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The role of human capital and technological change in overeducation

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Abstract

We employ Portuguese data to test two competing hypotheses about the impact of overeducation and undereducation on earnings. First, undereducation is the outcome of a process in which market-acquired capital substitutes for insufficient school-supplied qualifications, whereas overeducation is associated with excess schooling but short tenure and job experience. The second hypothesis calls upon changes in the technology of production and marketing to explain why some workers end up as inadequately educated for the tasks that they perform, while at the same time, others (holding identical jobs but more schooling) are perceived to be overeducated. Our findings appear to leave little room for explanations of the overeducation/undereducation phenomenon rooted in the trade-off between different forms of human capital. The hypothesis of technology-induced pockets of overeducation and undereducation is consistent with Portuguese reality, characterized in the last decade by intensive efforts to promote economic growth, to modernize the industrial structure and to upgrade educational qualifications. [*JEL* J24, I21, O30] © 2000 Elsevier Science Ltd. All rights reserved.

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1. Introduction

In the growing body of literature on overeducation and undereducation, perhaps the single most remarkable feature has been the consistency and robustness of empirical findings concerning the relationship between overeducation/undereducation and individual earnings. As stylized facts go, overeducated workers tend to earn higher returns to their years of schooling than co-workers who are not overeducated, but lower returns than workers with similar education who work in jobs that require the level of education they possess. Symmetrically, undereducated workers receive lower returns than their co-workers with the required, and thus higher, level of education, but higher returns than employees who have the

same educational attainment and work in jobs that just require their level of education.

These findings have been reported in a number of studies for economies at different stages of development, with widely different labor-market institutional frameworks or education systems, and employing strikingly different means of measuring overeducation and undereducation. A representative survey across countries might include reference to Duncan and Hoffman (1981); Rumberger (1987); Sicherman (1991); Tsang, Rumberger and Levin (1991) and Cohn and Khan (1995) for the United States; Hartog and Oosterbeek (1988) and Groot (1993) for the Netherlands; Alba-Ramírez (1992) for Spain and Kiker, Santos and De Oliveira (1997) for Portugal. Some authors employed workers' self-evaluation of educational requirements to measure overeducation/undereducation, as is the case with the seminal studies for the US and the Netherlands, whereas others relied upon independent evaluations of functional requirements

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and job-required qualifications (Burris, 1983; Tsang et al., 1991), and still others gave preference to data-based criteria (Verdugo & Verdugo, 1989; Kiker et al., 1997).

Despite the robustness of the findings, there is still little known about the inner mechanisms of the overeducation/undereducation phenomenon. Paucity or insufficiency of data generally have precluded analysts from probing deeper into the issue. It may be easy to understand why undereducated workers would prefer jobs for which they are not qualified enough, or why employers would hire overeducated workers below the rates of pay they could get at a job where their educational attainments were fully utilized; it is not as easy to explain why employers hire undereducated workers at a premium over their market rate, or why overeducated workers accept positions that pay below their market rate.

Two possible explanations for the existence of overeducation/undereducation emphasize either the role of human capital or that of technological change. Under the former, it is often argued that overeducated workers may substitute education for the lack of previous job experience, accepting jobs requiring less education than they actually possess in order to acquire the necessary experience and improve their chances of finding a better job match (Rosen, 1972; Sicherman & Galor, 1990). Similarly, undereducated workers may substitute experience for the lack of education and thus acquire a mix of human-capital endowments adequate enough for job performance. Overeducation might be seen as a transitory situation (at the individual level), as promotion (within the job) or job mobility would lead overeducated workers over time to positions compatible with their educational achievements. On the contrary, undereducation might be thought of as a long lasting situation, where employers and employees have reached a point where accumulated experience compensates for the lack of school-acquired qualifications. If this is the case, we would expect that workers who happen to hold a job for which they are not fully qualified would not experience a deterioration of their earnings status as tenure with the same employer increases. Overeducated workers, on the other hand, being more prone to turnover, should not expect substantial gains from staying longer with the same employer. Further, if overeducation has negative effects on productivity, by increasing job dissatisfaction and adverse workplace behavior (Tsang & Levin, 1985; Tsang, 1987), increased tenure would not be rewarded. This line of reasoning emphasizes a possible trade-off between different forms of human capital.

