Education Policy, Occupation-Mismatch and the Skill Premium

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January 2015

Barcelona GSE Working Paper Series

Working Paper nº 807
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Preliminary Version

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 40% lower fraction of mismatched workers and a 10% 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 was comparable to other OECD countries, 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.\(^1\)\(^2\) 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%. In regards to occupation-mismatched workers, the fraction in Spain is about 0.34, 14 points above the average of the OECD countries. Interestingly, the fraction of the population with tertiary education in Spain is however similar to the average of the OECD.

<table>
<thead>
<tr>
<th></th>
<th>Spain</th>
<th>OECD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unemployment Rate of Tertiary Educ.</td>
<td>0.05</td>
<td>0.03</td>
</tr>
<tr>
<td>Unemployment Rate of Dropouts</td>
<td>0.08</td>
<td>0.07</td>
</tr>
<tr>
<td>Tertiary Educ. Wage Premium</td>
<td>1.51</td>
<td>1.72</td>
</tr>
<tr>
<td>Fraction of Tertiary Educ. Mismatched*</td>
<td>0.34</td>
<td>0.20</td>
</tr>
<tr>
<td>Fraction of Workers with Tertiary Educ.</td>
<td>0.29</td>
<td>0.28</td>
</tr>
<tr>
<td>Average Skills Tertiary Educ., PIAAC (2012)</td>
<td>278</td>
<td>295</td>
</tr>
</tbody>
</table>

Statistics come from Education Glance (2010) and from 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 EU27 in 2009.

Table 1: Spain versus OECD

Why is then the return to education and the fraction of mismatched workers so different in Spain? The claim in this paper is that the quality of the educated labor is an important variable to account for these facts. The reason why the education system is a promising candidate to explain the aforementioned facts is that according to the Programme for the International Assessment of Adult Competencies (PIAAC, 2012), the Spanish education system -and specially the tertiary education level- performs poorly compared to other OECD countries. In particular, 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

\(^1\)Occupation-mismatched workers are workers with tertiary education or higher who hold a job that requires an educational level beneath their qualification. 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 Oosterbeek 2011 and the many references therein).

\(^2\)In Spain the incidence of mismatch is higher for education programs related to social science than to engineering degrees but the phenomena is spread across all college graduated (see for instance the data in the Labor Force Survey which provides information on education and occupation). Furthermore, the incidence of occupational mismatch is sizable across all age groups: for instance Hidalgo et al. 2014 report that the fraction of mismatched workers within the age group 50-54 is about 50% in 2007. Finally, Montalvo 2013 reports that mismatch among young workers is more persistent in Spain than in other similar countries.
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. 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.

Our model incorporates frictions in the labor market à la Mortensen and Pissarides and workers are heterogeneous in terms of the endowment of innate ability and in terms of their education level, which is the outcome of the selection process and quality embedded in the educational policy. We assume that there are two production sectors in the economy and that education is valuable because only educated workers can operate the technology of the most advanced sector. Hence, our model can be seen as an extension to that in Albrecht and Vroman (2002) [AV] in which we explicitly incorporate an educational policy. A closely related paper to our work is Cuadras-Morató and Mateos-Planas 2013 [CMMP] where the authors put forth skill bias technological change (SBTC) as an explanation for the overeducation observed in the U.S. In particular, CMMP show that as a result of the SBTC overeducation 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 ability, but not education, is an input in the production functions of goods. In particular, CMMP assume that education and ability are imperfectly correlated, and that only educated workers are able to operate the technology of technologically advanced sector. Thus for a given fraction of educated workers a SBTC rises their bargaining power with the firm, and since the operation of the technology is costly, firms in the technologically advanced sector will reject low ability workers, which then will look for jobs in the less advanced sector in which the college degree is not a requirement.

3In Spain there have been 7 major reforms of the education system between 1970 and 2012. There are additional signs of serious problems with the quality of the Spanish education system at different levels. Concerning performance of compulsory secondary education students, in Spain more than 30% of the students do not complete the cycle, and of those who do, the performance on PISA scores provided by the OECD is poor. Furthermore, the fraction of students at the 2 higher proficiency levels 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 with the 9% average of the OECD. Obviously the quality of education has 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.

