of having an interior equilibrium—all individuals want to become specialists.

## 4.2 Results for tertiary graduates

We consider all available countries from the OECD dataset. The list of countries does not coincide with the list in the case of upper-secondary graduates.

Table A2 in the Appendix gives the calibrated parameters for both values of  $\rho$ . The mean job creation cost varies between 9.7% and 10.5%. The mean schooling cost differential is roughly equal to zero when  $\rho = 0$ , whereas it is equal to 9.3% when  $\rho = 20\%$ .

Table 4 compares the actual allocation with the efficient one. Here again the actual proportion of specialists is too large when  $\rho = 0$ . However, the difference is less spectacular than in the case of secondary graduates: the efficient proportion is 19 points lower than the actual proportion; the proportion of specialists is even too small in Switzerland. Reducing the proportion of specialists to its efficient level would decrease the unemployment rate by half a point on average. The results are qualitatively similar when  $\rho = 20\%$ ; employment gains are nonexistent.

Table 4 also provides the productivity premium implying that the actual allocation is efficient. The values are much lower than in the case of upper-secondary graduates. However, the mean value across countries is still  $\rho = 50\%$ . Taken together our results suggest that the proportion of specialists is slightly too high at tertiary level.

[Insert Table 4]

## 5 Conclusion

There is a growing debate in education as to whether vocational education offers better labor market performances than general education. On the one hand, vocational education is closer to employers' needs, and students who follow such programs are more employable as a result. On the other hand, general education affords adaptability skills and gives access to more jobs. In this paper, we provide a matching model of the labor market. The model features two sectors, endogenous job creation, and skill type heterogeneity. Specialists are more productive but can only work in one sector. Generalists are less productive but seek for jobs in both sectors. To account for the fact that employers prefer specialists to generalists in each sector, we consider a particular matching technology. The matching function displays asymmetric cross-type congestion externalities. Specialists create congestion for all and generalists do not affect the odds of employment for the specialists. In other words, generalists can participate in several job queues at a time, but stay behind in each queue; specialists are given a unique chance, but are put first in the queue.

Self-selection in education type vehicles three main externalities. First, the proportion of specialists boosts job creation in each sector: specialists are more productive and so rent-sharing allows employers to obtain more profits with them. Second, generalists improve the efficiency of the matching technology: a specialist can be seen as an input of the matching technology in a single sector, whereas a generalist is an input in both sectors. Third, generalists may receive several job offers at a time. This possibility exacerbates firms' coordination problems and reduces the ratio of vacancies to job seekers in each sector. Such externalities may lead to multiple equilibria and imply that subsidizing a particular program can improve welfare.

We calibrate the model on OECD data at country level. The focus is on upper-secondary graduates. We match the actual proportion of specialists and unemployment rates by education type and then compare the actual allocation with the efficient one. Our calibrations show that too many people have become specialists in OECD countries. Unemployment risk could be reduced by about 1.5 point if the proportion of specialists were set at an efficient level. We also focus on tertiary educated and reach similar qualitative results: there are too many specialists on average. However, the magnitude of inefficiency is much lower than in the case of upper-secondary graduates: employment gains are negligible and the proportion of specialists proves to be too small in a minority of countries.

The present paper can be extended in several directions. By design a static model does not afford an insight as to the impact of education type on job loss probability. Specialists should be less exposed to the risk of dismissal in regular times; generalists should be more able to cope with technological change. The model, similarly, does not say anything about job-to-job transitions. Moreover the productivity premium benefiting specialists is exogenous. It may depend on experience and tenure. It may even reverse if generalists accumulate human capital faster than specialists. Finally, our model abstracts from worker ex ante heterogeneity. Such heterogeneity may lead to rich composition effects in education groups. It may also involve the use of micro data.