A second explanation for the overeducation/undereducation phenomenon focusses on the effects of technological change. It is argued that the rapid pace of technological change may require school-provided skills higher than those possessed by currently employed workers. In the presence of positive adjustment costs, replace-

ment of the workforce by better-educated workers cannot be made instantaneously. That is, both the employer and the employees could be locked into a situation of disequilibrium (at least in the short run) and hence pockets of undereducation would arise. In less flexible labor market settings (as is the case, in general, in European countries), these pockets might be persistent. At the same time, firms upgrade their hiring standards and recently-hired employees, with higher educational qualifications than their older co-workers, are perceived to be overeducated.

Empirically testable hypotheses derived under the technology-based hypothesis contradict those of the human capital approach. Overeducated workers are those that the employer wishes to retain and for whom the bulk of training and firm-specific investments is slotted; hence, their tenure is rewarded. Undereducated workers, on the other hand, confined in dead-end jobs, should expect no such benefits from continuing with the same employer.

We report below on research results that appear to be more supportive of the role of technological change than of human capital in explaining overeducation/undereducation for the Portuguese economy. Taking advantage of a data set of uncommon richness, we are able to probe deeper into the links among overeducation/undereducation, job characteristics and workers' earnings than perhaps others have done.

The paper is organized as follows. In Section 2 we deal with data and measurement issues and present arguments in favor of a new approach towards the quantification of overeducation/undereducation. In Section 3 the models are explained and the hypotheses we propose to test are set forth. Results are discussed in Section 4 and some concluding remarks are offered in the final section.

2. The data and measurement issues

The sample used in this study was drawn randomly from an extensive data set based on staff logs (Quadros de Pessoal) collected in 1991 by the Portuguese Ministry of Employment from all business firms with more than one paid employee. Available in the data set is information on workers' characteristics such as gender, age, education, skill/qualification level, occupation, years with the employing firm, hours worked and earnings, and on-job attributes such as type of industry, geographic location, plant size, type of management and form of ownership. With this information, the variables listed in Table 1 were constructed. Sample means and other descriptive statistics are given in Table 2.

In the regressions below, the dependent variable, $\ln Y$, is the natural logarithm of gross monthly earnings in Portuguese escudos. Independent variables include education (EDUC) which is proxied by the number of years