4In 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).

5Blazquez and Jansen 2008 study the efficiency of equilibrium allocations in the AV model. Related to this, Charlot and Decreuse 2010 study the efficiency of educational choices in a similar model and show that overeducation (in the sense of too many individuals willing to acquire education) arises since workers do not internalize the impact of their decision on the wage and employment perspectives of others.

6See 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 assess the ability of changes in the relative supply of skilled labor.
We depart from the model in CMMP in that education is also valuable at the production of goods. Specifically, 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.

Equipped with the necessary condition for mismatch we calibrate the model to mimic key observations of the Spanish economy in the mid 2000’s. We conduct several counter-factual experiments to assess 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. For instance, an education policy that produced an ability level of tertiary educated workers comparable to the average of the OECD countries would reduce the mismatch and increase the education wage premium to levels similar to the ones in those developed countries. We also assess the impact of the housing boom (which we implement by lowering the productivity of the less developed sector). 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).

The paper is organized as follows. In section 2 we describe the model economy that we use as framework for our analysis. In section 3 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 4 concludes.

2 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 \( \sigma(a) : A \rightarrow [0, 1] \), 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 \( a \). We explain below that, in addition, educational increases the effective ability at work of educated workers.

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 it cannot be operated by non educated workers. 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 \( \delta_i \), 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.\(^8\) 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 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 \( M(v_i, u_i) \) defined on the number of vacancies \( (v_i) \) and of unemployed workers \( (u_i) \) participating in the corresponding market. The matching functions satisfy \( M(v_i, u_i) = m(\theta_i)u_i \), where \( \theta_i = v_i/u_i \) 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 \( m(\theta_i)/\theta_i \).

### 2.1 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:

\[
 rW_{ij}(a) = w_{ij}(a) + \delta_i(U_{ij}(a) - W_{ij}(a)),
\]

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

\[
 rU_{ij}(a) = b + m(\theta_i) \{ W_{ij}(a) - U_{ij}(a) \}.
\]

\(^8\)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.
In the current environment mismatch may arise if for some ability level we have that an educated 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 $a \in \tilde{A}$.

### 2.2 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:

$$rJ_{ij}(a) = y_{ij}(a) - w_{ij}(a) - c_i + \delta_i \left[ \max_{i' \in \{h,l\}} V_{i'} - J_{ij}(a) \right].$$  (3)

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

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:

$$y_{ij}(a) = y_i + \tilde{y}_{ij} \tilde{a}_j.$$  (4)

The term $y_i$ captures the component of production that is sector-specific and unrelated to the ability of the worker operating the technology. We think of the term $\tilde{a}_j$ as 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

$$\tilde{a}_j = \psi_j a,$$  (5)

with $\psi_e > \psi_ne = 1$, hence we think of $\psi_e$ as the quality of education because it measures the increase in the ability in efficiency units of a worker due to education. Finally, the term $\tilde{y}_{ij}$ allows us to capture the fact that marginal productivity of ability may be both education and sector specific.\footnote{It is worth mentioning that considering explicitly the term $\psi_j$ will also help us to match the average ability of tertiary educated workers observed in the data in a transparent way, i.e., including directly the quality of education in $\tilde{y}_{ij}$ is immaterial, but it would difficult our assessment of average abilities.}

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

$$rV_h = -c_v + \frac{m(\theta_h)}{\theta_h} \left\{ \max \{ E_{\mu}[J_{ij}(a)|a \notin \tilde{A}] - V_h, 0 \} \right\},$$  (6)

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 $E_{\mu}$ in the expression above is the expectation conditional on meeting an educated worker as implied by the measure $\mu(a)$ and taking into account that in equilibrium not all educated workers may be searching in the high-tech sector. We also have

$$rV_l = -c_v + \frac{m(\theta_l)}{\theta_l} \left\{ \frac{u_{le}}{u_l} \left( \max \{ E_{\mu}[J_{le}(a)|a \in \tilde{A}] - V_l, 0 \} \right) + \frac{u_{le}}{u_l} \left( E_{\mu}[J_{le}(a)] - V_l \right) \right\}.$$  (7)
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 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, \( u_{lne} \) stands for the mass of educated unemployed workers searching for a job in the low-tech sector (\( u_{lne} \) is the corresponding number of non educated workers). As before, notice also that \( E_\mu \) stands for the conditional expectations operator as implied by \( \mu \), 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.