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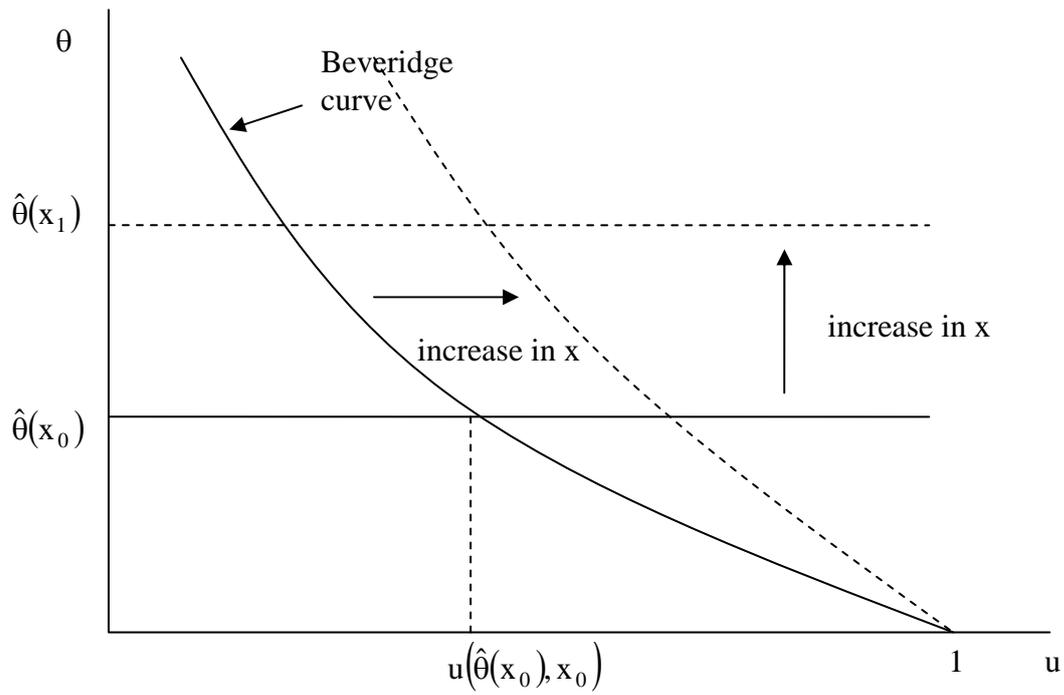


Fig.1 : Beveridge curve and the specialist proportion.

The Figure depicts the two effects of an increase in the specialist proportion. The Beveridge curve moves rightward *and* tightness moves upward in each sector.

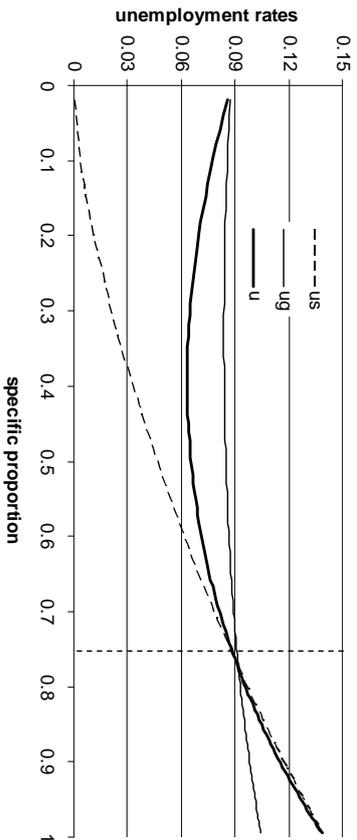


Fig.2a: Unemployment rates as a function of the specialist proportion;  $\rho = 0$

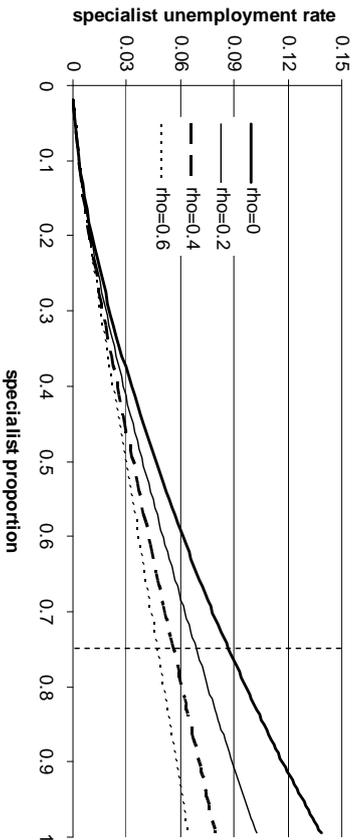


Fig.2b: Specialist unemployment rates as a function of the specialist proportion and productivity differential