Table 1
Definition of variables

Variable	Description
In Y	Natural logarithm of total monthly earnings in escudos
EDUC	Number of years of education completed
ADSCHOOL	Number of years of adequate schooling
OVERSCH	Number of years of overeducation
UNDERSCH	Number of years of undereducation
TENURE	Number of years of tenure in the current job
TENURE ²	TENURE squared
EXPER	Number of years of presumed work experience in firms other than the current one (age – education – tenure – 6)
EXPER ²	EXPER squared
ADTEN	Interaction term ADSCHOOL × TENURE
ADEXP	Interaction term ADSCHOOL × EXPER
OVTEN	Interaction term OVERSCH × TENURE
OVEXP	Interaction term OVERSCH × EXPER
UNDTEN	Interaction term UNDERSCH × TENURE
UNDEXP	Interaction term UNDERSCH × EXPER
LNHOURS	Logarithm of total monthly hours worked
MALE	Dummy variable, 1 if worker is male
PUBLIC	Dummy variable, 1 if job in a publicly-owned firm
OC0	Dummy variable, 1 if a professional
OC1	Dummy variable, 1 if in a upper-level highly skilled non-manual job
OC2	Dummy variable, 1 if in a highly skilled manual job
OC3	Dummy variable, 1 if in a skilled or semi-skilled non-manual job
OC4	Dummy variable, 1 if in a skilled or semi-skilled manual job
OC5	Dummy variable, 1 if in a non-skilled job
FIRM4	Dummy variable, 1 if number of employees in the plant is ≤ 4
FIRM99	Dummy variable, 1 if number of employees in the plant is > 4 and ≤ 99
FIRM499	Dummy variable, 1 if number of employees in the plant is > 99 and ≤ 499
FIRMBIG	Dummy variable, 1 if number of employees in the plant is ≥ 500
NORTH	Dummy variable, 1 if job in the Northern region
CENTER	Dummy variable, 1 if job in the Central region
LISBON	Dummy variable, 1 if job in the Lisbon-and-Tagus-Valley region
ALENT	Dummy variable, 1 if job in the Alentejo region
ALGAR	Dummy variable, 1 if job in the Algarve region
TEXTILE	Dummy variable, 1 if plant in the textile and garments industry
FOOD	Dummy variable, 1 if plant in the food and beverages industry
WOOD	Dummy variable, 1 if plant in the wood and furniture industry
PAPER	Dummy variable, 1 if plant in the paper and printing industry
CHEMICAL	Dummy variable, 1 if plant in the chemical industry
NONMETAL	Dummy variable, 1 if plant in the non-metal industry
METAL	Dummy variable, 1 if plant in the metal industry
MACHINE	Dummy variable, 1 if plant in the machinery industry
PUBUTIL	Dummy variable, 1 if plant is a public utility
CONSTRU	Dummy variable, 1 if plant in the construction and building industry
WHOLE	Dummy variable, 1 if plant in the wholesale trade industry
RETAIL	Dummy variable, 1 if plant in the retail trade industry
RESTHOT	Dummy variable, 1 if plant in the hotels and restaurants industry
TRANSP	Dummy variable, 1 if plant in the transportation industry
FINANCE	Dummy variable, 1 if plant in the finance, insurance and real estate industry
SERVICE	Dummy variable, 1 if plant in the services industry

of completed schooling, job tenure (TENURE) with the 1991 employer, and general work experience (EXPER) which is the number of years of presumed work experience in firms other than the 1991 employer. These variables purport to measure different individual endow-

ments of human capital, both general and firm-specific. Also included is LNHOURS, the logarithm of total monthly hours of work. A number of dummy variables were constructed, as defined in Table 1, to control for different occupations (OC0 to OC5), industry of employ-

Table 2
Sample mean and standard deviation of variables

Variable	Mean	Standard deviation
ADSCHOOL	4.040	0.543
OVERSCH	1.106	2.116
UNDERSCH	0.132	0.620
TENURE	8.280	8.849
TENURE ²	146.868	250.917
EXPER	16.784	10.862
EXPER ²	399.665	510.132
ADTEN	33.456	36.301
ADEXP	67.511	43.775
OVTEN	6.233	22.314
OVEXP	11.344	27.065
UNDTEN	1.688	9.908
UNDEXP	3.760	20.513
LNHOURS	5.181	0.132
MALE	0.657	0.475
PUBLIC	0.063	0.243
OC0	0.010	0.100
OC1	0.050	0.218
OC2	0.123	0.329
OC3	0.148	0.355
OC4	0.473	0.499
OC5	0.196	0.397
FIRM4	0.023	0.151
FIRM99	0.324	0.468
FIRM499	0.425	0.494
FIRMBIG	0.228	0.419
NORTH	0.423	0.494
CENTER	0.159	0.366
LISBON	0.358	0.479
ALENT	0.030	0.171
ALGAR	0.030	0.171
TEXTILE	0.219	0.413
FOOD	0.049	0.215
WOOD	0.044	0.206
PAPER	0.023	0.148
CHEMICAL	0.033	0.179
NONMETAL	0.039	0.194
METAL	0.012	0.107
MACHINE	0.110	0.313
PUBUTIL	0.010	0.102
CONSTRU	0.115	0.319
WHOLE	0.063	0.244
RETAIL	0.076	0.266
RESTHOT	0.053	0.224
TRANSP	0.076	0.264
FINANCE	0.020	0.140
SERVICE	0.057	0.233

ment (TEXTILE, FOOD, etc.), plant size (FIRM4 to FIRMBIG) and location (NORTH, CENTER, etc.). Two other control variables are MALE, a binary gender indicator, and PUBLIC, which distinguishes between publicly-owned business firms and privately-owned concerns.