2.3 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

\[ w_{ij}(a) = \arg\max (W_{ij}(a) - U_{ij}(a))^{\beta} (J_{ij}(a) - V_{ij})^{1-\beta}, \]

where \( \beta \in (0,1) \) represents the bargaining power of the workers, which follows after imposing the FOC of the bargaining problem:

\[ (1 - \beta)(W_{ij}(a) - U_{ij}(a)) = \beta(J_{ij}(a) - V_i). \]

2.4 Equilibrium

Given \( \lambda(a) \) and \( \sigma(a) \), a stationary equilibrium for the previous economy is a set \( \tilde{A} \) and a list \( u_h, u_le, u_{lne}, e_h, e_{le}, e_{lne}, v_h, v_l \) such that:

i) Equations (1) to (8) hold with \( u_l = u_{lne} + u_{le}, \theta_l = v_l/u_l \), and \( \theta_h = v_{h}/u_{h} \),

ii) the free entry condition \( V_h = V_l = 0 \) holds,

iii) \( u_h, u_{le}, u_{lne}, e_h, e_{le}, \) and \( e_{lne} \) are consistent with \( \tilde{A} \) given \( \mu(a) \) implied \( \lambda(a) \) and \( \sigma(a) \),

iv) labor markets are stationary:

\[ u_h m(\theta_h) = (e_{he} - u_h) \delta_h, \]

\[ u_l m(\theta_l) = (e_{le} + e_{lne} - u_l) \delta_l, \]

where \( e_{ij} \) stands for the mass of employed \( j \)-educated agents in the \( i \)-sector.

As previously noted in AV and in CMMP in similar models 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. The linearity assumption introduced in Equation (4) 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 \( \theta_l \):

\[ w_{ij}(a) = w_i + w_{ij}a, \]
where
\[ w_i = \frac{\beta(r + \delta_i + m(\theta_i))(y_i - c_i) + (1 - \beta)l(r + \delta_i)}{r + \delta_i + \beta m(\theta_i)}, \]
(12)

and
\[ w_{ij} = \frac{\beta(r + \delta_i + m(\theta_i))y_{ij}}{r + \delta_i + \beta m(\theta_i)}, \]
(13)

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 (2) satisfies:
\[ rU_{ij}(a) - b = u_i + u_{ij}a, \]
(14)

with
\[ u_i = m(\theta_i) \frac{\beta(y_i - c_i - b)}{r + \delta_i + \beta m(\theta_i)}, \]
(15)

and where
\[ u_{ij} = m(\theta_i) \frac{\beta y_{ij}}{r + \delta_i + \beta m(\theta_i)}. \]
(16)

We therefore find 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, \( \bar{A} = \{ a \in A : a \leq \bar{a} \} \) and the equilibrium with mismatch is characterized by **positive assortative matching**:
\[ \frac{y_h - c_h - b}{y_{he}} < \frac{y_l - c_l - b}{y_{le}} \]
(17)

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.\(^{10}\) 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 \( \bar{A} = \{ a \in A : a \geq \bar{a} \} \).\(^{11}\) 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 \( \bar{A} = \emptyset \) (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 rely on this simple test to establish the uniqueness of the equilibrium with mismatch we study in Section 3.2.

It is clear from the Equation (17) 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 \( \theta_i \)'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

\(^{10}\)See Sattinger (1975) for an early development of a sorting condition along this lines.

\(^{11}\)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 \( y_{ij} > 0 \).
results in AV and CMMP. First, in line with the results in CMMP, it is clear from Equation (17) that SBTC consisting in increasing \( y_h \) relative to \( y_l \) (the marginal productivity of ability in the \( h \)-sector relative to the \( l \)-sector) will favor the existence of mismatch. Second, the fact that this sort of SBTC is able to give rise to mismatch is at odds with the predictions in the AV model, in which search is undirected (there is a single labor market) and thus increasing \( y_h \) relative to \( y_l \) tends to reduce mismatch favoring an equilibrium with ex-post segmentation.\(^{12}\) 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. Finally, note that 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.