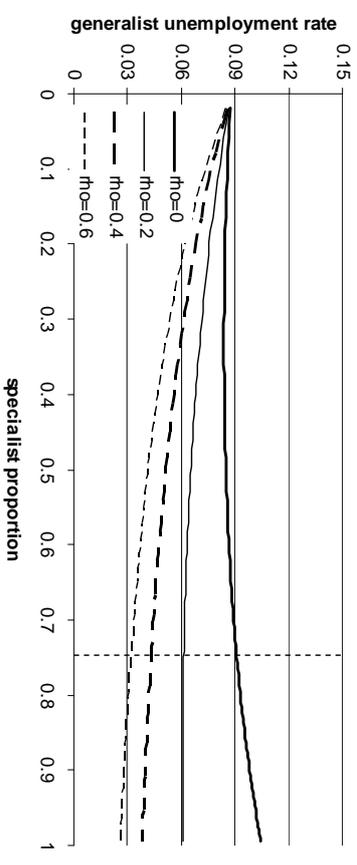


Fig.2c: Generalist unemployment rate as a function of the specialist proportion and productivity differential

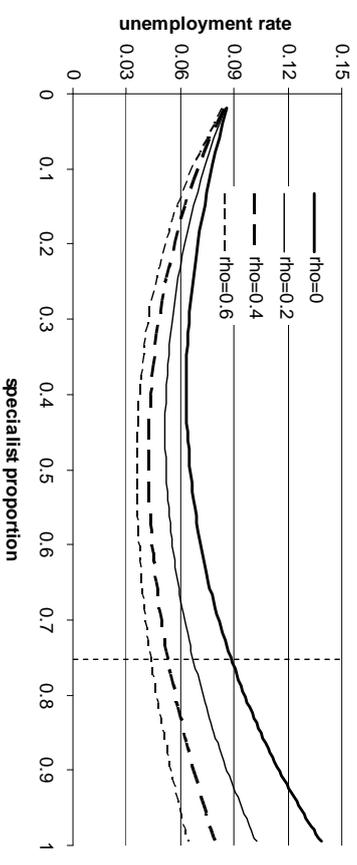


Fig.2d: Overall unemployment rate as a function of the specialist proportion and productivity differential

Table A1: Calibrated parameters as a function of  $\rho$ , case of upper-secondary graduates

	lambdabar	rho = 0		rho = 20%	
		cbar	dchibar	cbar	dchibar
Australia	1.024	0.147	0.014	0.155	0.110
Austria	5.049	0.179	-0.001	0.210	0.096
Belgium	0.482	0.051	-0.014	0.054	0.077
Czech Republic	0.852	0.119	-0.013	0.132	0.079
Denmark	4.644	0.200	0.007	0.233	0.102
France	1.734	0.207	0.002	0.238	0.093
Germany	1.019	0.091	-0.027	0.108	0.065
Greece	0.412	0.102	-0.001	0.106	0.084
Hungary	0.787	0.091	-0.014	0.100	0.078
Ireland	1.503	0.131	0.003	0.143	0.100
Italy	0.651	0.138	0.011	0.145	0.102
Luxembourg	2.313	0.138	-0.001	0.156	0.097
Netherlands	2.289	0.162	0.005	0.181	0.103
New Zealand	1.741	0.162	-0.005	0.186	0.090
Poland	0.503	0.124	-0.021	0.137	0.060
Slovak Republic	0.424	0.099	-0.029	0.109	0.050
Switzerland	15.350	0.167	0.004	0.196	0.102
Turkey	0.636	0.125	-0.002	0.134	0.087
Mean	2.301	0.135	-0.005	0.151	0.087

In each country, the parameters  $\lambda$ ,  $c$ , and  $\Delta\chi$  are computed so as to match equilibrium unemployment rates by education type and specialist proportion with their empirical counterparts. The row "Mean" gives the average value for each variable.