Of most interest to the present study are the variables related to overeducation and undereducation. In the pioneering study by Duncan and Hoffman (1981), the worker's own evaluation of required educational standards to perform his or her job was used to ascertain whether there was overeducation or undereducation. The Duncan and Hoffman measurement has been criticized on the grounds of subjectivity, recall bias, and possibly conflicting evaluation by workers holding identical jobs and schooling levels. This criticism has led to subsequent research attempting to improve upon the methodology. An alternative measure rested on the evaluation of required skills by independent job analysts and their correspondence to school-provided abilities. Examples of this methodology can be found in the use of the general educational development (GED) information contained in the Dictionary of Occupational Titles of the US Department of Labor (Rumberger, 1981) and in Dutch job qualification scales (Hartog & Oosterbeek, 1988). In this research, conversion of GED scores or qualification levels into equivalent years of schooling has proved to be a difficult task.

Rather than relying upon the worker's own evaluation or upon exogenously-designed criteria, Verdugo and Verdugo (1989) proposed a different indicator of overeducation/undereducation based on the distribution of actual educational attainments in each occupation defined at the three-digit level. Their index classifies as undereducated a worker whose schooling deviates (negatively) from the observed occupation average by more than one standard deviation, and as overeducated those with (positive) deviation from the mean in excess of one standard deviation.

In previous work (Kiker et al., 1997), we experimented with a variant of the procedure, replacing Verdugo and Verdugo's mean-centered bracket with a different measure of central location, the distribution mode. The mode is less sensitive to the presence of outliers in the data and provides a more accurate measure of the extent of surplus or deficit schooling than can be garnered from the mean.

Both arguments can best be illustrated by means of a simple numerical example. Consider a group of ten workers with the same three-digit occupation code, of which eight are college graduates (16 years of schooling); the ninth is a high-school graduate (12 years) and let x denote years of schooling of the tenth worker. According to the mode criterion, the ninth worker will be classified as undereducated with 4 years of deficit schooling, no matter what the education level of the last worker turns out to be. In contrast, the mean-centered criterion will classify the ninth worker as undereducated or adequately educated depending on whether the tenth worker has at least 8 ($x \geq 8$) or less than 8 ($x < 8$) years of schooling. Furthermore, if the ninth worker is deemed undereducated, the amount of the assigned education

deficit may vary from 0.1 years to around 2.3 years as the last worker's attainment increases from 8 to 16 years of schooling. Particularly striking are the results when $x = 16$, that is, when all but one worker are college graduates. The mode-based criterion plausibly takes 16 years to be the required schooling level and measures the extent of the schooling deficit of the undereducated worker to be 4 years, while the mean-centered evaluation produces a 14.3–16.9 range for years of required schooling and a value of 2.3 for the amount of undereducation. If one is to resort to observed data to establish incidence of overeducation/undereducation and measure the extent of surplus or deficit schooling, the arguments presented above suggest clearly that a mode-based criterion will produce better results than the mean-based alternative.

