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THE CHOICE OF MAJORS AS A SIGNALING DEVICE*

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Abstract

This work analyzes the ability signaling hypothesis using a rich set of data of a homogeneous population –Business and Economics graduates of University X– who share similar occupations in the labor market. After studying three years of a common core curriculum, students must choose between either a Business or an Economics major. The work investigates if the choice of major is employed by the labor market as a signal of ability and of expected productivity, and if this is reflected in differences in the earnings profiles of graduates of each field. Given the detailed nature of the data, we employ an unusually rich measure of ability, namely the grades obtained in the core curriculum.
This work presents multiple evidence in favor of this hypothesis. The evidence is based on seven empirical results, properly derived from a simple theoretical signaling model. The empirical facts support the signaling hypothesis under the assumption that an individual's ability is gradually revealed to the labor market as experience increases.

Keywords: *Signaling, Choice of Majors, Human Capital.*

JEL Classification: *I21, J24, C70, D82.*

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I. Introduction

Since Spence's (1974) influential work, the ability signaling hypothesis has received a great deal of attention from labor economists.[1] This hypothesis states that employees can convey to employers private information about their ability by means of an observable signal. If the cost of obtaining the signal decreases with an employee's ability, employers would rationally interpret the signal as an indication of high ability. The implications of this hypothesis are significant. For example, the empirical association between educational attainment and earnings could be caused by signaling if the former is employed as the ability signal. As a result, schooling and earnings would be associated even if education did not increase labor productivity.

However, testing the signaling hypothesis empirically has proven difficult because researchers have often experienced the asymmetric information problem about employees' abilities in a similar way to employers in the labor market. Thus, the measures of ability employed have been rather limited- such as performance in multiple-choice tests and the extent to which they sufficiently reflect the variety of abilities that are relevant in a population with heterogeneous occupations is debatable at best.[2]

In this study we examine the effects of signaling on the earnings profiles of a relatively homogeneous group of employees –graduates of a particular Economics and Business school– who share similar occupations in the labor market. A significant feature of our work is that, as we shall argue, our measure of ability is more comprehensive than most of the ability measures employed in the literature, being also more directly associated with the abilities used in practice in this particular profession.

We employ a rich set of data of Business and Economics graduates of University X. These graduates had to take a common core curriculum of three years (6 semesters), after which they had to choose a two-year specialization (or major) in either Economics or Business. These majors differ in the types of skills required. While the former emphasizes the development of analytic skills by means of formal and rigorous theoretical models and the teaching of advanced statistical techniques, the latter focuses on the development of practical abilities learned often by means of applied case studies. We investigate whether the choice of major is used by the labor market as an ability signal, and if this is reflected in differences in the profile of earnings of graduates of each field. The ability measure we employ is the average qualification obtained in the three-year common core curriculum. This involves 37 compulsory semester-long courses, such as several courses of calculus, algebra, statistics, business, economics, accounting, human sciences and language.[3] These courses demand different cognitive abilities and employ diverse evaluation methods. Hence, the average performance in the common curriculum is a particularly rich measure of ability because it encompasses a wide variety of abilities. Moreover, performance in the core curriculum depends also on a variety of non-cognitive skills, such as effort, responsibility and motivation, which are also likely to be associated with productivity in the labor market.

We develop a game-theoretical incomplete information model of signaling to formally obtain the testable propositions that are required by the signaling hypothesis in our specific context. The key underlying notion of the empirical analysis is that if labor experience allows employers (or the labor market) to gradually learn an employee's ability, the premium to the signal should decrease with experience, while ability should become more important in explaining earnings as experience increases. In this respect, our empirical analysis share some similarities with some recent contributions in the related literature, such as Ooterbeeck (1992), Tucker III (1986), Farber and Gibbons (1996), Altonji and Pierret (1998) and Lang (2001). Other empirical strategies include Psacharopoulos (1974), who studied the signaling returns to various types of academic qualification. Psacharopoulos (1979) and Riley (1979) examined the returns of the signal by comparing the earnings profiles of groups interested in signaling ability and groups lacking such motivation, namely the self-employed.

Our paper addresses one criticism that can generally be made to the empirical signaling literature: signal-holders and non-holders may end up in occupations with different non-pecuniary characteristics. If this effect is not properly controlled, earnings gaps between signal holders and the rest would not provide a correct measure of the true signaling effect. Our data allow us to address this criticism as follows; nearly half of Economics majors and all Business majors have Business-oriented jobs. By focusing on these individuals we attempt to keep job characteristics and non-pecuniary effects fairly constant across signal holders and non-holders. Under the plausible assumption that a Business major should be more relevant and productive than an Economics major in a business-oriented job, observing an earnings premium in favor of Economics majors should be regarded as evidence of ability signaling.

The rest of the work is structured as follows. Section two develops the game theoretical model of signaling from which the testable hypothesis are derived. Section three describes the data employed and discusses some stylized facts. Section four reports the empirical results concerning the hypothesis derived in section two. Finally, section five concludes.

II. A Simple Signaling Model

Suppose there are many identical risk-neutral, price-taking firms. They hire employees to maximize their expected benefits, $E(\pi)$. There is a single employee who must send a signal $S = \{B,E\}$ before entering the labor market, where B and E stand for Business and Economics majors, respectively. The employee can be of different types, depending on his ability and his pure preferences for B and E. Let $\theta \in [\underline{\theta}, \bar{\theta}]$ denote the employee's ability level, which determines his productivity when working for any of the firms. Let $\varepsilon \in [\underline{\varepsilon},\bar{\varepsilon}]$ denote the employee's relative preference for B and E, such that $\varepsilon > 0$ indicates that the employee prefers B to E, and $\varepsilon < 0$ indicates that

E is preferred to B. Accordingly, the employee's type is denoted by the pair (θ, ε), which is privately known by the employee. The employee's type is drawn from the joint density function $f(\theta,\varepsilon)$, which is common knowledge, where $0 \leq \underline{\theta} < \bar{\theta} < \infty$, and $-\infty < \underline{\varepsilon} < \bar{\varepsilon} < \infty$. We assume that for all possible ability levels, employee's types are, on average, indifferent between signals B and E, such that $E(\varepsilon|\theta) = 0$. We assume also that there does not exist a relationship between ability level and the preferences for B and E, such that $Cov(\varepsilon, \theta) = 0$. Lastly, we assume that the variance of preferences are similar for employee types with different abilities, that is, $Var(\varepsilon) = \sigma^2$.