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

### 3.1 Functional forms

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

\[
M(v_i, u_i) = m_i v_i^\eta u_i^{1-\eta}, \quad i = h, l,
\]

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 \( \alpha \), so that the density satisfies

\[
\lambda(a) = \alpha a_m^{\alpha} a^{-\alpha-1}, \quad a \geq a_m
\]

if \( a \geq a_m \) and zero otherwise. We require this density to have finite mean, hence we assume \( \alpha > 1 \).\(^{13}\) With respect to the educational policy we explore the implications of a general form such that for all \( a \geq a_m \):

\[
\sigma(a) = \sigma_0 + \sigma_1 \left( 1 - \frac{a_m}{a} \right).
\]

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,

\(^{12}\)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.

\(^{13}\)In fact, we will assume that \( \alpha > 2 \), which in addition assures that the distribution of ability has finite variance.
notice that the function $\sigma(a)$ is bounded, strictly increasing and strictly concave. Under these assumptions we have that

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

(21)

where $\mu_0 = (\sigma_0 + \sigma_1) a m^\alpha$, and that $\mu_1 = \sigma_1 a m^{1+\alpha}$. 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

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

(22)

hence the fraction of educated workers increases with both $\sigma_0$ and $\sigma_1$. In addition, the average ability of educated workers satisfies

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

(23)

If is straightforward to show that $\partial a_e/\partial \sigma_0 < 0$, but that $\partial a_e/\partial \sigma_1 > 0$. Hence, $\sigma_0$ and $\sigma_1$ 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 $\sigma_0$ and $\sigma_1$ 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 $\sigma_0$ 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 in the $h$-sector is less so), and thus, we expect a reduction in the wage premium and higher mismatch. This intuitive reasoning rightly suggests that increasing $\sigma_1$ will have the opposite effects.

### 3.2 Benchmark

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 interest rate, which is set to 0.03, the discount factor, which we fix at 0.5, the parameters that govern the matching technology, and the job separation rates for the Spanish economy, which are assumed to be equal to 0.07 as estimated by Hobijn and Sahin (2009). We also set $\psi_e = 1.15$ ($\psi_{ne}$ is normalized to 1), that is, we assume that as a result of tertiary education ability is increased by 15% (see the more detailed justification for this choice below when we discuss the role of ability and education). Furthermore, in the benchmark calibration the operation cost in the $l$-sector is normalized to zero and the productivity component of the technology in that sector is normalized to 1.

There is a second set of eleven parameters that we calibrate to match specific targets of the Spanish labor market and of the distribution of ability according to PISA and PIACC in the mid 2000’s. 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 fraction of individuals with tertiary education is about 0.31, 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
Unfortunately, this survey does not provide information on the quality of the job match for each worker, so 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 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.

Finally, we need to fix the parameters that govern the distribution of ability and the policy education function. To this end we identify $a_m$ and $\alpha$ by targeting the mean and dispersion in the PISA scores (Science) in 2006. We also calibrate $\sigma_0$ and $\sigma_1$ 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 dropouts of 1.2, as calculated from the Programme for the International Assessment of Adult Competencies (PIAAC, 2012). Obviously, the relative PIAAC score (or effective ability in the model economy) of tertiary educated individuals is affected both by the selection process of individuals into tertiary education and by the additional capacities individuals gain through the education system. It is hard to disentangle the role played by each of these forces in shaping the relative higher mean score of tertiary educated workers with respect to dropouts. So our approach here is to assume that ability of individuals is increased by 15% as a result of education (as we said above, $\psi_e = 1.15$ ). Given this for our model to account for the 1.2 ratio of PIAAC abilities of tertiary educated to dropouts, the average effective ability (that is the model object equivalent to the adult competencies) of a tertiary educated worker has to be equal to 5.77. Table 2 contains the parameter values and it also reproduces the relevant statistics in the model and in the data. In regards to the existence of other type of equilibrium we performed the test explained at the end of Section 2.4 and found that the segregated equilibrium fails to exist, thus the mismatch equilibrium reported in Table 2 is unique.