In this study, we refine the mode-based methodology. In some occupations, the number of workers may be so small, or the dispersion of the observed educational attainments so wide, that any estimate of required education that rests on a measure of central location may be unreliable, whether it is the mean or the mode. Accordingly, we chose to retain in our sample only those individuals working in occupations, defined at the three-digit level, for which the modal number of years of schooling was shared by at least 60% of workers in that occupation. Albeit strict, this criterion virtually ensures that errors of measurement of over-, under- and required education are minimized. Furthermore, this adjustment should lead to results that mimic more closely the results (concerning both the incidence and the extent of overeducation/undereducation) produced by an exogenous criterion. In fact, if such a clear majority of workers in a given occupation possessed a certain level of schooling, and job analysts considered this level insufficient or in excess of the level required for adequate performance, the incidence of over- or undereducation in the occupation would have to be greater than 60%, an outcome that, to our knowledge, is out of line with published research. It would take an environment of pervasive barriers to entry, extensive closed-shop procedures or severely diminished competition to produce such an outcome. Firms hiring so great a share of overeducated workers would bear a sizably higher wage bill than needed or, if undereducation were the rule, sustain substantial productivity costs.

Along with workers in occupations with ill-defined modal education levels, also excluded from the sample were farmers and farm laborers, self-employed, part-time and unpaid family workers, individuals under 14 years of age, apprentices, and those who were simultaneously owners and executives. The working sample in the results to be reported below comprises 23,306 individuals.

The variables denoting adequate education, overeducation, and undereducation are ADSCHOOL, the number of years of schooling judged adequate enough to perform a given job (on grounds of that being the level shared by

at least 60% of the workers with the same occupation), OVERSCH, the number of years of observed individual schooling above the occupation's modal value, UNDERSCH, a similarly constructed proxy for undereducation, and the interaction terms ADTEN, OVTEN, UNDTEN, ADEXP, OVEXP and UNDEXP defined by the product of the three variables just mentioned and those purporting to measure firm-specific and market-related general human capital, TENURE and EXPER.

3. Hypotheses and models

Previous research has focused on the role of schooling variables in earnings determination. Observed years of schooling, EDUC, are decomposed into three parts:

$$EDUC = ADSCHOOL + OVERSCH - UNDERSCH.$$

After evaluation of the number of years of schooling required for adequate job performance (ADSCHOOL), if the individual's observed educational attainment is different then the excess is assigned to OVERSCH or, alternatively, the deficit is attributed to UNDERSCH. Earnings regressions patterned after the Mincerian framework (Mincer, 1974) are thus expressed as

$$\ln Y = \alpha + \phi_a \text{ADSCHOOL} + \phi_o \text{OVERSCH} \\ + \phi_u \text{UNDERSCH} + \mathbf{X}\boldsymbol{\beta} + \epsilon,$$

where α is a constant; \mathbf{X} is a (row) vector of non-education related variables which include the logarithm of hours worked and dummy variables for plant size, geographical location, industry, occupation, gender and public ownership (of the business firm); $\boldsymbol{\beta}$ is a conformable (column) vector of coefficients; ϵ is a random disturbance; and marginal returns to schooling are distributed by the three ϕ coefficients. It is generally expected (and evidence supports the view) that the signs are positive for ϕ_a and ϕ_o and negative for ϕ_u , with $\phi_o < \phi_a$.

The first explanation for the overeducation/undereducation phenomenon reviewed above stresses the possible substitutability or complementarity of different forms of the human capital endowment (educational, general or firm-specific, chiefly). Supposedly, deficit schooling might be compensated by a larger stock of firm-specific capital or of general labor-market experience, whereas surplus schooling might be viewed as a substitute for the lack of firm seniority or of work experience. We thus posit that these factors could be taken into account by modifying the earnings equation to read

$$\ln Y = \alpha + \phi_a \text{ADSCHOOL} + \phi_o \text{OVERSCH} + \\ \phi_u \text{UNDERSCH} + \delta_{at} \text{ADTEN} + \delta_{ae} \text{ADEXP} + \\ \delta_{ot} \text{OVTEN} + \delta_{oe} \text{OVEXP} + \delta_{ut} \text{UNDTEN} + \\ \delta_{ue} \text{UNDEXP} + \mathbf{X}\boldsymbol{\beta} + \epsilon,$$

where the newly-added variables are the interaction products defined in the preceding section. Under this speci-

fication, marginal returns to a year of required schooling are proxied by the partial derivative

$$\frac{\partial \ln Y}{\partial \text{ADSCHOOL}} = \phi_a + \delta_{at} \text{TENURE} + \delta_{ac} \text{EXPER}.$$

