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Job Market Signaling under Two-Dimensional Asymmetric Information

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Abstract

This paper analyzes what happens to the Spence signaling model when there is heterogeneity in two dimensions, competency and character. Competency is productivity at work. Character is the taste for study. If heterogeneity in character is low, the equilibrium is separating. If heterogeneity in character is high, the equilibrium is partially pooling. In the partially pooling equilibrium, only extreme types can be distinguished. Expected competency is monotonically increasing in the level of education. Supplementary information can reveal personal characteristics, acting as a sign of work productivity.

Key words: asymmetric information, adverse selection, indices, signals, signs

JEL: J31, D10

1 Introduction

In Spence (1973), though education does not increase productivity, it acts as a signal of productivity because more productive individuals have lower costs

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of education. Signals as a way to solve problems of asymmetric information were pointed out in Akerlof (1970), e.g. the use of guarantees by sellers of high-quality goods for whom guarantees were less expensive.

However, signals may depend on other factors besides quality. This paper specifically asks what happens when the costs of education also depend on differences in the taste for study. Once other personal traits are taken into account, does education still act as a separating signal? That individuals can differ both in competency and in character is already recognized in the Akerlof (1970) lemons model. The problem with lemons arises not only because there are different quality cars, but also because there are dishonest sellers who are willing to misstate the quality of a used car.

The influence of a person's character on the costs of education leads to asymmetric information in an additional dimension. The reason for asymmetric information is quite simple. Differences in the taste for study are part of personal preferences, so this is private information. These preferences have to be inferred from actions, just like competence at work.

This paper shows that with two-dimensional asymmetric information, if heterogeneity in character is low a separating equilibrium still exists. If heterogeneity in character is high, no separating equilibrium exists. Instead, there is a partially pooling equilibrium. In the partially pooling equilibrium, the probability the worker is competent is monotonically increasing in the signal. Signaling is still informative, but only extreme types can be told apart.

An implication of the result that education may not lead to a separating equilibrium is that other types of information will be used by employers to sort out the productivity of workers. To formalize this, we embed the education signaling game in a two-period model.

A two-period framework is a simple way to separate the early and the later job career. Education may be specially important as a signal on entry to the job market, and can be used by firms to sort workers in a rough way. Later on, firms can use additional information such as the previous employment record. Work experience, and the continuity of employment relationships, may work as a sign of quality for workers already in the job market. The implication of this information will depend on whether it is private or it becomes public. If it becomes public, there is a separating equilibrium in the second period in which wages do not depend on education. If it remains private to the firms, firms will enjoy an informational monopoly and need not adjust wages to productivity.

2 Education as a signal

The signaling model is a variant of Spence (1973). The players are workers and firms. The timing is that workers first decide the level of education, that is used as a signal in the job market. Competitive firms then make their wage offers, based on the expected productivity of the workers.

We first describe preferences, and the consequent heterogeneity of types along the dimensions of productivity and character. Spence (1973) implicitly assumes that heterogeneity in character is null. Hence, there is only asymmetric information in one dimension, the degree of productivity. Once there is heterogeneity in character, there will be asymmetric information in two dimensions. However, whether this affects the original Spence results will depend on the degree of heterogeneity.

2.1 Preferences

Let a workers' utility depend positively on wages and negatively on the cost of education,

$$U(w, e, \theta, \nu) = w - c(e, \theta, \nu), \tag{1}$$

where w stands for wage and e for education level, where $e \geq 0$. The utility cost of education c depends on a worker's productivity type θ, and on taste for education ν.[1]

In keeping with the original Spence model, the influence of the parameters θ and ν on the costs of education are given an extremely simple formulation,

$$c(e, \theta, \nu) = \frac{c(e)}{\theta\nu}, \tag{2}$$

where high productivity θ and high taste for education ν both lower the costs of education, and $c\prime(e) > 0$ (in the figures below, we assume $c(e) = e^2$ for concreteness). These assumption imply that the slope of the indifference curves in space (e, w), $\frac{U_e}{Uw} = -\frac{c\prime(e)}{\theta\nu}$, are flatter for more productive individuals (higher θ). Indifference curves are also flatter for individuals fonder of education (higher ν).

[1] Alternatively, the desire to achieve social recognition, or other factors, could explain differences in the psychic costs of education.

Firms are risk-neutral and maximize profits. Profits equal a worker's productivity minus wages:

$$\pi = \theta - w \tag{3}$$

In a setting with perfectly competitive markets, expected profits will be zero, so in expected value wages will equal productivity. The behavior of competitive firms that compete à la Bertrand can be represented by a single player that minimizes a loss function given by the quadratic difference between wages and productivity (Fudenberg and Tirole 1991, chap. 11).

2.2 Worker heterogeneity

We assume that productivity may be either low or high, $\theta \in \{\underline{\theta}, \overline{\theta}\}$, and taste for education may also be low or high, $\nu \in \{\underline{\nu}, \overline{\nu}\}$. Heterogeneity among individuals implies that there are four types of agents:

<please insert Table 1>

Let heterogeneity in character be denoted by

$$h \equiv \overline{v} - \underline{v} \tag{4}$$

The knife-edge case of heterogeneity $\widetilde{h}$ that separates low and high heterogeneity is given by

$$\underline{\theta}(\underline{\nu} + \widetilde{h}) = \overline{\theta}\underline{v} \tag{5}$$

The interval of low heterogeneity corresponds to $h \in [0, \widetilde{h})$, while the interval of high heterogeneity corresponds to $h \in [\widetilde{h}, H]$, for some positive $H > \widetilde{h}$. In the knife-edge case $h = \widetilde{h}$, the indifference curves of types $(\underline{\theta}, \overline{\nu})$ and $(\underline{\nu}, \overline{\theta})$ are exactly superimposed on each other.

