Education Policy, Occupation-Mismatch and the Skill Premium

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Abstract

A relatively low tertiary education wage premium and a large occupational mismatch are two salient features of the Spanish labor market that distinguish it with respect to the labor markets in other developed countries. In this paper we provide an equilibrium model of the labor market with frictions in which workers are heterogeneous in terms of ability and education. We specifically model an education policy as delivering either a particular selection of individuals into the tertiary education system or a higher ability of individuals, or both. Our model economy is calibrated to mimic several of the Spanish labor market statistics together with key aspects of the achievement levels from the Programme for International Student Assessment (PISA) and the Programme for the International Assessment of Adult Competencies (PIIAC). We then explore the implications of alternative education policies on mismatch and tertiary education wage premium. We find that under an education policy able to produce ability levels of tertiary educated workers comparable to the average of the OECD countries a 60% lower fraction of mismatched workers and a 11% higher tertiary education wage premium would be observed in Spain.

Keywords: occupational-mismatch, tertiary education wage premium, ability
JEL Classification: I26, J21, J24

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1 Introduction

In the years preceding the last recession the unemployment rate in Spain reached the lowest value of the last two decades, both for tertiary educated workers and dropouts (see Table 1 below). This was a remarkable achievement for Spain after several years reporting much higher unemployment rates than other similarly developed countries. However, two less well-known aspects of the Spanish labor market during that period are a substantially lower tertiary education wage premium than in other OECD countries, and a prominent higher fraction of *occupation-mismatched* workers. First, as reported in Table 1 the tertiary educated worker's wage is 51% higher than the non-educated worker's wage in Spain, whereas the average of the OECD for that figure is 72%. Second, the fraction of *occupation-mismatched* male workers in Spain is about 0.34, 14 points above the average of the OECD countries.[1] We follow here the definition of vertical mismatch by Eurostat: a worker is considered to be occupational mismatched if her educational attainment is at least ISCED 5[2], but her occupation is not considered to be ISCO[3] 1, 2 or 3. [4] Interestingly, the fraction of the population with tertiary education in Spain is however similar to the average of the OECD. In section 2 we provide a more accurate description of this occupational mismatch phenomena that in Spain is spread across fields of specialization and age groups.

Table 1: Spain versus OECD

	Spain	OECD
Unemployment Rate of Tertiary Educ.	0.05	0.03
Unemployment Rate of Dropouts	0.08	0.07
Tertiary Educ. Wage Premium	1.51	1.72
Fraction of Tertiary Educ. Mismatched	0.34	0.20
Fraction of Workers with Tertiary Educ.	0.29	0.28
Average Skills Tertiary Educ., PIIAC (2012)	278	295

Source: Education al Glance (2010) and Eurostat. All statistics are for male 25-64 in 2007, except average skills of tertiary educated. The fraction of tertiary educated mismatched workers is for the UE-27 in 2009.

Why is then the return to education and the fraction of mismatched workers so different in Spain? In this paper we claim that the quality of the educated labor is an important variable to account for these facts. There are signs of a poor performance of the education system in Spain -and specially the tertiary education level- and we think of it as a promising candidate to explain the aforementioned facts. In particular according to the Programme for the International

[1]The fraction of mismatched male workers in the EU-27 ranges from 3% in Luxembourg to 34% in Spain. The mode is 21%, and the standard deviation is 8.

[2]International Standard Classification of Education (ISCED): levels 0 to 4 include education between pre-primary school and upper-secondary education. - Levels 5 and 6 are tertiary education levels (respectively, not leading/leading to an advanced research qualification).

[3]International Standard Classification of Occupations (ISCO): Categories 1, 2 and 3 include legislators, senior officials, managers, professionals, technicians and associate professionals. Categories 4 to 9 include clerks, service workers, etc., to elementary occupations.

[4]In the literature this notion of mismatch is sometimes called *over-education* or *over-qualification* and there are several alternatives to measure it. See for instance Leuven and Oosterbeeck (2011) and the many references therein.

Assessment of Adult Competencies (PIAAC, 2013) in 2013 the average score of the tertiary educated individuals in Spain is 278, whereas the average for the OECD countries is 295. This difference may not seem large, but the fact is that the average score in Spain for this education group is similar to the average score for *secondary* educated individuals in countries like Sweden, the Netherlands or Austria. Our view is that this sort of indicators are to a large extent the result of the policy stance with respect to education in different countries. For instance, the low scores observed in Spain could be seen as the result of either a poor selection of high ability students into tertiary education, or a poor performance of the tertiary education system in shaping the capacities of the population, or of a combination of both.[5] The bottom line is that changes in the tertiary education system are likely to modify the average quality of both educated and non educated workers, which may have sizable implications on the equilibrium in the labor market. Hence, our aim is to provide a model taking into account the effects of education and quantitatively explore its ability to explain the facts of the Spanish labor market relative to the performance observed in other developed countries.

An important feature of our model is that we distinguish between innate ability or skills, and effective ability, a point made in just a few preceding papers such as Albrecht and Vroman (2002) [AV] and Cuadras-Morató and Mateos-Planas 2013 [CMMP]. This is an essential ingredient in our model because we think of education as a technology to increase the productivity of ability in the labor market, in contrast to [AV] and [CMMP]. Although we do not model education decisions here we think it is important to consider a framework in which those individuals who would end up being mismatched would still have an incentive to enroll in college education.[6] Unlike previous papers we consider a continuum of abilities, hence education is instrumented by a *selection margin* (what abilities receive education) and by a *quality margin* (by how much the productivity of ability in the labor market increases). Finally, in our model we incorporate frictions in the labor market à la Mortensen and Pissarides. Given the quantitative nature of our exercise, a model with frictions is needed to capture the interaction between education policy, unemployment, and mismatch.

In our quantitative work we calibrate the model to mimic key observations of the Spanish economy in the mid 2000's. We conduct several counter-factual experiments to asses the effects of alternative educational policies regarding tertiary education. We find that a lower occupational mismatch and a higher tertiary education wage premium could have been observed in Spain if the education policy had been more selective or if it had provided individuals with more capacities.[7] We also asses the impact of the housing boom. Our results suggest that the housing boom effects have gone in the direction of increasing occupational mismatch and decreasing the wage premium for tertiary workers (albeit in absence of the housing boom a slightly larger unemployment rate would had been observed).

[5] In the same way, one can think that the widespread increase in the fraction of tertiary educated workers in developed countries could have been achieved by simply relaxing the criteria to access tertiary education, or, alternatively, by augmenting the chances of those with higher ability to complete tertiary education (this may involve increasing the funding for high-ability students belonging to poor families rather than simply increasing the number of students that receive some funding to complete tertiary education).

[6] Blazquez and Jansen 2008 study the efficiency of equilibrium allocations in the AV model. Regarding education choices, Charlot and Decreuse 2010 study the efficiency in a similar model and show that *overeducation* (in the sense of too many individuals choosing to acquire education) arises since workers do not internalize the impact of their decision on the wage and employment perspectives of others.

[7] Hence our findings are consistent with empirical literature supporting the view that over- educated workers have lower skills than the same level of education workers who are well-matched, see Nieto 2014.

A closely related paper to our work is CMMP where the authors put forth skill bias technological change (SBTC) as an explanation for the overeducation observed in the U.S.[8] In particular, CMMP show that as a result of the SBTC over-education increases because firms opening vacancies with college requirement may reject candidates that hold a college degree but that are poorly skilled (their ability endowment is small). This result critically hinges on the fact that only innate ability is an input in the production functions of goods. We depart from the model in CMMP in that we characterize technologies by a sector specific component, which is independent of the ability of the worker operating the technology, and by an additional component that depends on her ability *and* education level. These assumptions allow us to state a condition for the existence of occupation mismatch in terms of the characteristics of the technologies, such that mismatch can only arise when the ability of an educated worker displays comparative advantage in the technologically advanced sector.