The game's sequence of play is as follows:

1. Nature draws the employee's type, that is, a level of ability θ and a preference parameter ε from the common knowledge joint density function $f(\theta,\varepsilon)$.
2. The employee privately observes his ability θ and preferences ε, and then chooses a signal, $S = \{B,E\}$.
3. Firms observe the signal S (but neither ability θ nor preference ε) and make earnings offers W_S.
4. The employee accepts or rejects the highest earnings offer.

For simplicity we assume that choosing signal B or E before entering the labor market does not modify the productivity of the employee. The cost of choosing signal S is $C(S,\theta)$, which is a continuous function in θ. We assume that $C(E,\theta) - C(B,\theta) > 0 \; \forall \; \theta$, so that E is more costly than B for all employee types. This assumption implies that, for all ability levels, the Economics major is more demanding than the Business major in terms of, say, effort and study hours. This assumption shall be empirically justified in the next section. We assume that the relative cost of sending signal E vs. B decreases with ability θ, such that $\left[\frac{\partial(C(E,\theta)-C(B,\theta))}{\partial\theta} < 0\right]$.

The employee optimally chooses between B and E taking into account his pure preferences, the relative cost and the expected earnings of signals B and E. Let $\rho \in [0,1]$ be a parameter that measures the importance of the earnings gap between signal E and B relative to his preferences and the relative costs. If $\rho = 0$, the employee places no value on the earnings differential in his choice of field (although he might be fully aware of the earnings differentials between E and B). If $\rho = 1$ the employee internalizes fully the earnings differential in his decision. Parameter ρ can be interpreted either as a measure of how important is to the employee income relative to other considerations, or how reliable is the information available to the employee regarding the expected earnings of choosing B or E. Accordingly, the employee would rationally choose field E if $\rho(W_E - W_B) > C(E,\theta) - C(B,\theta) + \varepsilon$.

Since this is a dynamic game of incomplete information, the appropriate solution concept is a Perfect Bayesian Equilibrium where:

- For each signal $S = \{E,B\}$, firms should form a conjecture $\mu(\theta,\varepsilon|S) = \frac{f(\theta,\varepsilon)}{F(\theta,\varepsilon)}$, where $F(\theta,\varepsilon)$ is the joint probability distribution function specifying the

probability that the employee has ability θ and preferences ε, where $\sum \mu(\theta, \varepsilon \mid S) = 1$. Whenever possible, $\mu(\theta, \varepsilon \mid S)$ should be derived from Bayes's Rule. From μ, the expected productivity $E(\theta|S)$ can be obtained.[4]

- For each S, firms maximize their expected utility given their conjectures about the type of the employee conditional upon S, $\mu(\theta, \varepsilon \mid S)$. As it has been customary in the ability signaling literature, we assume that competition for employees among the firms extinguishes profits, such that $\pi = 0$. This implies that earnings should be equal to expected productivity, that is, $W_S = E(\theta|S)$.
- For each $\theta \in [\underline{\theta}, \bar{\theta}]$ and $\varepsilon \in [\underline{\varepsilon}, \bar{\varepsilon}]$ the employee must choose his optimal signal S^* anticipating the firms' equilibrium wage offer $W_S = E(\theta \mid S)$.

2.1 Full information benchmark

As a benchmark, let us consider the case where the employee's type (θ, ε) is perfectly observed by employers.

Result 1. If the employee's type (θ, ε) is observed by employers there is a unique Perfect Bayesian Equilibrium, where $W = \theta$, and where signal B is chosen only if $C(\bar{\theta},E) - C(\bar{\theta},B) < \varepsilon$, and E would be chosen otherwise.

This result establishes a trivial fact. If ability is directly observable, competition among firms would make earnings to be fully driven by ability. Therefore, conditional upon an ability level there would be no earnings gap between graduates of both majors. Accordingly, the choice of major would be driven by cost and preferences considerations only.

2.2 Incomplete information

In this case the employee's type (θ,ε) is not perfectly observed by employers.

Result 2. The continuity of the preferences, ability and cost function guarantees a Perfect Bayesian Equilibrium, such that $(W_E = E(\theta|E)) > (E(\theta|B) = W_B)$, and;

$$(W_E - W_B) - E(\theta|E) - E(\theta|B)) = 0 \tag{1}$$

In a Perfect Bayesian Equilibrium under incomplete information, firms offer wages equal to expected productivity conditional upon the observed signal, $W_B = E(\theta|B)$ and $W_E = E(\theta|E)$, derived from Bayes's Rule. The employee chooses the major that maximizes his utility level. An equilibrium will exist if $W_E - W_B = E(\theta|E) - E(\theta|B)$, where a fixed point exists, as shown in Figure 1 (point E). It is direct to verify that in an equilibrium where some employee types optimally choose B and the remaining ones choose E we have necessarily that $E(\theta|E) > E(\theta|B)$. Although some employee types in B can have higher ability than some employee types in E as a result of a

strong pure preference for B, in equilibrium, the expected ability of types in E is higher than in B.

Let us consider the case where $W_E - W_B = C(\bar{\theta}, E) - C(\bar{\theta}, B) + \varepsilon + \delta$, where $\varepsilon \to \underline{\varepsilon}$ and $0 < \delta \to 0$. In this case, for employee types with similar preferences ($\underline{\varepsilon}$) and ρ only a type of the highest ability will choose E. The firms' Bayesian expectations of productivity are $E(\theta|E) = \bar{\theta}$ and $E(\theta|B) \cong E(\theta)$. Since the highest ability type has smaller cost differentials between fields, we have that $\bar{\theta} - E(\theta) > C(\bar{\theta}, E) - C(\bar{\theta}, B) + \underline{\varepsilon}$, which yields point Q in Figure 1.