Similarly, marginal returns to surplus schooling (for overeducated workers) and to deficit schooling (for undereducated workers) are given by

$$\frac{\partial \ln Y}{\partial \text{OVERSCH}} = \phi_o + \delta_{ot} \text{TENURE} + \delta_{oc} \text{EXPER}$$

and

$$\frac{\partial \ln Y}{\partial \text{UNDERSCH}} = \phi_u + \delta_{ut} \text{TENURE} + \delta_{uc} \text{EXPER},$$

respectively. In this way, we allow for different profiles of the returns to overeducation and undereducation in relation to tenure and experience.

Of particular interest for the purposes of this study are the signs of δ_{ot} and δ_{ut} , and, to a lesser extent, those of δ_{oc} and δ_{uc} . According to the human capital view, overeducation is a transitory stage in which individuals with good educational qualifications improve their chances of finding a better job match. Under this view, we would expect worker human-capital investments to be more search-oriented rather than directed toward the acquisition of firm-specific capital and, in turn, we would expect employers to have little incentive to invest in a worker who is in the market for a better job match. A negative sign for δ_{ot} or, at least, a value indistinguishable from zero would be consistent with this hypothesis.

On the other hand, undereducation is sometimes seen as a more stable situation in which a given stock of non-educational capital compensates for schooling deficits. Under this view, educational attainments being the same (and equally inadequate), it appears that preference should be granted to workers with larger endowments of other forms of human capital. Accordingly, the penalty paid by undereducated workers should be lower the higher are their tenure and experience levels, and positive signs would be expected for δ_{ut} and δ_{uc} .

Expectations concerning the sign of the δ parameters are different under the technology-related hypothesis. If a process is taking place by which undereducated workers are gradually being replaced by more qualified individuals, the obsolescence and devaluation of the educational endowments of the former might show up in the form of negative signs for δ_{ut} and δ_{uc} . Employers would tend to shift their investments in training and firm-specific capital to overeducated workers whose educational background provides a better match with the job skills now rendered necessary by technological change, and marginal returns to surplus schooling would be positively correlated with tenure, thus leading to a positive sign for δ_{ot} .

The first set of results reported below deals with our probe of the effects of the interaction terms between overeducation/undereducation and the human-capital variables for the full sample under the mode-based measurement discussed above. These results appear to leave virtually no room for explanations of overeducation/undereducation rooted in the trade-off between different forms of human capital.

A second set of results also reported below probes the same issues, but employs an exogenously-defined measure of overeducation/undereducation. Available in our data set is the worker's skill/qualification level, defined by Portuguese law for the purposes of determination of pay scales. In fact, labor market regulation in Portugal mandates that collective wage agreements negotiated between unions and associations of employers be extended, upon registry by the Ministry of Employment, to all the workers and firms in the relevant occupation or industry, irrespective of union membership status or employer affiliation. Previous work by analysts from the Ministry (Coelho, Soares & Feliz, 1982), taking into account job functional contents requiring training and knowledge, has established a correspondence between qualification level and years of schooling. Drawing upon that work, we are able to define adequate education levels by skill/qualification level and the related measures of over- and undereducation.

The general form of the second set of regressions reported below is

$$\ln Y = \alpha + \mathbf{X}\delta + \mathbf{H}\beta + \mathbf{Z}\gamma + u$$

where α is a constant, \mathbf{X} is a (row) vector of variables related to the overeducation/undereducation issue which includes OVERSCH, UNDERSCH and the six interaction terms, δ is a conformable (column) vector of coefficients, \mathbf{H} is a vector of human-capital and hours-worked variables (ADSCHOOL, TENURE and its square, EXPER and its square, LNHOOURS), β is the vector of coefficients of the variables in \mathbf{H} , \mathbf{Z} is a vector of dummy variables to control for plant size, occupation, industry, geographical location, gender and public ownership, with different contents in the three sets of results, γ is the associated vector of coefficients, and u is a random term.