Alternative explanations of the facts that we discussed above have been considered. For instance Díaz and Franjo (2014) provide evidence of poor investment in Specific Technical Change in Spain. So one could possibly argue that, compared to other OECD countries, in Spain labor productivity in high-skilled sectors is low relative to that in low-skilled sectors due to a rather small investment in equipment. Their model, however, is silent with respect to the specific issues regarding the labor market that are central in our work. Finally, Marimon and Zilibotti (1999) explore the differences in the generosity of unemployment benefits across countries as a mechanism to explain the differences between Continental Europe and the United States in unemployment rates, in the growth rate of productivity per worker, and in wage inequality. In their analysis unemployment benefits act as a subsidy to search for "better" jobs, which promotes a more efficient allocation albeit at the cost of larger unemployment rate. Hence, the more generous unemployment benefits the smaller should be the mismatch, which runs counter to the particular situation in Spain.

The paper is organized as follows. In section 2 we provide a more detailed description of the facts that we discuss in this Introduction. Next in section 3 we describe the model economy that we use as framework for our analysis. In section 4 we undertake the quantitative analysis to assess the ability of different education policies to account for the differences between Spain and the average of the OECD countries in terms of labor market outcomes. In addition we explore the consequences of a housing boom. Finally, section 5 concludes.

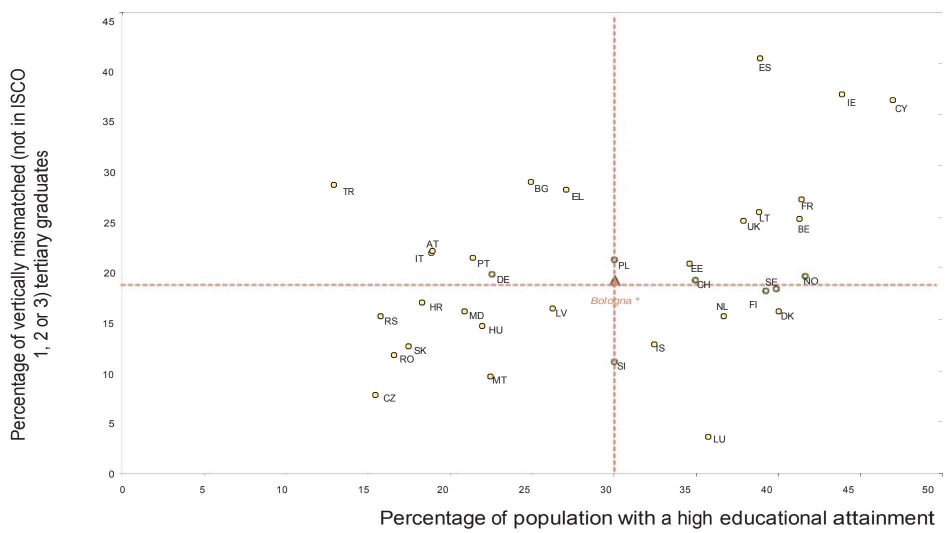
2 Facts

In this section we introduce a more detailed account of the facts that motivate our research and that were reported in the Introduction. Figure 1 portrays a graphical representation of the differences in mismatch across several European countries using the notion of vertical mismatch used in this paper. The fraction of population aged 25-34 with higher education in Spain is similar to that in European countries such as U.K., Sweden, France, Belgium or Finland, and yet, Spain is the country with the highest degree of mismatch, way above the levels observed in the previous countries.

We argue first that the distribution of students in higher education (ISCED levels 5A, 5B,

[8]See also Krusell et al. 2000. The literature on the SBTC tries to account for mismatch and the skill premium by changes in the relative demand of educated workers. Our approach here is to asses the ability of changes in the relative supply of skilled labor.

Figure 1: High educational attainment (ISCED 5-6) and vertical mismatch 2007 (age group 25-34)



Source: Table **Figure D.5b in Eurostat (2009).**

Table 2: Distribution of students in higher ISCED levels as a percentage of all tertiary students, 2001-06

	2001			2002			2003			2004			2005			2006		
ISCED	*5A*	*5B*	*6*	5A	5B	6	5A	5B	6	5A	5B	6	5A	5B	6	5A	5B	6
EU-27	83	15	3	82	15	3	82	15	3	83	14	3	83	14	3	84	13	3
ES	86	11	3	84	12	4	83	13	4	82	14	4	82	14	4	82	13	4

Source: UIS, UOE (The Bologna process in higher education in Europe 2009, Table 0 p. 189).

and 6) in Spain is comparable to European country average, so that the explanation for the higher mismatch is not due disproportionately large/small fraction of students involved in scientific/academic activity.[9] The Statistical Book of Eurostat corresponding to the Bologna Process in Higher Education in Europe (2009) reports the distribution of tertiary students in the ISCED levels 5A, 5B, and 6 as a percentage of all tertiary students in private and public institutions for the period 2001 to 2006 (see the table 2). It is clear from the table that the differences between Spain and the average EU-27 are remarkably small.

We now wonder whether the distribution of the population across fields of specialization in Spain is similar or not to the average of the EU countries. Obviously, given that the incidence of occupational mismatch varies across fields of specialization, it could be the case that the higher fraction of mismatched workers in Spain was due to a higher concentration of workers in certain fields of specialization. According to the statistics calculated from the Research into Employment and professional FLEXibility database (REFLEX survey, 1999-2000) and reported in Table 2 this is not the case. Roughly speaking the fraction of workers in “Humanities”, “Education”, “Agriculture”, “Health” and “Social sciences” is similar in Spain to the average of the EU countries. There are only moderate differences in the fraction of workers in “Science” (about 12% in the EU in contrast to 19% in Spain) and “Engineering” (about 32% in the EU in contrast to 27% in Spain). Therefore we conclude that the phenomena of occupational mismatch is not due to compositional differences in terms of the fraction of educated workers in each field of specialization.

We report in table 2 the fraction of workers aged 25 to 34 who are considered to be mismatched by field of education. The incidence of mismatch by field of specialization in Spain is higher than the European average (with the sole exception of Agriculture and Veterinary). It is clear that the average fraction of occupational mismatched workers across fields of specialization is substantially higher in Spain than in EU-27, and also that mismatch is not a phenomenon concentrated in a very specific subset of fields. In EU-27 the highest fraction of mismatched workers is found in Services (49) and it is followed by Agriculture (39) and Social Sciences (29). In Spain the highest fraction if found in Services (64) and it is followed by Engineering field (50) and Social Science (44). Both in Spain and in the average of the EU-27 the lowest fraction of

[9]ISCED level 5A are tertiary programs that are largely theoretically based and are intended to provide sufficient qualifications for gaining entry into advanced research programs and profession with high skills requirements. Programs in ISCED 5B are typically shorter than those in 5A and focus on occupationally specific skills geared for entry into the labor market, although some theoretical foundations may be covered. Level ISCED 6 is reserved for tertiary programs which lead to the award of an advanced research qualification (they typically require the submission of a thesis or dissertation of publishable quality (see the Statistical book of Eurostat pp. 239-240 for further details).

Table 3: Distribution of Recently Graduated Individuals Across Fields of Education 2000

	UE	Spain
Education	5	5
Humanities and Arts	7	7
Social sciences, Business and Law	30	29
Science, Mathematics and Computing	12	19
Engineering, Manufacturing and Construction	32	27
Agriculture and Veterinary	5	4
Heath and Welfare	7	7
Services	3	1

Source: REFLEX 1999-2000. UE includes Portugal, Spain, Italy, France, Switzerland, Austria, Germany, Netherlands, Belgium, United Kingdom, Norway, Sweden and Finland.