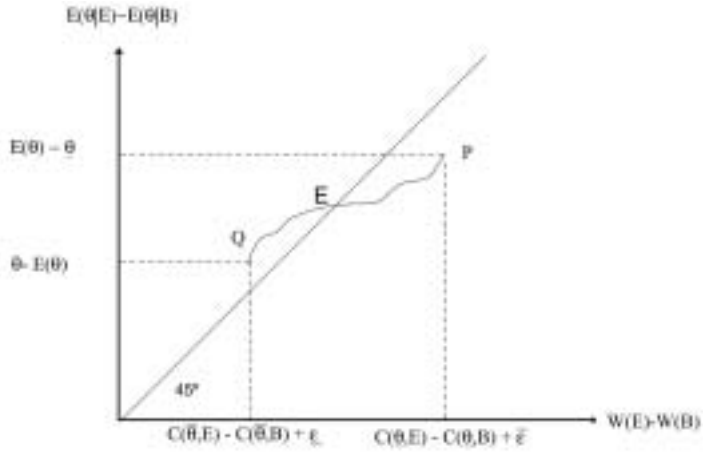
Let us consider the case where $W_E - W_B = C(\underline{\theta}, E) - C(\underline{\theta}, B) + \varepsilon - \delta$, where $\varepsilon \to \bar{\varepsilon}$ and $0 < \delta \to 0$. In this case, for employee types of similar preferences ($\bar{\varepsilon}$) and ρ only a lowest ability type will choose B. The firms' Bayesian expectations of productivity will be $E(\theta|E) \cong E(\theta)$ and $E(\theta|B) = \underline{\theta}$. Since $W_E - W_B \leq W_{\bar{\theta}} - W_{\underline{\theta}}$ it is necessarily the case that $E(\theta) - \underline{\theta} < W_{\bar{\theta}} - W_{\underline{\theta}}$, which is illustrated by point P in Figure 1.

The continuity of the preferences, ability and cost function guarantees at least one Perfect Bayesian Equilibrium.

In any Perfect Bayesian Equilibrium there will be employees types with different abilities and preferences mixing in a certain field, and at least one employee indifferent between the two signals for whom equation 1 holds. Note that, in contrast with the full information benchmark, earnings are now fully driven by the choice of major (E or B), and not by the unobserved ability θ. It is this contrast between the extreme complete vs. the incomplete information situations that provides the

FIGURE 1

EQUILIBRIUM



theoretical foundations for the empirical testing of the signaling hypothesis, as we shall discuss in the next section.

The model can be easily modified to illustrate some cases of interest. In particular, suppose that the employee is not willing or does not have enough information to base his choice of major on future earnings, such that $\rho = 0$. In this case the choice of signal is driven only by preferences and relative costs. Under these assumptions the model provides equivalent results; the most skilled types would still choose Economics, although only for preferences and cost considerations.[5] It is again the case that Economics field would be rewarded a higher wage than Business, even though the equilibrium earnings gap does not play any role in the employee's choice between Business and Economics. This illustrates that the sorting of different abilities into fields E and B does not need to be the result of *deliberate* signaling by the employees. If preferences are not observed by the analyst, it is impossible to disentangle sorting driven by expected earnings from sorting driven by preferences and cost considerations. However, in both models, wages must reflect the differential sorting of abilities into fields E and B, which necessarily generates an earnings gap between both fields.

2.3 Testable hypothesis and empirical strategy

The theoretical model provides various testable hypothesis that are required by the signaling hypothesis. First, it must be established that the Economics major is indeed more demanding –and therefore more costly– than the Business major. Second, if incomplete information exists, high ability students should tend to sort themselves into the Economics major, while lower ability students should tend to choose the Business major. Accordingly, there must be a positive statistical relationship between ability and choice of the signal. Third, the latter implies that, as long as there is asymmetric information about employees' abilities, a competitive labor market must reward each signal differently such that there must be an earnings premia for Economics graduates, that is, $W_E > W_B$. Finally, the Results 1 and 2 of the theoretical model suggest the last testable hypothesis; when ability is unknown, earnings should be a function of the signal only. However, when ability is observable, earnings should depend only on ability. Under the assumption that the employer (or the labor market) gradually learns an employee's true ability as he gains labor experience, earnings should be more strongly determined by ability as experience increases, while the premium to the signal should tend to vanish. More formally, consider the following equation:

$$W_i = \beta_1 + \beta_2 Experience_i * Field_i + \beta_3 Experience_i * Grades_i + \gamma X + \varepsilon \quad (2)$$

where W_i is employee i's earnings, Experience is the number of years of experience of employee i, Field is a dummy variable equal to 1 if the employee chose the Eco-

nomics major, Grades is an ability measure equal to the grades obtained by the employee in the Core curriculum, X is a vector of other relevant variables and ε is an error term distributed $N(0,\sigma^2)$.

As explained above, the asymmetry of information about ability between employees and employers is likely to be particularly severe during the first years of an employee's working experience. Accordingly, the earnings of young employees is likely to be determined mainly by his signal, and not by his largely unobserved ability. As the employee gains working experience, employers gradually begin to observe his ability. Accordingly, the earnings of employees with many years of experience are likely to be determined mostly by the true ability, and not by their signal, which must have faded as the asymmetry of information about their ability became increasingly less severe. As a result, as experience increases, the signal must become less important and ability should become more important in explaining earnings. Hence, we should expect $\beta_2 < 0$ and $\beta_3 > 0$ in equation (2).[6]

Finally, both interactive effects would be visible even in a context where employees change jobs during their labor lifetime, since their curriculum vitae and the references from previous employers would provide some information to the new employers about the employees' performance and abilities in previous jobs.

III. Data

The dataset comes from a follow-up survey carried out by the Economics Department of University X in 1999, one of the largest in the country. The survey was responded by a sample of Business and Economics majors graduated between 1988 and 1998. The total number of interviewees is 322, 190 and 132 Business and Economics graduates, respectively. These samples are representative of their respective populations. The survey contains detailed information of each employee's performance in the labor market, as well as job and employer characteristics. This data base has been merged with data containing information about each employee's socioeconomic and school background coming from CASEN survey and the SIMCE test.[7] In addition, University X has provided detailed data about each graduate's academic performance throughout their undergraduate studies.

Table 1 presents some descriptive statistics about the graduate's characteristics, their academic performance at University X and some aspects of their performance in the labor market. The first three columns correspond to Business graduates (we report statistics for sex too), the following three columns to Economics graduates and the last two columns report the results for the combined population and mean-difference test between both majors.