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 show in section 3.3.3 that when we adjust the fraction of tertiary educated workers to the one observed in the mid 90’s, the predictions of the model regarding the evolution of mismatched

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14 Our sample is made of male individuals aged 25 to 54. Statistics of wages are for the sample of full-time workers after trimming the bottom and top 1% of the distribution of wages in each education group.

15 This is a sample of Social Security Administration records.

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

17 Note that this figure is different in Table 2 to the figure in Table 1 because normalization of effective ability in the model is different than normalization of PIAAC scores. In particular, in the model economy, effective ability is the result of transforming individuals’ ability through $\psi_e$ and $\psi_{ne}$.
workers and the tertiary education wage premium are consistent with the ones observed over the last decade in Spain. We take these results as reassuring because the equilibrium of the model does not bluntly contradict the empirical evidence.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$b$</td>
<td>1.07</td>
</tr>
<tr>
<td>$c_v$</td>
<td>0.22</td>
</tr>
<tr>
<td>$c_h$</td>
<td>-0.17</td>
</tr>
<tr>
<td>$y_h$</td>
<td>-2.50</td>
</tr>
<tr>
<td>$\tilde{y}_{he}$</td>
<td>0.7043</td>
</tr>
<tr>
<td>$\tilde{y}_{le}$</td>
<td>0.0583</td>
</tr>
<tr>
<td>$\tilde{y}_{lne}$</td>
<td>0.036</td>
</tr>
<tr>
<td>$a_m$</td>
<td>4.10</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>6.30</td>
</tr>
<tr>
<td>$\sigma_0$</td>
<td>0.25</td>
</tr>
<tr>
<td>$\sigma_1$</td>
<td>0.42</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Target</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>PISA mean score science (OECD 2006)</td>
<td>4.88</td>
<td>4.88</td>
</tr>
<tr>
<td>PISA standard deviation to mean (OECD 2006)</td>
<td>0.19</td>
<td>0.19</td>
</tr>
<tr>
<td>Fraction of workers with tertiary educ. (EU-SLIC 2007)</td>
<td>0.31</td>
<td>0.31</td>
</tr>
<tr>
<td>Average skills tertiary educ. (PIAAC 2012)</td>
<td>5.77</td>
<td>5.77</td>
</tr>
<tr>
<td>Unemp. rate dropouts (EU-SLIC 2007)</td>
<td>0.09</td>
<td>0.09</td>
</tr>
<tr>
<td>Unemp. rate tertiary educ. (EU-SLILC 2007)</td>
<td>0.04</td>
<td>0.05</td>
</tr>
<tr>
<td>Fraction tertiary educ. mismatched (Eurostat 2009)</td>
<td>0.33</td>
<td>0.32</td>
</tr>
<tr>
<td>Tertiary educ. wage premium (EU-SLIC 2007)</td>
<td>1.47</td>
<td>1.51</td>
</tr>
<tr>
<td>Std. dev. to mean wages, tertiary (EU-SLIC 2007)</td>
<td>0.47</td>
<td>0.46</td>
</tr>
<tr>
<td>Std. dev. to mean wages, dropouts (EU-SLIC 2007)</td>
<td>0.34</td>
<td>0.32</td>
</tr>
<tr>
<td>Tertiary educ. wage premium, mismatched (Hidalgo et al. (2014))</td>
<td>1.10</td>
<td>1.08</td>
</tr>
</tbody>
</table>

Table 2: Calibrated Parameters and Targets

3.3 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. In order to discipline our exercise we pursue two policy reforms that together deliver a similar ability level of tertiary educated workers than 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.
3.3.1 Education policies

In the column labeled Selection of Table 3 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. This is represented in the model with a combination of the policy education parameters such that relative to the benchmark calibration $\sigma_0$ is smaller and equal to 0.2, and such that $\sigma_1$ is larger and equal to 0.8. As it is shown in Table 3, with the improved selection the fraction of mismatched workers reduces to about 27%, which is 5 points below its value in the benchmark. At the same time, the education premium increases from 1.51 to 1.59. Obviously, in this economy the mean ability of tertiary educated workers is higher than in the benchmark (5.92 in contrast 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 3 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). In particular we consider a value of $\psi_e$ 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 0.23) and simultaneously increasing the tertiary education wage premium (to 1.57) with respect to the benchmark.