Table 4: Percentage of Workers Vertical Mismatched, aged 25-34 by Field of Education

	UE-27	Spain
Education	13	28
Humanities and Arts	25	37
Social sciences, Business and Law	29	44
Science, Mathematics and Computing	16	28
Engineering, Manufacturing and Construction	26	50
Agriculture and Veterinary	39	35
Heath and Welfare	12	27
Services	49	64

Source: Eurostat, EU-LFS, 2003-2007.

mismatched workers is found in Health fields (12 in UE-27 in contrast to 27 in Spain) and in Education (13 in EU-27 and 28 in Spain). The largest gap between Spain and the UE-27 (more than double) is found in Education field and it is followed by Engineering field.

In view of the facts above, we explore the possibility of the mismatch in Spain is affecting just a reduced age-specific group of workers. With this regard, Hidalgo-Pérez et al. (2015) use a sample of the Social Security Records of the Spanish population (Muestra Continua de Vidas Laborales, MCVL) to explore the puzzling fall in the wage skill premium in Spain over the last decades. They study the evolution of occupational mismatch among college graduated workers. According to their analysis the fraction of mismatched college workers decreases with age, but very moderately (from 60% in the age group 30 to 34 to 50% in the age group 50 to 54). This persistence of *over-qualification* is consistent with the findings in Montalvo (2013). They use the Spanish School to Work Transition database to study these questions and find that *over-qualification* is a very absorbing state since transition matrices show that the probability to continue overqualified after moving to a new job is 76%.

Finally, one may wonder about the comparability of tertiary educated workers in terms of the official number of years of education across countries. In Table 2 we can see that for the selected sample of countries there are noticeable differences in the distribution of years in primary, secondary and high school. However, looking specifically at tertiary education the differences

Table 5: European education systems

	Formal school	Prim.+sec. +high s.	Voc. educ. starts	Univ. starts	Univ. educ. (min. years)
Austria	6	4+4+4	14/15	18	3+
Denmark	6	11+2	16	19	3+
Finland	7	9+3	16	19	3+
France	6	5+4+3	15	18	2+
Germany	6	4+6+3	16	19	4+
Italy	6	5+3+5	14	19	3+
Spain	6	6+4+2	15	18	4+
UK	5	6+3+2(+2)	16	18	3+

Source: Eurydice, The structure of the European Education systems 2009-10.

seem rather small: in Spain higher education starts a year before than in other countries, but it takes one more year (together with Germany) to complete college education. Given this, we would find difficult to justify the lower performance of tertiary educated workers in Spain in terms of PIAAC scores simply on a lower number of years of education.

We now briefly turn to the outcome of the Spanish education system. We mentioned in the introduction the poor performance of the Spanish education system, which is reflected in the lower average score of the tertiary educated individuals in the PIAAC, 278 in Spain in contrast to 295 for the OECD countries. According to OECD Skills Outlook 2013, an additional year of education roughly represents about 7 additional points in the score (see p. 61). Hence, Spanish adults would need about two years of additional education to eliminate the difference with respect to the average adult in the OECD. There are other signs of poor performance of the Spanish education system that are worrisome. The fraction of students at the 2 higher proficiency levels of the Programme for International Student Assessment (PISA) on the science scale is among the lowest in the OECD: in Spain only 5% of the students are classified in those categories, in contrast to the 9% average of the OECD.

The picture that emerges from the previous discussion is that the Spanish eduction system in terms of length and in terms of the distribution of students over the degree and field of specialization is comparable to the systems in place in other similar countries. In addition, the empirical evidence reported above suggests that mismatch is a widespread phenomena across fields of specialization and age, rather than a specific issue of a particular subset of workers. For these reasons we think it is natural to consider the quality of education as a relevant aspect to explain the mismatch observed in the Spanish labor market.[10]

[10]Obviously the quality of education has sizable implications beyond the labor market. For instance, Hanushek and Kimko (2010) find that direct measures of labor-force quality from international mathematics and science test scores are strongly related to growth.

3 The Model

Time is continuous and in the economy there is a mass one of infinitely lived workers which are endowed with an ability level a. The key feature of our model is that ability is distributed according to a continuous density $\lambda(a)$ on a set of possible abilities A. We also assume that workers differ in their education level: some of them are *educated*, denoted e, and some of them are not, denoted ne. Thus, unlike ability, education is a discrete variable with only two mass points. We think of the differences in education as the result of an *educational policy* $\sigma(a) : A \to [0, 1]$, which indicates the fraction of agents with education amongst those with ability level a. We use $\mu(a) = \sigma(a)\lambda(a)$ to denote the fraction of (educated) e-agents with ability level a. Education in the economy is valuable because it increases the *effective ability* at work (i.e., the efficient units of labor) of educated workers. Specifically, the term $\tilde{a}_j$ measures the effective ability of the worker at the work place which takes into account not only the innate ability of the worker but also the effect of education. Specifically, we assume that

$$\tilde{a}_j = \psi_j a, \tag{1}$$

with $\psi_e \geq \psi_{ne} = 1$. Thus it is natural to think of ψ_e as the quality of education because it measures the increase in the efficiency units of labor of a worker due to education.

In the production side of the economy there are firms/jobs that are either vacant or filled. These jobs differ in the minimum education requirement that a worker needs to satisfy to be able to successfully operate the corresponding technology. This means that there are firms with a technology such that ne-workers are unable to properly operate. We refer to these firms as *high-tech* firms, denoted h. Also, there are firms such that their technology can be operated by both educated and non educated workers, which we informally label as *low-tech* firms, and denote them by l. We denote by $y_{ij}(a)$ the output of a firm type $i = h, l$ employing a worker with education $j = e, ne$, and ability level $a \in A$. We assume that $y'_{ij}(a) > 0$, so that for all worker types and sectors output is larger the larger is the ability of the worker. Creating a vacancy has a cost c_v, and once the vacancy is filled with a worker, there is a cost c_i, $i = h, l$ of operating the technology. Finally, an employment relationship breaks up at exogenous rate δ_i, and once unemployed a worker receives unemployment benefits b.

We follow the Mortensen-Pissarides tradition and we assume that there are frictions in the labor market, such that both firms and workers need to spend some resources before a productive match can be formed. These frictions are captured by a matching function relating the number of new matches to the number of unemployed workers and to the number of outstanding vacancies. Hence, in this formulation of the labor market externalities due to congestion naturally arise and play an important role in shaping the equilibrium configuration. Notice that given the technological constraint about the education requirements, it is clear that ne-workers would never look for a job in the h-sector, hence in this sense the labor market is segmented by education. The assumptions on technology place no restriction on educated workers being able to operate the low-tech technology, and yet, we cannot rule out that the labor market be additionally segmented by ability: it is possible that some educated workers choose to search jobs in the low-tech sector. This is the notion of mismatch that we study in this paper.[11] In order to better focus on this issue, we will assume that unemployed workers can only search for a job in one market, hence educated workers must choose beforehand whether to search for a

[11]See Herz and Van Rens 2011 for a notion of mismatch based on *inefficient unemployment*: the excessive unemployment above the level a planner would have chosen.

job in the high or in the low sector. Likewise, a firm willing to create a vacancy needs to choose beforehand the sector in which it will be created.

Given these assumptions the number of productive matches in sector $i = h, l$ is given by a constant returns to scale matching function $M(v_i, \mu_i^u)$ defined on the number of vacancies (v_i) and the mass of unemployed workers (μ_i^u) participating in the corresponding market. The matching functions satisfy $M(v_i, \mu_i^u) = m(\theta_i)\mu_i^u$, where $\theta_i = v_i/\mu_i^u$ and $m(\theta_i) = M(\theta_i, 1)$. This means that the probability of an unemployed worker finding a vacancy, and the probability of a vacant position to be filled with an unemployed worker, are given respectively by $m(\theta_i)$ and $m(\theta_i)/\theta_i$.