The data shows that most graduates come from private schools and from higher socioeconomic backgrounds (68 percent and 68 percent respectively, eighth column). However, differences between fields are not statistically significant.

Table 1 does suggest that Economics graduates hold higher average grades than Business graduates, this difference being larger for women. However, these grades include the courses studied by each field and the courses of the Core Curriculum,

TABLE 1

GENERAL STATISTICS

	B			E			Total	Dif-Test
	Women	Men	Total	Women	Men	Total		B v/s E
Background Data								
% Men			0.63			0.70	0.66	−1.36
% High SES School	0.74	0.67	0.69	0.74	0.66	0.65	0.68	0.42
% Medium SES School	0.22	0.26	0.25	0.26	0.28	0.27	0.26	−0.55
% Low SES School	0.04	0.07	0.06	0.00	0.06	0.08	0.06	0.18
% Private School	0.76	0.68	0.70	0.77	0.58	0.64	0.68	1.47
% Subsidized School	0.10	0.18	0.15	0.08	0.25	0.20	0.17	−0.99
% Municipally School	0.14	0.14	0.15	0.15	0.17	0.16	0.15	−0.42
University Data								
Grades	5.08	4.90	4.96	5.25	4.91	5.01	4.98	−0.49
PAA	693.09	697.40	695.77	702.78	691.41	694.84	695.39	0.17
% receiving Financial aid	0.33	0.41	0.38	0.33	0.45	0.41	0.39	−0.65
% interrupted previous studies	0.11	0.19	0.16	0.08	0.10	0.09	0.13	1.69
Grades in Core Curriculum	4.92	4.86	4.88	5.11	4.99	5.03	4.94	−3.85
Major Grades	5.00	4.89	4.93	5.06	4.94	4.97	4.95	−0.92
% Top Mark in Finals	0.93	0.76	0.82	0.67	0.83	0.78	0.81	0.95
Labor Market Data								
% Postgraduate Studies	0.19	0.19	0.19	0.41	0.45	0.44	0.29	−4.96
Earnings (Ln)	13.89	14.29	14.15	13.96	14.13	14.08	14.12	1.09
Experience	6.64	6.47	6.52	6.48	6.64	6.58	6.56	−0.16

PAA is a yearly national multiple-choice test required to apply to a University degree in Chile.

such that their comparability is inappropriate. However, the difference in favor of Economics graduates is larger and statistically significant for the grades in the Core Curriculum. This could be suggesting that, under the assumption that grades are a good proxy of ability, the Economics major recruits on average the more skilled students, which provides some support for the first testable hypothesis.

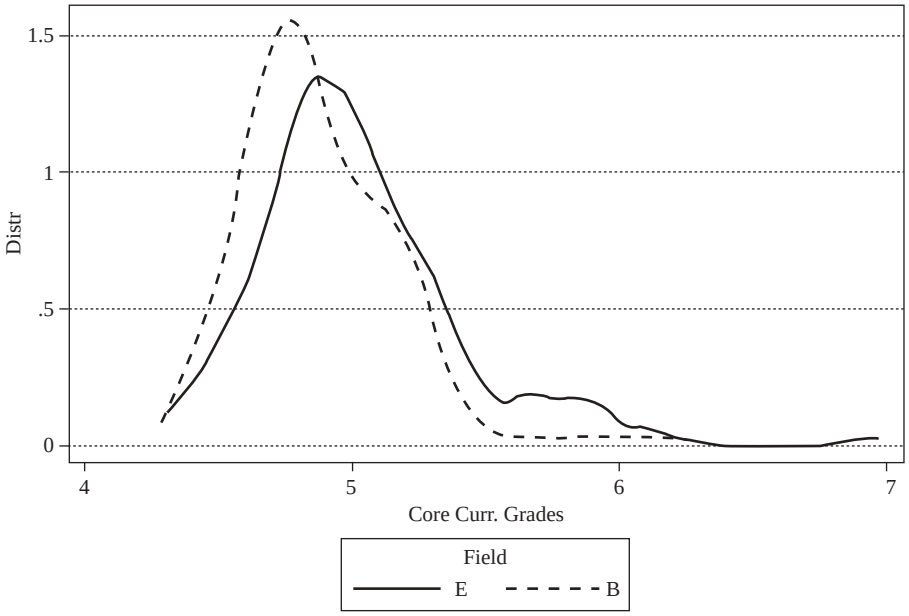
Figure 2 shows the kernel estimates of the distribution of the grades obtained in the Core Curriculum grades for each field.

Figure 2 shows indeed that the Economics graduates have, on average, higher ability than Business graduates, which is consistent with the mean difference test reported in Table 1. According to the model in Section II, this pattern of self-selection of students according to their ability should be driven by a combination of expected differential earnings between both fields, relative costs of studying Economics vs. Business, as well as pure preferences for both fields.

Table 1 shows that the average field grades are smaller than Core Curriculum grades for Economics graduates, but this is not the case for Business graduates. This suggests that the courses of the Economics major have a higher level of difficulty than courses of the Business major, which provides empirical support for the as-

FIGURE 2

KERNEL ESTIMATION



sumption made in the model, namely that the Economics major is more costly than the Business major. This issue is addressed in the next section in more detail.[8]

The labor market data reported in Table 1 indicates that the average level earnings is higher for Business graduates, although not statistically significant. Note however, that business graduates also have higher labor experience than economics graduates.[9]

In order to study the professional development of graduates, they were divided according to their major and the areas where they work. In the follow-up survey respondents were requested to define their current work as "fundamentally B", "fundamentally E" or a "mixture of B and E". For this last category graduates had to provide percentages of how important each field was. Four groups were defined, namely Business graduates who have Business-oriented jobs (B/B), Economics graduates who have Economics-oriented jobs (E/E), Business graduates who have Economics-oriented jobs (B/E) and Economics graduates who have Business-oriented jobs (E/B).

Table 2 summarizes the distribution of graduates by major and type of job.