4. Results

Table 3 provides information on the estimates obtained with the full sample of 23,036 individuals, using our preferred mode-based measure of overeducation/undereducation. Without accounting for possible interaction effects of tenure and experience, marginal returns to schooling adequate for job performance are estimated at close to 10%, in line with previous research for the Portuguese labor market. If differential

Table 3
Selected coefficient estimates, mode-based criterion

Variable	Coefficient	Coefficient estimate
ADSCHOOL	ϕ_a	0.1015 (12.31)
OVERSCH	ϕ_o	0.0430 (21.01)
UNDERSCH	ϕ_u	– 0.0131 (– 1.03)
ADTEN	δ_{at}	0.0022 (5.01)
ADEXP	δ_{ae}	– 0.0010 (– 1.64)
OVTEN	δ_{ot}	0.0017 (13.66)
OVEXP	δ_{oe}	0.0003 (2.55)
UNDTEN	δ_{ut}	– 0.0021 (– 5.36)
UNDEXP	δ_{ue}	0.0001 (0.38)
TENURE	–	0.0099 (5.23)
TEN2	–	– 0.0003 (– 13.18)
EXPER	–	0.0177 (7.23)
EXPER2	–	– 0.0002 (– 16.16)
LNHOURS	–	0.7488 (47.56)

Notes: dependent variable is $\ln Y$. Besides those reported in the table, included as regressors were a constant, three plant-size dummies, four region dummies, 15 industry dummies, five occupation dummies, a gender dummy and a dummy for public ownership. $R^2 = 0.537$. Number of observations: 23 036. In the last column, t -ratios are shown in parentheses.

effects of tenure and experience are allowed, returns are shown to improve marginally, albeit significantly, with the former; this is not the case with the latter, as the coefficient of ADTEN is not statistically significant at the 0.05 level and, in any case, of negligible magnitude.

Returns to schooling in excess of that level required by the job are positive, but lower than those obtained in a job for which educational attainment is fully adequate. More importantly for our purposes, the returns clearly improve with the accumulation of market-originated capital, whether general or firm-specific, as evidenced by the positive and statistically significant estimates for δ_{ot} and δ_{oe} . These results run counter to the view of overeducated workers being in a transient stage moving toward a better job match. Tenure, in particular, is fairly well rewarded, which we take to be strongly suggestive of sizable investments in firm-specific capital by both employee and employer.

Deficit schooling is penalized. The coefficient estimates of UNDERSCH and of the interaction term UNDEXP are not statistically different from zero at the usual levels, but the coefficient of UNDTEN has a strongly significant negative sign. Marginal returns to the schooling investment of undereducated workers do not cease to deteriorate with prolonged tenure with the same employer, a result that cannot be reconciled with a view in which market- and firm-experience compensate for the lack of adequate education.

The estimates of the coefficients on β and γ (the latter not shown, for the sake of brevity) are standard. Tenure-earnings and experience-earnings profiles reveal the

classic concave shape and the hours-elasticity of wages is estimated at around 0.75, again in line with published results for the Portuguese labor market.

In our second set of results, we rely on an exogenous definition of required schooling by skill/qualification level (Coelho et al., 1982) and the implied measure of overeducation/undereducation. For purposes of comparison, Table 4 displays selected information on the results.

The estimate of the coefficient on ADSCHOOL is still close to 10%, as in Table 3. Without accounting for possible interaction effects of tenure and experience, marginal returns to overeducation are positive, statistically significant, and (at around 3%) lower than the returns that could be earned if the educational attainment were fully utilized. Again ignoring interaction effects, marginal returns to undereducation are negative (around – 5%) and statistically significant, unlike the results reported in Table 3.