3.1 The problem of a worker

Workers are assumed to be risk neutral and thus they maximize the present value of income: wages and unemployment benefits. We denote $w_{ij}(a)$ the wage of a worker type $j = e, ne$, with ability level a, who is matched to a firm in sector $i = h, l$, and we denote $W_{ij}(a)$ the value of this match. Similarly, $U_{ij}(a)$ stands for the value of searching for a job in sector $i = h, l$, for a type $j = e, ne$ worker with ability level a. The asset value of employment for a worker is given by:

$$rW_{ij}(a) = w_{ij}(a) + \delta_i(U_{ij}(a) - W_{ij}(a)), \tag{2}$$

for $i = h, l$, $j = e, ne$, all $a \in A$, and where r is the discount rate. The asset value of looking for a job in the i-sector for a worker with education level j and ability level a is given by

$$rU_{ij}(a) = b + m(\theta_i)\left\{W_{ij}(a) - U_{ij}(a)\right\}. \tag{3}$$

In the current environment mismatch may arise if for some ability level we have that an e-worker looks for (and accepts) jobs in the l-sector. That is, mismatch occurs when there is a subset $\tilde{A} \subseteq A$ such that $U_{he}(a) \leq U_{le}(a)$ for $a \in \tilde{A}$.

3.2 The problem of the firm

Firms create vacancies at a cost c_v, irrespectively of the sector of operation. Once the vacancy is filled, however, the operation cost is c_i for $i = h, l$. The value of an operative match between a job in sector i and a worker type j and ability a is given by $J_{ij}(a)$, and it satisfies:

$$rJ_{ij}(a) = y_{ij}(a) - w_{ij}(a) - c_i + \delta_i[\max_{i' \in \{h,l\}} V_{i'} - J_{ij}(a)]. \tag{4}$$

Notice that once the current match is broken the firm is allowed to reconsider its sector of operation.

The value of creating a vacancy in the h-sector satisfies:

$$rV_h = -c_v + \frac{m(\theta_h)}{\theta_h}\left\{\max\{E_\mu[J_{he}(a)] - V_h, 0\}\right\}, \tag{5}$$

The max operator reflects the fact that it may not be profitable for a firm in the h-sector to offer a job to an educated worker. Notice also that E_μ in the expression above is the expectation conditional on meeting an educated worker as implied by the measure $\mu(a)$. We also have

$$rV_l = -c_v + \frac{m(\theta_l)}{\theta_l}\left\{\frac{\mu^u_{le}}{\mu^u_l}\left(\max\{E_\mu[J_{le}(a)] - V_l, 0\}\right)\right.$$
$$\left. + \frac{\mu^u_{lne}}{\mu^u_l}\left(E_\mu[J_{lne}(a)] - V_l\right)\right\}, \qquad (6)$$

for the case of a vacancy in the low-tech sector. Again, the max operator in the previous equation reflects the fact that for a firm in the l-sector it may not be profitable to hire an educated worker (hence notice that we implicitly assume that a firm in the l-sector always finds desirable to hire a non educated worker, irrespectively of her ability level). In the previous expression, μ^u_{le} stands for the mass of educated unemployed workers searching for a job in the low-tech sector (μ^u_{lne} is the corresponding number of non educated workers). Thus $\mu^u_{u,le}/\mu^u_l$ is the probability of meeting an e-worker who is searching in the l-sector, and μ^u_{lne}/μ^u_l is the probability of meeting an unemployed ne-worker. As before, notice also that E_μ stands for the conditional expectations operator as implied by μ, the distribution of education and ability. Finally, in the equilibrium we consider we will assume free entry, so that $V_h = V_l = 0$ will hold.

3.3 Wage setting rule

We assume that once an unemployed worker is matched to a posted vacancy, the firm and the worker engage in a Nash bargaining process in order to split the surplus that the match may potentially create. Under these assumptions the wages satisfy

$$w_{ij}(a) = \operatorname{argmax}\left(W_{ij}(a) - U_{ij}(a)\right)^\beta \left(J_{ij}(a) - V_i\right)^{1-\beta}, \qquad (7)$$

(where $\beta \in (0,1)$ represents the bargaining power of the workers), which is obtained by satisfying the FOC of the bargaining problem:

$$(1-\beta)(W_{ij}(a) - U_{ij}(a)) = \beta(J_{ij}(a) - V_i). \qquad (8)$$

3.4 Stationary equilibrium

Subtituting Eq. (2), Eq. (3) and the expression for $J_{ij}(a)$ from Eq. (4) after imposing the free entry condition $V_i = 0$ in Eq. (7) we obtain:

$$w_{ij}(a) = \frac{\beta(r + \delta_i + m(\theta_i))(y_{ij}(a) - c_i) + (1-\beta)b(r+\delta_i)}{r + \delta_i + \beta m(\theta_i)}. \qquad (9)$$

Also, inserting Eq. (2) into Eq. (3) and rewriting produces:

$$rU_{ij}(a) - b = m(\theta_i)\frac{[w_{ij}(a) - b]}{r + \delta_i + m(\theta_i)}. \qquad (10)$$

It is also useful to obtain a closed form expression for the value of an active vacancy. Imposing again the free entry condition in Eq. (4) and rewriting:

$$J_{ij}(a) = \frac{y_{ij}(a) - w_{ij}(a) - c_i}{r + \delta_i}. \qquad (11)$$

Finally we write the free entry conditions as:

$$0 = -c_v + \frac{m(\theta_h)}{\theta_h} \left\{ E_\mu[J_{ij}(a)|a \notin \tilde{A}] \right\}, \tag{12}$$

and

$$0 = -c_v + \frac{m(\theta_l)}{\theta_l} \left\{ \frac{\mu^u_{le}}{\mu^u_l} \left(E_\mu[J_{le}(a)|a \in \tilde{A}] \right) + \frac{\mu^u_{lne}}{\mu^u_l} \left(E_\mu[J_{lne}(a)] \right) \right\}. \tag{13}$$

Notice that in Eq. (12) and (13) we take into account that in equilibrium not all educated workers may be searching in the high-tech sector. The previous equations are useful because they help to characterize the stationary equilibrium, which we introduce below. The definition is standard in that it involves a wage rate consistent with the wage setting rule, a labor market tightness and a stationary value for unemployment that are consistent with free entry (see for instance Pissarides 2000, p. 18). The non standard ingredient of our economic environment is that with the possibility of mismatch and a continuum of abilities the free entry conditions involve expectations defined by probability measures which are themselves endogenous.

Definition: Given $\lambda(a)$ and $\sigma(a)$ implying $\mu(a)$, a stationary equilibrium consists of a list θ_i, a set $\tilde{A} \subseteq A$, a distribution of employment and unemployment over types and sectors $(\mu^e_h, \mu^e_{le}, \mu^e_{lne}, \mu^u_h, \mu^u_{le}, \mu^u_{lne})$ and wages $w_{ij}(a)$ such that for $i = h, l$, $j = e, ne$ and all $a \in A$:

i) Given $m(\theta_i)$, $w_{ij}(a)$ satisfy Eq. (9).
ii) Given $m(\theta_i)$, the set $\tilde{A} \subseteq A$ is consistent with the mismatch condition $U_{he}(a) \leq U_{le}(a)$, where $U_{ij}(a)$ satisfy Eq. (10).
iii) The set $\tilde{A}$ is consistent with the distribution of employment and unemployment:

$$\mu^e_{hc} + \mu^u_{hc} = \int_{a \in \tilde{A}^c} \mu(a)da, \;\; \mu^e_{lc} + \mu^u_{lc} = \int_{a \in \tilde{A}} \mu(a)da, \;\; \text{and} \;\; \mu^e_{lnc} + \mu^u_{lnc} = \int_A \mu(a)da. \tag{14}$$

where μ^e_{ij}/μ^u_{ij} stand for the mass of employed/unemployed j-educated agents in the i-sector.
iv) labor markets are stationary:

$$\mu^u_h m(\theta_h) = \mu^e_{he}\delta_h, \;\; \mu^u_{le} m(\theta_l) = \mu^e_{le}\delta_l, \;\; \text{and} \;\; \mu^u_{lne} m(\theta_l) = \mu^e_{lne}\delta_l. \tag{15}$$

v) The free entry conditions in Eq. (12) and (13) hold when $J_{ij}(a)$ is given by Eq. (11).