Table 3: Efficient allocation vs observed allocation, case of upper-secondary graduates

	observed allocation				efficient allocation when rho = 0						efficient allocation when rho = 20%						limit rho
	x0	u0	ug0	u0	xeff	useff	ugeff	ueff	xeff	useff	ugeff	ueff	xeff	useff	ugeff	ueff	
Australia	0.270	0.039	0.067	0.059	0.086	0.012	0.065	0.061	0.210	0.031	0.068	0.060	0.35				
Austria	0.880	0.033	0.032	0.033	0.637	0.011	0.032	0.019	0.742	0.020	0.035	0.024	0.725				
Belgium	0.250	0.089	0.061	0.068	0.020	0.026	0.057	0.056	0.072	0.050	0.060	0.059	1.4				
Czech Republic	0.560	0.090	0.065	0.079	0.178	0.034	0.060	0.055	0.298	0.055	0.066	0.063	1.85				
Denmark	0.830	0.041	0.054	0.043	0.574	0.013	0.053	0.030	0.680	0.024	0.058	0.035	0.87				
France	0.750	0.087	0.091	0.088	0.374	0.029	0.084	0.063	0.496	0.049	0.095	0.072	.				
Germany	0.940	0.085	0.031	0.082	0.403	0.035	0.028	0.031	0.524	0.050	0.032	0.041	.				
Greece	0.210	0.152	0.150	0.150	0.010	0.043	0.140	0.139	0.049	0.084	0.146	0.143	1.7				
Hungary	0.510	0.076	0.048	0.062	0.152	0.029	0.044	0.042	0.265	0.047	0.049	0.048	1.4				
Ireland	0.450	0.025	0.030	0.028	0.272	0.012	0.030	0.025	0.416	0.023	0.030	0.027	0.27				
Italy	0.250	0.090	0.112	0.107	0.030	0.023	0.105	0.103	0.109	0.054	0.112	0.105	0.87				
Luxembourg	0.650	0.020	0.018	0.019	0.482	0.011	0.018	0.015	0.621	0.018	0.018	0.018	0.26				
Netherlands	0.570	0.022	0.032	0.026	0.422	0.012	0.033	0.024	0.559	0.021	0.032	0.026	0.225				
New Zealand	0.730	0.055	0.045	0.052	0.397	0.021	0.043	0.034	0.527	0.035	0.048	0.041	1.05				
Poland	0.510	0.192	0.151	0.172	0.091	0.079	0.134	0.129	0.186	0.118	0.146	0.141	.				
Slovak Republic	0.500	0.210	0.152	0.181	0.077	0.093	0.135	0.132	0.165	0.133	0.146	0.144	.				
Switzerland	0.870	0.023	0.033	0.024	0.656	0.006	0.032	0.015	0.756	0.014	0.035	0.019	0.585				
Turkey	0.350	0.109	0.105	0.106	0.058	0.035	0.097	0.093	0.152	0.066	0.104	0.098	1.4				
Mean	0.560	0.080	0.071	0.077	0.273	0.029	0.066	0.059	0.379	0.049	0.071	0.065	.				

The calibrated parameters are given by Tables 2 and A1. The efficient allocation maximizes the social criterion given in Sub-section 3.3. We distinguish two configurations, whether  $\rho = 0$  or  $\rho = 20\%$ . The row "Mean" gives the average value for each variable. The column "limit rho" provides the value of rho (if any) such that the actual allocation is efficient.

Table A2: Calibrated parameters as a function of  $\rho$ , case of tertiary graduates

	lambdabar	rho = 0		rho = 20%	
		cbar	dchibar	cbar	dchibar
Australia	0.689	0.055	-0.010	0.059	0.085
Austria	2.423	0.145	0.004	0.160	0.103
Belgium	1.585	0.140	0.000	0.156	0.097
Canada	1.167	0.122	-0.004	0.134	0.091
Denmark	4.124	0.190	0.008	0.218	0.105
Finland	0.920	0.094	-0.011	0.104	0.083
France	1.276	0.154	0.003	0.169	0.098
Germany	0.994	0.103	-0.004	0.111	0.091
Greece	0.637	0.104	-0.003	0.110	0.089
Ireland	1.135	0.081	-0.003	0.087	0.095
Korea	0.550	0.038	-0.015	0.040	0.078
Luxembourg	1.194	0.068	-0.002	0.073	0.096
Netherlands	0.677	0.042	0.000	0.043	0.098
New Zealand	1.356	0.137	0.003	0.149	0.100
Portugal	0.972	0.095	0.001	0.101	0.098
Slovak Republic	0.272	0.008	-0.017	0.008	0.074
Switzerland	2.316	0.137	0.006	0.149	0.105
United States	0.592	0.028	-0.004	0.028	0.094
Mean	1.271	0.097	-0.003	0.105	0.093