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 above 1 (1.02 and 1.04 respectively) in contrast to a ratio of 0.87 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.

Finally in the fourth column of Table 3 we combine the education policies in the second and third columns. These two policies together produce an average ability of tertiary 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 0.19 (14 points lower than in the benchmark and similar to the figure for the average of the EU27) and that the tertiary education wage premium is increased up to 1.66 (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 1.21.

3.3.2 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

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18Since 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 3 are negligible.
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 second column of Table 4 we report the effect of a 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 0.25) and an increase in the tertiary education wage premium from 1.51 to 1.56. Furthermore, the unemployment rate is higher under these circumstances for the dropouts, going up from 10% to 13%. One could interpret from here (if we move from the second column to the first column of Table 4) 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 a relevant aspect in order to account for several of the differences between Spain and the OECD countries that we reported previously.

Finally in the third column of Table 4 we report labor market outcomes in an economy in which the housing boom is absent and the Selection and Quality policies we introduced before are in operation. We obtain an additional decrease of the fraction of mismatched workers of 12 points and an increase in the tertiary education wage premium of 16 points. As reported in the last row of the Table, the number of vacancies in the $h$-sector almost doubles the number of vacancies in the $l$-sector in this economy. To sum up the absence of the housing boom would be able to account for about 40% of the total decrease in the occupational mismatch and about 24% of the total increase in the tertiary education wage premium that we report in the last column.

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**Table 3: Policy Experiments**

<table>
<thead>
<tr>
<th></th>
<th>Bench</th>
<th>Selection</th>
<th>Quality</th>
<th>Selection+Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraction of workers with tertiary educ.</td>
<td>0.31</td>
<td>0.31</td>
<td>0.31</td>
<td>0.31</td>
</tr>
<tr>
<td>Average skills tertiary educ.</td>
<td>5.77</td>
<td>5.92</td>
<td>5.92</td>
<td>6.07</td>
</tr>
<tr>
<td>Unemp. rate dropouts individuals</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>Unemp. rate individuals with tertiary educ.</td>
<td>0.06</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Fraction of tertiary educ. mismatched</td>
<td>0.33</td>
<td>0.27</td>
<td>0.23</td>
<td>0.19</td>
</tr>
<tr>
<td>Tertiary educ. wage premium</td>
<td>1.51</td>
<td>1.59</td>
<td>1.57</td>
<td>1.66</td>
</tr>
<tr>
<td>Std. dev. to mean wages, tertiary</td>
<td>0.46</td>
<td>0.48</td>
<td>0.46</td>
<td>0.48</td>
</tr>
<tr>
<td>Std. dev. to mean wages, dropouts</td>
<td>0.32</td>
<td>0.31</td>
<td>0.32</td>
<td>0.32</td>
</tr>
<tr>
<td>Tertiary educ. wage premium, mismatched</td>
<td>1.09</td>
<td>1.09</td>
<td>1.09</td>
<td>1.09</td>
</tr>
<tr>
<td>Ratio vacancies high to low sector</td>
<td>0.87</td>
<td>1.02</td>
<td>1.04</td>
<td>1.21</td>
</tr>
</tbody>
</table>

---

19 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.
3.3.3 Changing the fraction of educated workers

In this section we quantify what will be the implications of changing the fraction of tertiary educated workers. In Table 5 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 similar figure to the one observed in Spain in the mid 90s. We obtain that the fraction of mismatched workers decreases from 0.32 to 0.29 and the tertiary education wage premium increases from 1.51 o 1.55. 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, 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.