As previously noted in AV and in CMMP in similar models with a discrete number of ability levels there are three possible equilibrium configurations which are respectively characterized by (1) *ex-post segmentation*, when all educated workers work or look for jobs in the h-sector (remember that non educated workers can operate only the technology of the l-sector), (2) employment *mismatch*, which is observed when some educated workers look for and accept jobs in the l-sector, or (3) the case of multiple equilibria in which both types are simultaneously possible. In addition to these possibilities, in our model with a continuum of abilities we cannot rule out the possibility of multiple equilibria with employment mismatch. We return to this issue in our quantitative work in section 4.2.

3.5 The possibility of a mismatched equilibrium

To fix some ideas from now on we will assume that the technology to produce goods is linear in ability and it takes a general form that will be useful in our quantitative analysis:

$$y_{ij}(a) = y_i + \tilde{y}_{ij}\tilde{a}_j. \tag{16}$$

The term y_i captures the component of production that is sector-specific and unrelated to the ability of the worker operating the technology. The term $\tilde{y}_{ij}$ allows us to capture the fact that marginal productivity of ability may be both education and sector specific.[12] The linearity assumption of the technology is useful to characterize the set $\tilde{A}$ by means of a simple threshold level for ability $\bar{a} \in A$. In fact, after some tedious algebra we can show that for given θ_i:

$$w_{ij}(a) = w_i + w_{ij}a, \tag{17}$$

where

$$w_i = \frac{\beta(r + \delta_i + m(\theta_i))(y_i - c_i) + (1-\beta)b(r+\delta_i)}{r + \delta_i + \beta m(\theta_i)}, \tag{18}$$

and

$$w_{ij} = \frac{\beta(r + \delta_i + m(\theta_i))y_{ij}}{r + \delta_i + \beta m(\theta_i)}, \tag{19}$$

end where we have simplified notation by letting $y_{ij} = \tilde{y}_{ij}\psi_j$. The above characterization is useful because it allows us to write the asset value of unemployment in each sector also as a linear function of a. That is, the right hand side of Equations (3) satisfies:

$$rU_{ij}(a) - b = u_i + u_{ij}a, \tag{20}$$

with

$$u_i = m(\theta_i)\frac{\beta(y_i - c_i - b)}{r + \delta_i + \beta m(\theta_i)}, \tag{21}$$

and where

$$u_{ij} = m(\theta_i)\frac{\beta y_{ij}}{r + \delta_i + \beta m(\theta_i)}. \tag{22}$$

With the linearity in a of $U_{ij}(a)$ it is clear that there can be mismatch if the straight lines described by $U_{he}(a) < U_{le}(a)$ for some $a \in A$. That is, we conclude that there can be an equilibrium with mismatch only if $u_h \leq u_l$ and $u_{he} \geq u_{le}$ (with at least one strict inequality), or if $u_h \geq u_l$ and $u_{he} \leq u_{le}$ (also with at least one strict inequality). In the former case there is $\bar{a}$ such that $U_{he}(\bar{a}) = U_{le}(\bar{a})$ and $U_{he}(a) > U_{le}(a) \iff a \geq \bar{a}$. That is, $\tilde{A} = \{a \in A : a \leq \bar{a}\}$ and the equilibrium with mismatch is characterized by *positive assortative matching*:

$$\frac{y_h - c_h - b}{y_{he}} < \frac{y_l - c_l - b}{y_{le}} \tag{23}$$

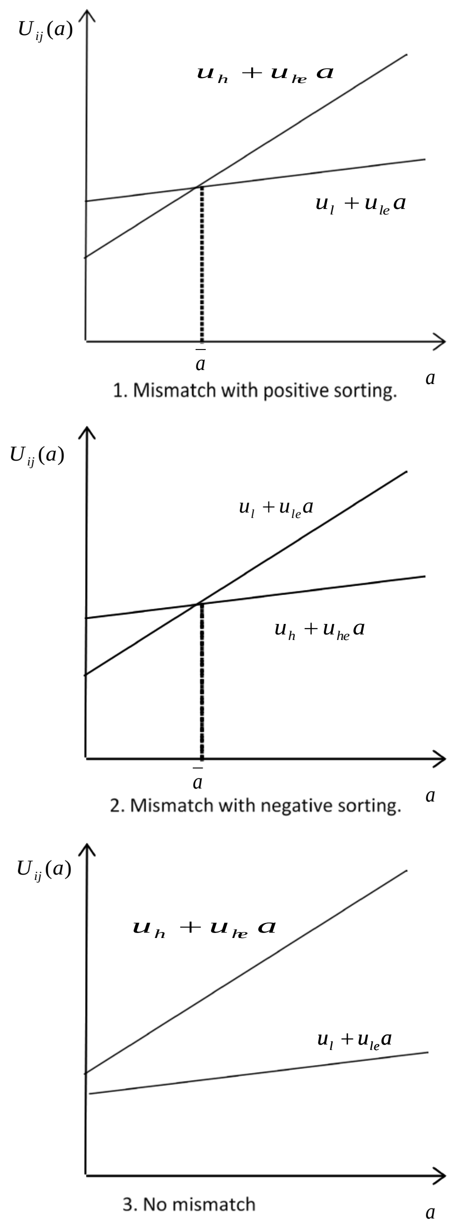
In this case ability displays comparative advantage in the h-sector and thus educated but low-ability workers end up looking for jobs in the l-sector.[13] If the opposite inequality holds then the equilibrium is characterized by *negative assortative matching*, and so high-ability workers end up looking for jobs in the l-sector, hence $\tilde{A} = \{a \in A : a \geq \bar{a}\}$.[14] Figure 2 below portrays examples of the different types of mismatch.

[12] We discuss in Section 4.2 that by considering separately the effect of education on ability (by the term ψ_e), and the associated marginal productivity of effective ability in production (by the term $\tilde{y}_{ij}$) will help us to calibrate the model in a transparent way and consistently with the empirical observations on the distribution of ability and the average effective ability of tertiary educated workers.

[13] See Sattinger (1975) for an early development of a sorting condition along this lines.

[14] The case of positive sorting is the one empirically relevant (see CMMP and the references therein), thus in our quantitative analysis we disregard negative sorting. For completeness, it is worth mentioning that the theoretical model admits additional forms of mismatch but they violate the assumption that $y_{ij} > 0$.

Figure 2: Different types of equilibrium



Whether the equilibrium with mismatch is unique or not is unclear (to the very best of our knowledge no general results are available on this issue), and such a characterization is out of the scope of this paper. For future reference, however, notice that for an equilibrium candidate with $\tilde{A} = \emptyset$ (i.e., the one obtained when all educated agents look for jobs in the h-sector) to fail to constitute a segmented equilibrium it suffices to check that the educated agents endowed with the lowest ability level would be better off by looking for jobs in the l-sector. We will relay on this simple test to establish the uniqueness of the equilibrium with mismatch we study in Section 4.3.[15]

It is clear from the Equation (23) on the condition for positive sorting that there are many parameter configurations that will favor the existence of such mismatch. At this stage however it is not possible to trace back the effect of the educational policy on the equilibrium value of $\bar{a}$ through θ_i's, on the size of the occupational-mismatch nor on the educated workers' wage premium. Therefore in the following section we resort to quantitative methods in order to explore the implications for labor market outcomes of alternative education policies. Before we continue, however, we briefly discuss the connections between the previous condition and the results in AV and CMMP.