Table 2 shows that 93 percent of Business graduates have jobs related with this area. For Economics graduates the situation is different; half of them carry out jobs related with their area and the other half of them have jobs related to Business. Why

TABLE 2

GRADUATES DISTRIBUTION

	Total	Type of Job	
		B	E
Major			
B	177	0.93	0.07
E	127	0.48	0.51

TABLE 3

SUBGROUPS STATISTICS

	E/E	B/B	E/B	Other	Total	Dif-Test B/B v/s E/B
Grades	5.17	4.99	4.84	4.84	4.98	1.39
Grades in Core Curriculum	5.10	4.88	4.98	4.88	4.94	−2.26
Field Grades	5.12	4.93	4.84	4.93	4.95	1.98
% Postgraduate Studies	0.49	0.20	0.37	0.20	0.29	−2.68
Earnings(Ln)	13.97	14.13	14.19	14.29	14.12	−0.79
Older Cohorts Earnings	14.41	14.48	14.32	14.52	14.43	1.82
Younger Cohorts Earnings	13.76	13.91	14.01	13.99	13.89	−0.90
Experience	5.42	6.70	8.02	5.29	6.56	−3.07

The subgroup "Other" includes Business graduates who have Economics-oriented jobs and it also includes the employees that did not report type of jobs and therefore they were not classified. The Older Cohorts correspond to graduates of years 1988-1991 and the younger cohorts those among years 1991-1998.

do half of Economics majors end up in jobs related with Business? The theoretical signaling model delivers a possible answers to this.

Table 1 indicated that Economics graduates receive lower earnings than Business graduates in spite of presenting higher grades in the Core Curriculum. However, once we analyze some statistics considering the subgroups defined in Table 2 new elements arise, which endorse the signaling hypothesis.

Economics graduates that work in Economics present smaller earnings in spite of having higher grades and more postgraduate studies, which can be the result of nonpecuniary differences between Economics and Business areas. However, when we focus only on graduates working in Business areas we observe indeed that Economics graduates (E/B) present higher earnings. This could be suggesting the existence of an earnings premium to having studied the Economics major. The earnings premium suggest the existence of signaling, which is more formally studied in the next section.

IV. Results

4.1 Relative difficulty of majors E and B

As argued earlier, employing the choice of major as a signaling device requires major E to be more demanding than B. Some evidence of this fact has been already provided in the previous section. However, in this section we report additional evidence, which is based on the student's subjective assessment of the relative difficulties of majors E and B. These are measured by means of a regular academic survey responded by students for each course every semester.[10]

Table 4 shows the averages obtained for two questions of the survey[11] carried out in the semesters Autumn 2002 and Spring 2002.[12]

In the Autumn 2002 survey each student was asked to estimate the weekly average number of study hours devoted to each course, excluding time spent in lectures. The survey also asked them to rank each course's level of difficulty in comparison to other courses using a five-point scale.[13]

From Table 4 it follows that students perceive the courses of the Common Core Curriculum related to Economics as more difficult than those related to Business. The students also allocate more study hours to courses related to Economics. Moreover, Economics students dedicate more study hours than the students of Business in

TABLE 4

REGULAR ACADEMIC SURVEY

	Business	Economics	T-Test	Total
2002 Autumn				
Core Curriculum				
Weekly Hours	2.1	2.7	−3.2	2.5
Difficulty Level	3.5	4.0	−3.1	3.8
Observations	15.0	31.0		46.0
Field				
Weekly Hours	2.6	2.7	−0.92	
Difficulty Level	3.4	3.6	−0.78	
Observations	25.0	9.0		
2002 Spring				
Core Curriculum				
Weekly Hours	3.2	3.8	−3.0	3.6
Difficulty Level	3.3	3.9	−2.9	3.7
Observations	16.0	25.0		41.0
Field				
Weekly Hours	3.3	3.7	−1.8	
Difficulty Level	3.3	3.7	−2.1	
Observations	28.0	9.0		

their respective fields. Considering that Economics students have, on average, more ability as shown earlier, the latter can be regarded as further evidence that the Economics major is more demanding and hence costlier than the business major. In conclusion, all these facts support the assumption made in the theoretical model that the Economics major presents higher costs in terms of difficulty than the Business major.

4.2 Sorting of abilities into signals E and B

The testable hypothesis developed in Section II require the existence of a positive relationship between the signal and graduates' ability. Table 5 presents probit estimates of the probability of studying the Economics major incorporating our ability measure, Grades in Core Curriculum, as a control variable.[14]

The effects of common core curriculum grades on the probability of choosing the Economics major is statistically significant[15]. Hence, students with better academic performance have a higher probability of choosing the Economics major. Also, we incorporated as control the gender variable and two dummy variables equal to 1 if the school of origin is private and of high socioeconomic status, respectively. The small magnitude of the year of entry indicates the stability of preferences toward fields across time.

TABLE 5

PROBIT ESTIMATION

	1 Probit(E=1)	2 Marginal(E=1)
Grades in Core Curriculum	0.962** [4.03]	0.371** [4.03]
Gender	0.258 [1.62]	0.098 [1.62]
High SES School	0.614 [1.62]	0.227 [1.62]
Previous Studies (=1)	−0.351 [−1.56]	−0.129 [−1.56]
Private School (=1)	−0.672 [−1.75]	−0.261 [−1.75]
Year of Entry	−0.001 [−0.40]	0.000 [0.40]
Constant	12.776 [0.29]	
Observations	316	316
Pseudo-R2	0.085	0.085

Absolute Values of t-test in brackets.
* significant at 5 per cent; ** significant at 1 per cent.
Previous Studies is a dummy variable equal to 1 if the graduate had previous studied other program courses.

This result provides robust evidence of one of the key testable implications of the model, namely that individuals of higher ability, represented for higher Core Curriculum grades, will sort themselves into the Economics major with higher probability. If so, the ability of an economics major expected by the labor market should be higher than the expected ability of a business major.

4.3 Earnings profiles of E and B graduates

The third outstanding aspect of the signaling model is the response of the labor market to the signal sent by graduates. Diverse methodologies have been used in literature for detecting empirically the presence of signaling. These methodologies, in general, have not directly incorporated an ability measure. Psacharopoulos (1979) proposes to compare the returns of the signal for groups with incentives to signaling ability and groups lacking such motivations.[16] Another methodology consists on analyzing the evolution of the signal return as labor experience increases. The signaling hypothesis would predict that the signal should be made less important, both in magnitude and in statistical importance, in explaining earnings as employees acquire more labor experience (Tucker, 1986 and Cohn *et al*., 1987). Lang (2001) examines the returns to college majors, job types and their interactions, identifying if the return to college mayors is explained by specific or general human capital or signaling. He studies the evolution of the signal return as labor experience increases. Finally, some authors analyze convergence of earnings for the different signals, as labor experience increases (Oosterbeeck, 1992; Groot and Oosterbeeck, 1994).