Obviously, an expansion of the educational attainment of the population beyond the average level of the OECD countries could also have consequences for the labor market. For instance, if we take the economy under Selection+Quality, that resembles the average OECD country, and we increase the fraction of tertiary educated workers up to 0.4, in line with the level that is currently observed in the US economy - the fraction of mismatched workers would increase up to 0.30 (this figure is in line with the one reported in Slonimezyk 2013 for the US) and the average ability of tertiary educated workers would go down by about 3% (also in line with the difference between the OECD and the US as reported by PIIAC). The evolution of the tertiary education wage premium would go however in the opposite direction to what it is observed in the data. In particular it would go down from 1.66 to 1.54, whereas in the data the premium in the US is about 1.91, quite above the 1.77 average of the OECD countries. Hence, it is clear that the

---

Table 4: Without Housing Boom

<table>
<thead>
<tr>
<th></th>
<th>Bench</th>
<th>No Housing Boom</th>
<th>Selection+Quality + No Housing Boom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraction of workers with tertiary educ.</td>
<td>0.31</td>
<td>0.31</td>
<td>0.31</td>
</tr>
<tr>
<td>Average skills tertiary educ.</td>
<td>5.77</td>
<td>5.77</td>
<td>6.07</td>
</tr>
<tr>
<td>Unemp. rate dropouts individuals</td>
<td>0.10</td>
<td>0.13</td>
<td>0.14</td>
</tr>
<tr>
<td>Unemp. rate individuals with tertiary educ.</td>
<td>0.06</td>
<td>0.06</td>
<td>0.05</td>
</tr>
<tr>
<td>Fraction of tertiary educ. mismatched</td>
<td>0.33</td>
<td>0.25</td>
<td>0.13</td>
</tr>
<tr>
<td>Tertiary educ. wage premium</td>
<td>1.51</td>
<td>1.56</td>
<td>1.72</td>
</tr>
<tr>
<td>Std. dev. to mean wages, tertiary</td>
<td>0.46</td>
<td>0.47</td>
<td>0.49</td>
</tr>
<tr>
<td>Std. dev. to mean wages, dropouts</td>
<td>0.32</td>
<td>0.32</td>
<td>0.32</td>
</tr>
<tr>
<td>Tertiary educ. wage premium, mismatched</td>
<td>1.09</td>
<td>1.08</td>
<td>1.09</td>
</tr>
<tr>
<td>Ratio vacancies high to low sector</td>
<td>0.87</td>
<td>1.37</td>
<td>1.97</td>
</tr>
</tbody>
</table>

---

20 In order to do that we set $\sigma_0 = 0.15$, instead of the $\sigma_0 = 0.25$ in our benchmark.
21 We achieve that figure by setting $\sigma_0 = 0.3$ and $\sigma_1 = 0.7$
Table 5: Changing tertiary education attainment

<table>
<thead>
<tr>
<th></th>
<th>Benchmark</th>
<th>mid – 90s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraction of workers with tertiary educ.</td>
<td>0.31</td>
<td>0.21</td>
</tr>
<tr>
<td>Average skills tertiary educ.</td>
<td>5.77</td>
<td>5.85</td>
</tr>
<tr>
<td>Unemp. rate dropouts individuals</td>
<td>0.10</td>
<td>0.10</td>
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<tr>
<td>Unemp. rate individuals with tertiary educ.</td>
<td>0.06</td>
<td>0.05</td>
</tr>
<tr>
<td>Fraction of tertiary educ. mismatched</td>
<td>0.32</td>
<td>0.29</td>
</tr>
<tr>
<td>Tertiary educ. wage premium</td>
<td>1.51</td>
<td>1.55</td>
</tr>
<tr>
<td>Std. dev. to mean wages, tertiary</td>
<td>0.46</td>
<td>0.48</td>
</tr>
<tr>
<td>Std. dev. to mean wages, dropouts</td>
<td>0.32</td>
<td>0.25</td>
</tr>
<tr>
<td>Tertiary educ. wage premium, mismatched</td>
<td>1.08</td>
<td>1.08</td>
</tr>
<tr>
<td>Ratio vacancies high to low sector</td>
<td>0.87</td>
<td>0.60</td>
</tr>
</tbody>
</table>

relative performance of the US labor market with respect to other developed countries cannot be accounted alone by differences in the supply side of educated labor.\textsuperscript{22}

4 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

\textsuperscript{22}See the discussion along the lines of capital skill complementarity and the supply of skilled labor in Krusell et al. (2000).
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.

References


OECD, 2007: “Science Competencies for Tomorrow’s World.”


PIAAC, 2013: “Programa internacional para la evaluacin de las competencias de la poblacin adulta.”

PISA, 2006: Report of the OECD.