Remarks

Remark 1: In line with the results in CMMP, it is clear from Equation (23) that SBTC consisting in increasing y_{he} relative to y_{le} (the marginal productivity of ability in the h-sector relative to the l-sector) will favor the existence of mismatch. Hence our condition in Equation (23) offers a new insight for the existence of mismatch based on increased comparative advantage of higher ability e-workers in the h-sector.

Remark 2: The fact that the above sort of SBTC is able to give rise to mismatch is not possible in the AV model, in which search is undirected (there is a single labor market) and thus increasing y_{he} relative to y_{le} tends to reduce mismatch favoring an equilibrium with ex-post segmentation.[16] Without disregarding the importance of undirected search, we notice that in our model with directed search a SBTC consisting in increasing y_h relative to y_l (that is, the sector specific parameter in the technology) will produce the same effects as in the AV model.

Remark 3: In the particular case in which $c_l = c_h = 0$ there may be mismatch as long as y_l is large relative to y_h. Thus, the costs of operating a vacancy stressed in CMMP as a necessary condition to generate mismatch appear to be irrelevant once production depends not only on the ability of the agent but also on the sector where she is (potentially) employed.

4 Quantitative Analysis

The aim of the quantitative analysis in this section is to shed light on the determinants of the position of Spain relative to other similarly developed countries in terms of the labor market statistics that we highlighted in the Introduction. With this goal in mind we introduce additional assumptions that facilitate the analysis and we discipline our quantitative exercise with

[15] Therefore with concave technologies in principle it would be possible to generate several intervals of abilities in which there would be mismatch with positive and negative sorting, as well as no mismatch.

[16] The intuition is that with a single labor market, skilled workers find profitable to remain unemployed and wait for the arrival of an offer from a h-tech firm only when the wage rate in that sector is sufficiently large relative to the l-sector. In the AV model the wage premium increases with this sort of SBTC.

a calibration of model parameters grounded on relevant statistics of the Spanish economy.

4.1 Functional forms

We assume that the matching functions are Cobb-Douglas of the form

$$M(v_i, \mu_i^u) = m_i v_i^{\eta} (\mu_i^u)^{1-\eta}, i = h, l, \tag{24}$$

where $\eta \in (0, 1)$ measure the vacancy-elasticity of the matching function. This assumption is in line with most of the quantitative literature about frictional labor markets (see for instance the closely related papers by AV and CMMP).

We assume that the distribution of ability $\lambda(a)$ is Pareto of parameters a_m and α, so that the density satisfies

$$\lambda(a) = \alpha \frac{a_m^{\alpha}}{a^{\alpha+1}} \tag{25}$$

if $a \geq a_m$ and zero otherwise. We require this density to have finite mean, hence we assume $\alpha > 1$.[17] With respect to the educational policy we explore the implications of a general form such that for all $a \geq a_m$:

$$\sigma(a) = \sigma_0 + \sigma_1 \left(1 - \frac{a_m}{a}\right). \tag{26}$$

Notice that if $\sigma_1 = 0$, then the fraction of educated workers is the same for all ability levels, and that if $\sigma_1 > 0$, then the fraction of educated workers increases with the level of ability. Finally, notice that the function $\sigma(a)$ is bounded, strictly increasing and strictly concave. Under these assumptions we have that

$$\mu(a) = \sigma(a)\lambda(a) = \frac{\mu_0}{a^{\alpha+1}} - \frac{\mu_1}{a^{\alpha+2}}, \tag{27}$$

where $\mu_0 = (\sigma_0 + \sigma_1)\alpha a_m^{\alpha}$, and that $\mu_1 = \sigma_1 \alpha a_m^{1+\alpha}$. The two-parameter family of educational policies is convenient because it allows us not only to control for the mass of educated agents, but also to disentangle the effects of the policy on the average ability in the educated group. To see this, notice that

$$\mu = \int_A \mu(a) da = \sigma_0 + \frac{\sigma_1}{1+\alpha}, \tag{28}$$

hence the fraction of educated workers increases with both σ_0 and σ_1. In addition, the average ability of educated workers satisfies

$$a_e = \mu^{-1} \int_A a\mu(a) da = \frac{a_m^{\alpha}(1+\alpha)}{\alpha - 1} \frac{\alpha\sigma_0 + \sigma_1}{(1+\alpha)\sigma_0 + \sigma_1}. \tag{29}$$

If is straight forward to show that $\partial a_e / \partial \sigma_0 < 0$, but that $\partial a_e / \partial \sigma_1 > 0$. Hence, σ_0 and σ_1 have opposite effects on a_e. Following a similar reasoning we would find that $\partial a_{ne} / \partial \sigma_0 > 0$ and that $\partial a_{ne} / \partial \sigma_1 < 0$ (a_{ne} stands for the average ability of non educated workers). Hence, changes in σ_0 and σ_1 have opposite effects on a_e and a_{ne}. This is important because as it will be seen, the amount of mismatch and the tertiary education wage premium critically depend on whether the educational policy increases or decreases the average quality of the educated workers. Intuitively, and increase in σ_0 increases the fraction of educated agents, and it improves a_{ne} but worsens a_e. Hence opening vacancies in the l-sector is more attractive than before (and opening vacancies

[17] In fact, we will assume that $\alpha > 2$, which in addition assures that the distribution of ability has finite variance.

in the h-sector is less so), and thus, we expect a reduction in the wage premium and higher mismatch. It will be seen below that this intuitive reasoning rightly suggests that increasing σ_1 will have the opposite effects.

4.2 Calibration

In our calibration strategy there is a first set of parameter values that we borrow directly from existing studies in the related literature. This is the case of the worker's bargaining power β, which we fix at 0.5, the parameters that govern the matching technology ($m_h = m_l = 1$, $\eta = 0.5$) and the quarterly interest rate r, which is set to 0.013. These are all the same as in AV. The job separation rates δ_h and δ_l for the Spanish economy are taken from Hobijn and Sahin (2009), who estimate a quarterly separation rate of 0.07.

Second, we fix the parameters that govern the distribution of ability and the policy education function. To this end we use the distribution of ability according to PISA and PIIAC in the mid 2000's and the distribution of education of the working population according to European Union Survey of Income and Living Conditions (EU-SILC) in 2007. In particular we identify a_m and α by targeting the mean and dispersion in the PISA scores (Science) in 2006.[18] These two parameters pin down the distribution of innate ability (i.e., before any effect of education). Given the distribution of innate ability we then calibrate σ_0 and σ_1 to target the fraction of individuals with tertiary education, 0.31, and the mean score in math test of individuals with tertiary education relative to non educated individuals of 1.2, as calculated from the Programme for the International Assessment of Adult Competencies (PIAAC, 2012). A difficulty in matching this statistic is due to the fact that it is hard to disentangle the role played by *selection of abilities that receive education* and the *quality of education* in shaping the relative higher mean score of tertiary educated workers with respect to non educated workers.[19] As a starting reasonable compromise, we assume that $\psi_e = 1.15$ (remember that ψ_{ne} is normalized to 1), that is, we assume that as a result of tertiary education effective ability is increased by 15%, and the rest of the differences between educated and non educated workers will be explained by selection. Given this choice, for our model to account for the 1.2 ratio of PIIAC abilities of tertiary to non-tertiary educated workers, the average *effective ability* of a tertiary educated worker has to be equal to 5.77.[20] Table 6 contains this second set of parameters values and it also reproduces the relevant statistics in the model and in the data.

Finally there are seven parameters that we calibrate to match specific targets of the Spanish labor market, which are reported in Table 7 (We try to be parsimonious and normalize the l-sector: $c_l = 0$ and $\tilde{y}_{lj} = 1$). Most of the statistics related to the labor market outcomes are calculated using the European Union Survey of Income and Living Conditions (EU-SILC) in 2007: the tertiary education wage premium is 1.47, the unemployment rate by education (4% for tertiary educated workers and 9% for dropouts) and the standard deviation to the mean of wages by education (0.47 for tertiary educated and 0.36 for dropouts).[21] Unfortunately, this

[18] Cubas, Ravikumar and Ventura 2013 also proxy the distribution of talent in several countries using the distribution of PISA scores.