In each country, the parameters  $\lambda$ ,  $c$ , and  $\Delta\chi$  are computed so as to match equilibrium unemployment rates by education type and specialist proportion with their empirical counterparts. The row "Mean" gives the average value for each variable.

Table 4: Efficient allocation vs observed allocation, case of tertiary graduates

	x0	observed allocation			efficient allocation when rho = 0						efficient allocation when rho = 20%						limit rho
		us0	ug0	u0	xeff	useff	ugeff	ueff	xeff	useff	ugeff	ueff					
Australia	0.328	0.050	0.030	0.036	0.063	0.016	0.028	0.028	0.174	0.033	0.030	0.031	0.82				
Austria	0.520	0.013	0.021	0.016	0.453	0.009	0.021	0.016	0.592	0.016	0.019	0.018	0.08				
Belgium	0.551	0.033	0.033	0.033	0.323	0.015	0.033	0.027	0.462	0.026	0.034	0.031	0.42				
Canada	0.516	0.047	0.039	0.043	0.230	0.019	0.038	0.033	0.364	0.033	0.040	0.037	0.67				
Denmark	0.736	0.027	0.042	0.031	0.556	0.012	0.043	0.025	0.671	0.021	0.044	0.029	0.38				
Finland	0.535	0.060	0.037	0.049	0.190	0.023	0.035	0.033	0.316	0.038	0.038	0.038	1.06				
France	0.498	0.051	0.056	0.053	0.230	0.020	0.055	0.047	0.364	0.036	0.058	0.050	0.62				
Germany	0.427	0.045	0.037	0.040	0.157	0.017	0.035	0.032	0.287	0.031	0.038	0.036	0.6				
Greece	0.299	0.086	0.081	0.082	0.044	0.025	0.076	0.073	0.127	0.051	0.081	0.077	1.05				
Ireland	0.389	0.023	0.017	0.019	0.186	0.010	0.017	0.016	0.330	0.019	0.017	0.018	0.32				
Korea	0.312	0.064	0.033	0.043	0.044	0.022	0.031	0.030	0.118	0.038	0.033	0.033	1.2				
Luxembourg	0.366	0.015	0.010	0.012	0.198	0.007	0.010	0.010	0.351	0.014	0.011	0.012	0.23				
Netherlands	0.106	0.020	0.021	0.021	0.000	0.000	0.020	0.020	0.044	0.011	0.021	0.020	0.38				
New Zealand	0.438	0.033	0.039	0.036	0.234	0.014	0.039	0.033	0.371	0.027	0.040	0.035	0.36				
Portugal	0.287	0.030	0.033	0.032	0.091	0.010	0.032	0.030	0.218	0.023	0.033	0.031	0.336				
Slovak Republic	0.061	0.090	0.055	0.057	0.000	0.000	0.056	0.056	0.000	0.000	0.056	0.056	0.24				
Switzerland	0.401	0.007	0.019	0.014	0.416	0.008	0.019	0.014	0.564	0.014	0.016	0.015	0				
United States	0.124	0.026	0.018	0.019	0.000	0.000	0.017	0.017	0.063	0.017	0.018	0.018	0.57				
Mean	0.383	0.040	0.034	0.035	0.190	0.013	0.033	0.030	0.301	0.025	0.035	0.032	0.519				

The calibrated parameters are given by Tables 2 and A2. The efficient allocation maximizes the social criterion given in Sub-section 3.3. We distinguish two configurations, whether  $\rho = 0$  or  $\rho = 20\%$ . The row "Mean" gives the average value for each variable. The column "limit rho" provides the value of rho (if any) such that the actual allocation is efficient.