When interaction effects are taken into consideration, the estimates of δ_{ot} and δ_{ut} obtained under the exogenous definition of overeducation/undereducation, albeit lower in magnitude than those shown in Table 3, are still clearly and significantly supportive of the same hypothesis. That is, marginal returns to overeducation improve with prolonged tenure with the same employer, whereas returns to undereducation deteriorate as tenure increases, a behavior that runs counter to the notion of the substitutability of on-the-job training for education.

Table 4
Selected coefficient estimates, skill/qualification-based criterion

Variable	Coefficient	Coefficient estimate
ADSCHOOL	ϕ_a	0.0998 (39.89)
OVERSCH	ϕ_o	0.0291 (10.79)
UNDERSCH	ϕ_u	– 0.0496 (– 12.57)
ADTEN	δ_{at}	0.0004 (2.73)
ADEXP	δ_{ae}	– 0.0007 (– 6.15)
OVTEN	δ_{ot}	0.0013 (5.65)
OVEXP	δ_{oe}	– 0.0001 (– 0.61)
UNDTEN	δ_{ut}	– 0.0008 (– 4.94)
UNDEXP	δ_{ue}	0.0007 (4.53)
TENURE	–	0.0164 (18.87)
TEN2	–	– 0.0003 (– 12.80)
EXPER	–	0.0146 (16.32)
EXPER2	–	– 0.0002 (– 14.02)
LNHOURS	–	0.7388 (48.54)

Notes: dependent variable is $\ln Y$. Besides those reported in the table, included as regressors were a constant, three plant-size dummies, four region dummies, 15 industry dummies, five occupation dummies, a gender dummy and a dummy for public ownership. $R^2 = 0.566$. Number of observations: 23 036. In the last column, t -ratios are shown in parentheses.

5. Conclusion

We employ Portuguese data to test two competing hypotheses about overeducation and undereducation. According to one hypothesis, undereducation is viewed as the outcome of a process in which market-acquired capital substitutes for insufficient school-supplied qualifications, whereas overeducation is associated with excess schooling but short tenure and experience. Both overeducation and undereducation arise, thus, as situations in which the mix of school- and market-provided human capital is not adequate for the job at hand. A second hypothesis calls upon changes in the technology of production and marketing to explain why some workers end up as inadequately educated for the tasks they are expected to perform; others, at the same time, who hold identical jobs but have more schooling, are perceived to be overeducated.

We experiment with a new method of measuring overeducation/undereducation that rests upon the distribution mode of education by occupations defined at the three-digit level, which we judge to be superior to other data-based criteria. Using that methodology, which we can be fairly confident of avoiding measurement errors, we proceed to decompose the returns to schooling in a way that sheds light on the possible interaction between education, on one side, and tenure and experience, on the other. For purposes of comparison, we present results obtained under a more conventional definition of overeducation/undereducation based upon independent evaluation of schooling requirements by skill\qualification level.

Our findings appear to leave little room for explanations of the overeducation/undereducation phenomenon based on the trade-off between different forms of human capital. The results reveal consistently that a sizable fraction of the (positive) returns to overeducation and of the (negative) returns to undereducation is tenure-dependent. That is, employers tend to value and prize overeducation and at the same time they penalize undereducation. With prolonged tenure, overeducated workers are granted an ascending path of their relative earnings, while undereducated workers will see their relative position eroded.

Available evidence for Portugal thus seems to favor an explanation of overeducation/undereducation that is not centered on the substitutability or complementarity between different stocks of human capital. The hypothesis of technology-induced pockets of overeducation and undereducation is surely consistent with the Portuguese reality, characterized in the last decade by intensive efforts to promote economic growth, modernization of the industrial structure, and the upgrade of educational

qualifications—which are recognizably very low by European Union standards. Future research for economies at a higher stage of economic development, with larger endowments of educational qualifications and more flexible labor market settings, might reveal the extent to which our results are country-specific.

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