[19] As discussed in Hendricks and Leukhina (2014) it is an open empirical question what is the importance of self-selection into education in accounting for differences in life-time earnings and this question goes beyond the aim of this paper.

[20] The difference in this figure between Table 6 and Table 1 is due to the difference between the normalization of *effective ability* in the model and in PIIAC scores.

[21] Our sample is made of male individuals aged 25 to 54. Statistics of wages are for the sample of full-time

survey does not provide information on the quality of the job match for each worker, so we cannot compute the fraction of mismatched workers in this data set. As an alternative we target the fraction of mismatched workers (those with tertiary education who hold a job beneath their educational level) as reported by Eurostat in 2009, which is 33%. As we stated above this is the highest figure amongst the EU countries, where the average is 20%. An important target in the calibration is the wage of workers with tertiary education relative to dropouts conditioning on the type of job match. According to Hidalgo et al. (2014) using the Muestra Continua de Vidas Laborales (this is a sample of Social Security Administration records) the average wage of college to non-college workers is about 1.15 when the college worker is mismatched. Since our focus here is on tertiary educated instead of college educated individuals we think it is appropriate to target a smaller value and thus we pursue a 10% premium.[22]

In the numerical calculations to determine the equilibrium we proceed iteratively: given initial guesses for θ_i we find the implied wages and a potential threshold level $\bar{a}$. Once this is found we integrate the values of active matches and check if the free entry conditions are close to zero. We iterate on the θ_i until the free entry conditions are approximately satisfied. Once a candidate equilibrium with mismatch is found it is straightforward to perform the test explained at the end of Section 3.4 (whether $U_{he}(a_m) > U_{le}(a_m)$ or not). Furthermore, once a candidate equilibrium is found we also check that no other equilibrium with mismatch can be found nearby: we restart the algorithm from many different initial conditions and check that we always converge to the same candidate. Thus, the mismatch equilibrium reported in Tables 6 and 7 appears to be unique.

Parameter		
a_m	4.10	
α	6.30	
σ_0	0.25	
σ_1	0.42	
Target	**Data**	**Model**
PISA mean score science (OECD 2006)	4.88	4.88
PISA standard deviation to mean (OECD 2006)	0.19	0.19
Fraction of workers with tertiary educ. (EU-SLIC 2007)	0.31	0.31
Average skills tertiary educ. (PIAAC 2012)	5.77	5.77

Table 6: Calibrated Parameters and Targets I

workers after trimming the bottom and top 1% of the distribution of wages in each education group.

[22] A negative value for the operation cost of the high-tech sector is needed to bring the fraction of mismatched workers to the level observed in the data.

Parameter		
b	7.5	
c_v	0.82	
c_h	3.5	
y_h	-5.65	
$\tilde{y}_{he}$	4.10	
$\tilde{y}_{le}$	3.15	
$\tilde{y}_{lne}$	2.60	
Target	**Data**	**Model**
Unemp. rate dropouts (EU-SLIC 2007)	0.09	0.09
Unemp. rate tertiary educ. (EU-SLIC 2007)	0.04	0.05
Frac. tertiary educ. mismatched (Eurostat 2009)	0.33	0.33
Tertiary educ. wage premium (EU-SLIC 2007)	1.47	1.46
Std. dev. to mean wages, tertiary (EU-SLIC 2007)	0.38	0.37
Std. dev. to mean wages, dropouts (EU-SLIC 2007)	0.27	0.26
Tertiary educ. wage premium, mismatched (Hidalgo et al. 2014)	1.10	1.11

Table 7: Calibrated Parameters and Targets II

4.3 Benchmark

As a result of our benchmark calibration we obtain that the equilibrium with mismatch in the model is able to account reasonably well for the differences in unemployment rates across educational levels, for the within education groups' inequality, for the relative ability of tertiary educated workers as well as for the observed tertiary education wage premium. In our view this is a comprehensive set of the statistics that characterizes relevant dimensions of the Spanish labor market. All in all, the model involves a rather large number of parameters and thus it is hard to find additional statistics that can be used as over-identifying restrictions to asses the suitability of the benchmark calibration. To gain additional confidence along these lines we explore the implications of changing the fraction of tertiary educated workers to the one observed in the mid 90's.

In Table 8 we compare the labor market outcomes of our benchmark economy with those in an economy in which the fraction of educated workers is equal to 0.21 (this is what we call $mid-90s$), a figure that is similar to the one observed in Spain in the mid 90s.[23] We obtain that the fraction of mismatched workers decreases from 0.33 to 0.29 and the tertiary education wage premium increases from 1.46 o 1.49. This evolution is consistent with empirical evidence for Spain as reported by Hidalgo et al. (2014), Dolado et al. (2000) and Pijoan-Mas and Sánchez-Marcos (2010) (these papers document a decrease in the tertiary education wage premium and an increase in the fraction of mismatched workers over the period 1997 to 2007). In other words,

[23] In order to do that we set $\sigma_0 = 0.15$, instead of the $\sigma_0 = 0.25$ in our benchmark.

	Benchmark	$mid - 90s$
Fraction of workers with tertiary educ.	0.31	0.21
Average skills tertiary educ.	5.77	5.85
Unemp. rate dropouts individuals	0.09	0.10
Unemp. rate of tertiary educ.	0.05	0.05
Frac. of tertiary educ. mismatched	0.33	0.29
Ter. educ. w. premium	1.46	1.49
Std. dev. to mean wages, tertiary	0.37	0.38
Std. dev. to mean wages, dropouts	0.26	0.26
Ter. educ., w. premium, mismatched	1.11	1.10
Ratio vacancies high to low sector	1.01	0.71
GDP	9.10	8.53

Table 8: Changing tertiary education attainment

the recent expansion of the educational attainment of the population in Spain could account to some extent for the decrease in the tertiary education wage premium and the increase in the fraction of occupational-mismatched workers. We take these results as reassuring because the equilibrium of the model does not bluntly contradict the empirical evidence.

4.4 Counterfactuals

In this section we explore the implications of alternative education policies in order to understand the lower fraction of mismatched workers and the higher tertiary education wage premium observed on average in OECD countries relative to the observations in Spain. We discipline our exercise by pursuing two policy reforms that together deliver an ability level of tertiary educated workers that is similar to the average of the OECD countries and that achieve their same fraction of tertiary educated individuals. In particular we implement a combination of a more selective education policy and of a policy that is more effective at increasing the efficient units of labor of the population.

4.4.1 Education policies

In the column labeled *Selection* of Table 9 we consider an education policy that is more selective in the sense that the correlation between ability and the probability of completing tertiary education is higher. In particular we implement a more stringent selection policy such that on average the ability of an educated worker increases by 50% of the observed difference in ability between an educated worker in the OECD and in Spain. This is represented in the model with a combination of the policy education parameters such that relative to the benchmark calibration σ_0 is smaller and equal to 0.2, and such that σ_1 is larger and equal to 0.8. As it is shown in Table 9, with the improved selection the fraction of mismatched workers reduces to about 24%, which is 9 points below its value in the benchmark. At the same time, the education premium increases from 1.46 to 1.55. Obviously, in this economy the mean ability of tertiary educated workers is higher than in the benchmark (5.92 in contract to 5.77). In qualitative terms, the relative performance of the benchmark economy with respect to the economy in the second column resembles well in all these three outcomes the performance of Spain relative to the average of the OECD countries.