These methodologies do not control for ability identifying the return to the signal only by focusing on the evolution of earnings as employees acquire labor experience. Table 6 presents results of applying the third approach to our data. The first and second column present robust estimates between earnings and experience for Economics and Business graduates, respectively.

In both majors experience exhibits a concave profile consistent with existent literature. Economics graduates presents higher earnings when they have lower post-

TABLE 6

SIMULATED RESULTS

Field	(E)	(B)
Postgraduate Experience	0.105*	0.217**
	[2.36]	[4.51]
Postgraduate Experience2	−0.001	−0.008*
	[0.15]	[2.24]
Constant	13.402**	13.145**
	[140.91]	[98.53]
Observations	116	174
R^2	0.38	0.39

T-test in brackets; *significant at 5 per cent; **significant at 1 per cent.

graduate experience. However, the Economics graduates's earnings grow to a smaller rate than Business graduates's earnings. This is the standard results predicted in the empirical signaling literature. However, the previous estimates control for experience alone, and the earnings differentials observed at the beginning of the labor cycle can be due to aspects other than signaling.

We next follow closely Altonji and Pierret (1998) and Farber and Gibbons (1996). We incorporate in the estimates some controls that capture educational aspects, such as postgraduate studies and top marks in finals. Also, we use controls by social origin factors as municipality per capita income and two dummy variables that take the value 1 if the secondary school was of high socioeconomic level and if graduate has either Basque or Non-Spanish European origin,[17] which is intended to capture a return to ascendancy.

The estimates reported in Table 7 were carried out considering all individuals of the sample (columns All) and individuals that work in Business (columns B,E/B) alone, also we report three different specifications.[18] The first specification does not directly include experience as independent variable, being included only in interactive forms (columns 1 and 2). The second specification include the total experience together with its interactive forms (columns 3 and 4). Finally, the third specification (column 5) included MBAs instead of postgraduate studies.[19]

In all cases men have significantly higher earnings than women (the interactive variable gender time experience is not statistically significant.). Total experience presents the typical signs observed in earnings equations, namely a concave profile, being statistically significant.

The coefficient of the interactive variable *Experience*Field* is negative, indicating that the return to experience is higher for Business graduates. Also, the coefficient of the interactive variable *Core Curr. Grades * Post S.Exp* is positive, indicating that ability becomes more important in explaining earnings when the experience years increase. These results would endorse the signaling theory; labor market experience gradually reveals ability information to the labor market. As the asymmetric information problem is reduced, the premium to the signal decreases, while true ability becomes observable and more directly rewarded in the labor market.

Next, we carried out predictions of the earnings considering the second specification[20] (column 5) shown in Table 7. Also, we considered only graduates that have fundamentally Business oriented jobs, that is sub groups E/B and B/B.[21]

Figure 3 shows the obtained predictions for individuals in sub groups E/B and B/B with the same characteristics.[22]

Economics graduates earn on average more at the beginning of the working cycle. Once the employees's ability is completely revealed the earnings differentials should represent the ability difference. In Section II we showed evidence that Economics graduates presented higher ability levels, measure as Common Core Curriculum grades. This would suggest that the Economics and Business earning profile should totally converge, just as it shows in Figure 3. However, we had hoped that the convergence will be carried out at a higher level of experience. This could not be happening for the following reasons: First, the courses studied by Business graduates could be providing knowledge valued in the market business-oriented jobs. Second, the Common

TABLE 7

RESULTS

	1 (ALL)	2 (B,E/B)	3 (ALL)	4 (B,E/B)	5 (B,E/B)
Gender	0.340***	0.393***	0.332***	0.388***	0.388***
	[7.52]	[7.34]	[7.33]	[7.19]	[7.22]
Total Experience			0.049**	0.046	0.042
			[2.12]	[1.50]	[1.36]
Total Experience2			−0.002**	−0.002*	−0.02*
			[2.52]	[1.94]	[1.74]
Post S.Experience*Field	−0.015**	−0.019**	−0.015**	−0.019**	−0.18**
	[2.37]	[2.57]	[2.31]	[2.52]	[2.51]
Core Curr. Grades*Post S. Exp.	0.021***	0.022***	0.018***	0.019***	0.019***
	[15.24]	[11.99]	[6.59]	[5.52]	[5.86]
Top Mark in Finals	0.111*	0.167***	0.120**	0.172***	0.17***
	[1.92]	[2.62]	[2.05]	[2.62]	[2.84]
Postgraduates Studies	0.115**	0.130**	0.089	0.107	
	[2.26]	[2.07]	[1.64]	[1.61]	
High SES school	0.138***	0.094*	0.140***	0.094*	0.089
	[2.95]	[1.74]	[3.00]	[1.73]	[1.61]
Municipality Average Income	0.001***	0.001***	0.001***	0.001***	0.001***
	[2.87]	[2.68]	[2.82]	[2.67]	[2.65]
Vaseur	0.070**	0.081**	0.072**	0.079**	0.072**
	[2.45]	[2.38]	[2.46]	[2.29]	[2.00]
Private Firms	0.136***	0.162***	0.117**	0.146**	0.118**
	[2.70]	[2.66]	[2.26]	[2.35]	[2.00]
Constant	12.752***	12.658***	12.649***	12.550***	12.586***
	[134.63]	[111.67]	[118.15]	[93.35]	[95.83]
MBA					0.136
					[1.50]
Observations	286	213	283	211	211
R^2	0.56	0.57	0.56	0.57	0.57

T-test in brackets; *significant at 10 per cent, ** significant at 5 per cent; *** significant at 1 per cent. Estimation Method: Ordinary Least Square with corrections for heteroscedasticity.

Core Curriculum grades could not be capturing all the abilities that are valued by the market. Third, there can be small non-pecuniary differences between Economics and Business graduates even though they all have business-oriented jobs.

There is evidence that the courses studied by Business graduates provided knowledge and skills valued in the market in business-related jobs. The survey asked all students to assess the quantity and quality of knowledge learned in different areas developed in theirs majors. Also, the survey asked all students to identify the level knowledge used in their jobs for the same areas. Table 8 shows the average difference between the knowledge actually learned and used at work for Economics and Business graduates in business-related jobs.