Quality in the third column of Table 9 refers to a policy of education that is more effective at increasing the efficient units of labor of the educated workers (but the calibration is otherwise identical to the benchmark).[24] In particular we consider a value of ψ_e equal to 1.18 (instead of 1.15 in the benchmark) that produces the same average ability of tertiary educated workers that in the economy of second column. Again this policy goes in the direction of reducing the fraction of mismatched workers (to 0.22) and simultaneously increasing the tertiary education wage premium (to 1.52) with respect to the benchmark. It is also remarkable that under *Quality* output is about 3% higher than in the benchmark case. This increase is substantially larger than the one observed under *Selection*, which is only .5% larger than in the benchmark case.

One important feature of these two economies is that the ratio of vacancies in the h-sector to the vacancies in the l-sector is substantially above 1 (1.63 and 1.28 respectively) in contrast to a ratio of 1 observed in the benchmark. This reflects the endogenous response of firms to the policy education and it is the driving force of the outcomes in the labor market that we highlight. That is, under both policy reforms the average quality of educated workers increases, and the average quality of non-educated workers decreases (relative to benchmark). Hence, both policy reforms increase the incentive to create vacancies in the h-sector and reduce the incentives to do so in the l-sector, and the effect is stronger under *Selection* because under this policy there are more educated agents with higher ability.

Finally in the forth column of Table 9 we combine the education policies in the second and third columns. These two policies together produce an average ability of educated workers that is comparable to the average of the OECD (about 6% higher than in Spain). In terms of labor market outcomes it is remarkable that the fraction of mismatched workers falls to 0.13 (about 60% lower than in the benchmark and even below the figure for the average of the EU27) and that the tertiary education wage premium is increased up to 1.62 (which is line with the average of the OECD countries). Not surprisingly, the combination of policies in this economy produces that the ratio of vacancies in the h-sector to the vacancies in the l-sector is 2.13. The fact that the fraction of mismatched workers under *Selection+Quality* is below the 20% of the average for the OECD countries may be due to several reasons. First, different combinations of *Selection* and *Quality* producing the same outcomes in terms of education performance (as measured by average skills of educated workers) could produce different labor market outcomes. Second, there may be other aspects in which Spain differs from the OECD countries that affect the fraction of mismatched workers. For instance, as shown by Marimon and Zilibotti (1999), the generosity of unemployment benefits has implications both for the level of unemployment and for the occupation mismatch.

[24]Since this policy reform increases the relative ability of tertiary educated agents then it is inconsistent with respect to the empirical evidence for the average of the OECD in which *both* educated and non educated workers are more productive than in Spain (see PIAAC 2012). We have computed the effects of also increasing in Spain the productivity of non educated agents in the same proportion of the educated agents, and the differences with respect to the results we report below in the third column of Table 5 are negligible.

	Bench	*Selection*	*Quality*	*Selection+Quality*
Frac. workers with ter. educ.	0.31	0.31	0.31	0.31
Average skills tertiary educ.	5.77	5.92	5.92	6.07
Unemp. rate dropouts	0.09	0.12	0.10	0.13
Unemp. rate ter. educ.	0.05	0.05	0.04	0.04
Frac. of ter. educ. mismatched	0.33	0.24	0.22	0.13
Ter. educ. wage premium	1.46	1.55	1.52	1.62
Std. dev. to mean wages, tertiary	0.37	0.39	0.37	0.39
Std. dev. to mean wages, dropouts	0.26	0.23	0.26	0.23
Ter. educ. w. premium mismatched	1.11	1.11	1.12	1.13
Ratio vacancies high/low sector	1.01	1.63	1.28	2.13
GDP	9.10	9.15	9.39	9.42

Table 9: Policy Experiments

4.4.2 Alternative explanations

It is often argued that the expansion of the housing sector that fueled the most recent boom of the Spanish economy may be responsible for some of the misbehavior of the labor market with respect to other developed countries.[25] In this section we try to remove the effect of the housing boom and explore the implications for the equilibrium under a relatively less productive l-sector. To this end, in the last three columns of Table 10 we report the effect of a 1%, 2% and 5% reduction of the fixed component of productivity of the l-sector. Not surprisingly, the reduction in the productivity of the l-sector promotes a decrease in the fraction of mismatched workers from 0.33 to 0.12 (in the case of the highest increase in productivity) and a small increase in the tertiary education wage premium from 1.46 to 1.49. Furthermore, the unemployment rate is higher under these circumstances for the dropouts, going up from 9% to 17% (again, in the case of the highest increase in productivity). One could interpret from here (if we move from any of the last three columns to the first column of Table 10) that the reduction in the unemployment rate from the mid-nineties to the 2000's in Spain is to some extent accounted for by the increase in the productivity of the l-sector. The housing boom seems also responsible of a sizable fraction of the increase of mismatched workers and of the decrease in the tertiary education wage premium. In view of these results the housing boom appears to be an alternative or complementary story to the one presented in the previous sections in order to account for several of the differences between Spain and the OECD countries that we reported in the Introduction.

[25] Between 1997 and 2007 house prices more than doubled in Spain. According to The Economist House price Index, the observed percentage change was 117.1 in Spain, only larger in Britain 142.7, and closely followed in France 112.1. In the U.S. the figure is 52.7.

	Bench	1%	2%	5%
Frac. of workers with ter. educ.	0.31	0.31	0.31	0.31
Av. skills ter. educ.	5.77	5.77	5.77	5.77
Unemp. rate dropouts	0.09	0.10	0.11	0.17
Unemp. rate ter. educ.	0.05	0.05	0.05	0.05
Frac. of ter. educ. mismatched	0.33	0.29	0.25	0.12
Ter. educ. wage premium	1.46	1.47	1.47	1.49
Std. dev. to mean wages ter.	0.37	0.37	0.37	0.38
Std. dev. to mean wages dropouts	0.26	0.26	0.25	0.24
Ter. educ. w. premium mismatched	1.11	1.10	1.09	1.07
Ratio vacancies high/low sector	1.01	1.16	1.36	2.73
GDP	9.10	9.07	9.02	8.78

Table 10: Without Housing Boom

5 Conclusions

We provide an equilibrium model of the labor market with frictions in which workers are heterogeneous in terms of ability and education. We depart from existing models in that we assume that education does not only represent a barrier for uneducated workers to obtain jobs in technologically advanced firms, but it also increases labor productivity of educated workers in the less advanced sector. Furthermore we consider a continuum of ability levels which allows us to address the question of how differences in the composition of educated workers affects firms' incentives to open different types of vacancies.

We perform a quantitative analysis in order to illustrate the implications of alternative education policies on occupational mismatch and on tertiary education wage premium. We discipline our model by calibrating the parameter values to match significant facts of the Spanish economy. The results of these counter-factual experiments suggest that the differences observed in the equilibrium labor market between Spain and the average of the OECD countries would disappear had Spain implemented a more selective education policy (improve the ability mix of the educated workers), and/or if the education system was able to increase labor productivity. Remarkably, these results are obtained in spite of the perverse effects of the housing boom observed in Spain.

There are several interesting extensions of our work that are worth investigating in future research. First, the model studied in this paper belongs to a broad class in which multiple equilibria are possible. Thus from the theoretical perspective it would be valuable to have a characterization of the conditions under which such a multiplicity arises and under which the equilibrium is unique. Second, in regards to the quantitative analysis, our model could be extended to consider education choices at the individual level. In our current model the fraction of educated workers is purely determined as the result of a particular educational policy. Since in our framework there are incentives to complete tertiary education even for those individuals who will end up working in the l-sector, then allowing for the choice of the education level will not necessarily eliminate mismatch. It would be interesting to quantify the effects of changes in the quality of education (say in terms of additional units of efficient labor) and compare them with the implications of more stringent requirements (in terms of minimal ability) to be allowed to complete tertiary education. Finally, related to this, it would also be interesting to explicitly account for the cost of education. In such a framework it would be possible to quantitatively characterize the optimal education policy at a steady state and to evaluate the costs associated to its implementation from a given initial condition.

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