FIGURE 3

PREDICTION EARNING

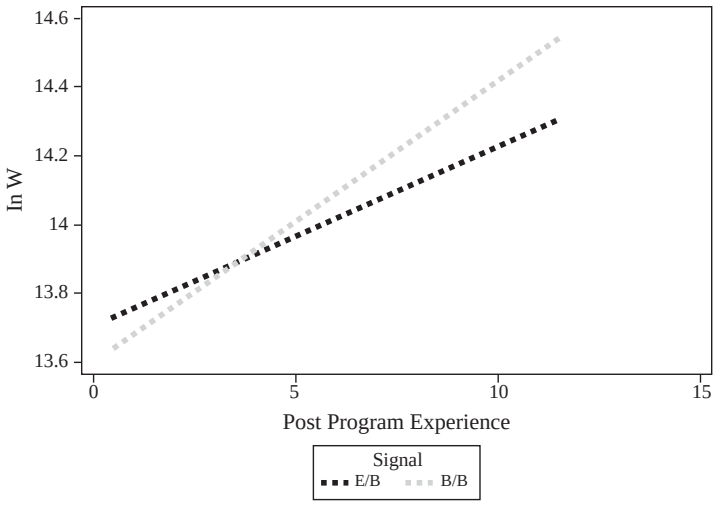


TABLE 8

USED SKILLS

	Areas		Deficit
	B/B	E/B	Test B/B vs E/B
General Administration	0.25	0.33	–0.59
Human Resources	0.12	0.57	–2.50
Marketing	0.20	0.48	–1.59
Accounting	0.22	0.22	–0.02
Finances	0.16	0.58	–2.97
Mean Deficit	0.19	0.45	–2.75

Economics graduates presented higher deficit in all outstanding areas for business-oriented jobs. This would suggest that the courses studied by Business graduates provided knowledge and skills valued in the market, which should provide a wage advantage to B-holders relative to economists, which is independent of the signaling hypothesis.

4.4 First-job search duration

The last piece of evidence that we provide in support of the signaling hypothesis is related to differences in first-job search duration between E vs. B graduates. If the hypothesis of signaling is empirically true, one would expect that, after graduation, E graduates should be more rapidly employable than B graduates because they are expected to have, on average, higher ability.

Table 9 presents evidence in favor of this conjecture. Table 9 reports the mean search duration time (in months) for E and B majors. The evidence shows that E majors have statistically shorter search times than B majors. Moreover, E majors who have a B-job also obtained their first jobs statistically faster that B majors.

TABLE 9

JOB SEARCH DURATION
(In months)

Time Searching First Job					Test B/B vs E/B	Test E vs B
B/B	E/E	E/B	Others	Total		
3.03	1.45	2.91	2.76	2.69	2.01	−2.16

In conclusion, although the evidence in Table 9 is not directly related to earnings differentials between E and B graduates, it should be regarded as additional supporting evidence of the signaling hypothesis.

V. Conclusions

This work has provided multiple evidence in favor of the ability signaling hypothesis. The main distinctive features of this work are the nature of the measure of ability and the signal employed by employees.

Various testable hypothesis derived from a formal game-theoretic model of signaling were empirically validated; the signal is indeed costly to achieve, and accordingly it is chosen mainly by high ability individuals, for whom the signal is relatively less costly to achieve. The signal is associated with a premium, which decreases with labor experience. This is consistent with the notion that experience gradually reveals ability to the labor market.

The results suggest that the effect of signaling is sufficiently important as to compensate the differences in productivity associated with both fields. In fact, Economics graduates who work in area business-oriented jobs earn more than Business graduates working in the same area to the beginning of the labor cycle. This is important because one would expect that studying a Business major is more directly relevant than studying an Economics major in a Business related job.

An aspect that remains open for future research is whether the choice of field is deliberately a response to expected earnings.[23] Although this is certainly plausible, the theoretical model suggests that our empirical results are observably equivalent to a situation where students are not concerned with future income.

However, some stylized facts support the idea that signaling is indeed deliberate; approximately 50 percent of Economics graduates hold jobs related to Business. Why do some students choose the Economics major, which is more costly if they expect to have a job related to Business? This is particularly puzzling considering that Economics is actually more demanding, and also that studying Business is expected to be more directly relevant than the Economics major in a business-related job. The deliberate intention of signaling ability of at least part of the student population stands out as a plausible answer to the puzzle.

The methodology followed in this work can be employed to examine other possible signals of ability, for example postgraduate studies. Also, similar works can be developed for other labor market niches, possibly involving other professions.

Notes

1 See for example the surveys of Willis (1986), Weiss (1995) and Jaeger and Page (1996).

2 For example, many studies just do not use any ability measure. Other studies have employed as an ability measure the results in multiple choice tests, such as the Armed Forces Qualifying Test (AFQT). However, these measures have been criticized mainly for two reasons. First, these measures are not able to measure satisfactorily the abilities that are important in the labor market. Second, if these measures were appropriate, these would be requested and even measured by the same employers due to the low cost of implementation of corresponding tests.

3 Eight and nine Core Curriculum courses are related directly with Economics and Business mayors, respectively. The other twenty Core Curriculums courses do not have direct relation with majors.

4 More formally, $E(\theta|B) = \int_{\underline{\theta}}^{\theta^*}\int_{\underline{\varepsilon}}^{\bar{\varepsilon}} \theta\mu(\theta,\varepsilon \mid B)d\theta d\varepsilon$ and $(\theta \mid E) = \int_{\theta^*}^{\bar{\theta}}\int_{\underline{\varepsilon}}^{\bar{\varepsilon}} \theta\mu(\theta,\varepsilon \mid E)d\theta d\varepsilon$, being θ^* the critical level of ability corresponding to the employee type that is indifferent between fields B and E.

5 This effect would be stronger if the assumption that higher ability types have relatively stronger preferences for E, that is, $Cov(\theta,\varepsilon) < 0$ were made.

6 This part of our methodology is similar to Farber and Gibbons (1996) and Altonji and Pierret (1998), who also incorporate interactive variables of the signal and ability with working experience.

7 The National Socio-Economic Characterization Survey (Casen) has been carried out for the Planning Ministry (Mideplan) since 1985. This is the most important socioeconomic study carried out in Chile. All data related to poverty, income distribution, access to social services and related issues, used in the country is produced by this Survey. The CASEN covers a large sample (around 60,000 households surveyed in the last version), which is representative for around half of the 365 communes that make up the country. It is carried out every two or three years. The SIMCE is a national test designed to assess students' and schools' academic performance.

8 Also, this would explain the insignificance statistic of the program grades between fields.

9 Note also that 30 percent of graduates have made some postgraduate studies, there being some important differences across majors.

10 We analyzed the results of the academic evaluation surveys carried out for Economics and Business Faculty of University X. This survey interviews asks all students to assess the difficulty level and acting of professors and assistants of each course, ranging from 1 to 4.

11 We report the results of the evaluations for the courses of the Core Curriculum and field. Also, we identified the Core Curriculum courses that have related with either Economics or Business and report the result for those groups.

[12] Is not possible to carry out a pool with the two academic periods since the questions employed are not completely comparable.
[13] In the Spring 2002 survey, students were asked them to rank from 1 to 5 the courses according to the weekly hours that they devoted in comparison to other courses.
[14] Tests of normality, orthogonality and heterocedasticity of errors were successfully passed.
[15] Only the ability variable is statistically significant. Any other variable that we included as control was not statistically significant, as presented in Table 5.
[16] Dependent employees are commonly used as a group with incentives and independent employees as the group without incentives. Survey does not have an important number of independent employees, therefore, we were not able to carry out this test.
[17] See Núñez and Gutiérrez (2004).
[18] We carried out two tests of non-nested models, Davidson, Mackinnon and White (1983) J test, and Cox (1961) test to evaluate those specifications. None presented overwhelming evidence in favor of one specification in particular.
[19] For the interactive variables involving experience we employed postgraduate experience in all cases.
[20] Although the three specifications exhibit similar R^2s. This specification was chosen because it had the smallest mean quadratic error.
[21] In the Section II we explained that the job groups were defined by the same graduates, the predictions consider the individuals that responded "fundamentally Business" alone. This allows to make jobs more comparable.
[22] The only difference is the major studied.
[23] This topic is analyzed by Arcidiacono (2004).

References

ALTONJI, J.G and C.R. PIERRET (1998). "Employer Learning and the Signaling Value of Education". in: T. Ohashi and T. Tachibanaki (eds.), *Internal Labour Markets, Incentives and Employment*, Houndmills: Macmillan Press LTD, pp. 159-195.

ALTONJI, J.G and C.R. PIERRET (2001). "Employer Learning and Statistical Discrimination". *Quarterly Journal of Economics*, 116 (1), pp. 313-350.

ARCIDIACONO, P. (2004). "Ability Sorting and the Returns to College Major,. *Journal of Econometrics*, 121 (1), pp. 313-350.

ARROW, K. (1973). "Higher Education as a Filter". *Journal of Public Economics*, 2 (3), pp. 193-216.

BECKER, G. (1964). *Human Capital: A Theoretical Analysis with Special Reference to Education*. New York, Columbia University Press.

COHN, E., B. KIKER and M. MENDES DE OLIVEIRA (1987). "Further Evidence on the Screening Hypothesis". *Economics Letters*, 25 (3), pp. 289-294.

COX, D. (1961). "Test of Separate Families of Hypotesis". *Proceedings of the Fourth Berkeley Symposium on Mathematical Statistics and Probability*. Vol. 1, Berkeley: University of California Press, pp. 105-123.

DAVIDSON, R.; J. MACKINNON y H. WHITE (1983). "Test for Model Specification in the Presence of Alternative Hypotheses; Some Further Results". *Journal of Econometrics*, 21 (1), pp. 53-70.

FARBER, H. and R. GIBBONS (1996). "Learning and Earnings Dynamics". *Quarterly Journal of Economics*, 111 (4), pp. 1007-1047.

GROOT, W. and H. OOTERBEECK (1994). "Earnings Effects of Different Component of Schooling Human Capital Versus Screening". *Review of Economics and Statistics*, LXXXVI (2), pp. 317-321.

JAEGER, D. and M. PAGE (1996), "Degrees Matter: New Evidence on Sheepskin Effects in the Return to Education". *Review of Economics and Statistics*, 78, pp. 733-740.

LANG, D. (2001), "College Majors, Job Types, and the Labor Markets: Is College a major Signal?". *Working Paper*. California State University, Sacramento.

LAYARD, R. and G. PSACHAROPOULOS (1974). "The Screening Hypothesis and the Returns to Education". *Journal of Political Economy*, 82 (5), pp. 985-998.

NUÑEZ, J. and R. GUTIERREZ (2004). "Class Discrimination and Meritocracy in the Labor Market: The Case of Chile". *Mimeo*, Departamento de Economía, Universidad de Chile.

OOSTERBEECK, H. (1992). "Study Duration and Earning. A Test in Relation to the Human Capital Versus Screening Debate". *Economics Letters*, 40 (2), pp. 223-228.

PSACHAROPOULOS, G. (1979). "On the Weak Versus the Strong Version of the Screening Hypothesis". *Economics Letters*, 4 (2), pp. 181-185.

RILEY, J. (1979). "Testing the Educational Screening Hypothesis". *Journal of Political Economy*, Vol. 87, pp. 227-251.

SPENCE, M. (1973). "Job Market Signaling". *Journal of Labor Economics*, 87 (3), pp. 355-374.

STIGLITZ, J. (1975). "The Theory of Screening, Education and the Distribution of Income". *American Economic Review*, 65 (3), pp. 283-300.

TUCKER III, I.B. (1986). "Evidence on the Weak and Strong Version of the Screening Hypothesis in the United States". *Economics Letters*, 21 (1), pp. 391-394.

WEISS, A. (1995). "Human Capital vs. Signaling Explanations of Earnings". *Journal of Economic Perspectives*, 9 (4), pp. 133-154.

WILLIS, R.J. (1986). "Earnings Determinants. A Survey and Reinterpretation of Human Capital Earnings Functions". In: O. Ashenfelter and R. Layard (eds.), *Handbook of Labor Economics*, Vol. 1. Amsterdam: North-Holland, pp. 525-602.