If no signal were available, all workers would have a common level of zero education. In that case, firms would offer workers a wage equal to expected productivity, i.e. $w = E(\theta)$, where $E(\theta) = p_{11} + p_{21})\underline{\theta} + (p_{12} + p_{22})\overline{\theta}$. Hence, equilibrium wages will be in interval $(\underline{\theta}, \overline{\theta})$. We now analyze what happens when a signal is available to differentiate workers.

2.3 Low heterogeneity in character

In terms of the present notation, the original Spence model corresponds to $h = 0$. This case boils down to two types of workers, high and low productivity. Spence (1973) shows there are a continuum of separating equilibria. By the Cho-Kreps intuitive equilibrium, only the least cost separating signal, where the unproductive worker is just indifferent between studying or not, remains.

There is also a pooling equilibrium in Spence(1973), which can be discarded applying the Cho-Kreps intuitive criterion. A competent worker has lower signaling costs, so it will be willing to deviate to levels of education higher than what an incompetent worker would ever pick.

These same results generalize to the case of $h \in (0, \widetilde{h})$. The ranking of marginal costs of education, which determine the slope of the indifference curves, is inversely related to the product $\xi \equiv \theta\nu$ in (2). In the interval with low heterogeneity, the single-crossing property is satisfied since the ranking of marginal costs of education is:

$$\underline{\theta\nu} < \underline{\theta}\overline{\nu} < \overline{\theta}\underline{\nu} < \overline{\theta}\overline{\nu} \tag{6}$$

That is to say, in this interval more productive workers have lower costs of education than less productive workers, so productivity still allows to rank workers unambiguously.

In a separating equilibrium, beliefs $\widehat{\theta}$ on expected worker productivity will be given by

$$\begin{aligned} e = 0 \quad &\Rightarrow \quad \widehat{\theta} = \underline{\theta} \\ e = e^s \quad &\Rightarrow \quad \widehat{\theta} = \overline{\theta} \end{aligned} \tag{7}$$

For out-of-equilibrium values of education e, we assume a firm will assign $\widehat{\theta} = \underline{\theta}$ if $e < e^s$, and $\widehat{\theta} = \overline{\theta}$ if $e > e^s$. These beliefs determine the conditional probability a worker is productive, for each observed level of education.

One can define the signal e^s uniquely by picking as signal the least-cost level of education that will differentiate productive and unproductive workers, as Figure 1 shows.

<please insert Figure 1>

The least cost separating signal is determined by the unproductive worker with a high taste for study, at point A in Figure 1. At point A, worker type $(\underline{\theta}, \overline{\nu})$ is indifferent between getting a high wage $w = \overline{\theta}$ with education $e = e^s$, and a low wage $w = \underline{\theta}$ with education $e = 0$. One can assume it will not signal when it is just indifferent (to break indifference, it would suffice to consider a signal $e^s + \epsilon$, with $\epsilon > 0$ that is arbitrarily small). Hence, behavior will conform to (7), so this is indeed a separating equilibrium.

One can discard a pooling equilibrium $w = E(\theta)$, where all workers are paid the average productivity of the pool of workers, by application of the Cho-Kreps criterion. This is shown in Figure 2.

<Please insert Figure 2>

The farthest that an incompetent worker is willing to deviate is point B, with education e^d. Productive workers have lower signaling costs, so they can be better off to the right of that point. Since those deviations are dominated in equilibrium for unproductive types, but not for productive types, firms can infer that a worker is productive if levels of education larger than (or equal to) e^d are observed. That restriction on out-of-equilibrium beliefs destroys any pooling equilibria.

Likewise, one can also discard partially pooling equilibria where either the three types with highest ξ choose the same signal, or where the two intermediate types of ξ choose the same intermediate signal. The reason is that the indifference curves of productive workers are flatter than the indifference curves of unproductive types, so productive workers will always be willing to deviate farther to the right than unproductive workers.

These results can be summarized as follows.

Proposition 1 *With low heterogeneity in character, there is a unique separating equilibrium. Unproductive workers pick low education and productive workers pick high education.*

Hence, with low heterogeneity in character the signaling results of the basic Spence model are robust to two-dimensional asymmetric information. In this interval, only the undominated separating equilibrium survives refinements of the Perfect Bayesian equilibrium that apply the intuitive criterion.

2.4 High heterogeneity in character

The interval of high heterogeneity corresponds to $h \in [\widetilde{h}, H]$. In this interval, the single-crossing property is no longer satisfied, since the ranking of types

2 and 3 is inverted:

$$\underline{\theta\nu} < \overline{\theta}\underline{\upsilon} < \underline{\theta}\overline{\nu} < \overline{\theta}\overline{\nu} \tag{8}$$

We will first show that no separating equilibrium exists. Why not is easy to see from Figure 3.

<please insert Figure 3>

When heterogeneity in character is high, an unproductive worker with high taste for studying is willing to invest in more education than a productive worker with low taste for studying. That is, a productive worker of type $(\overline{\theta}, \underline{\upsilon})$ is not willing to go farther than point C in Figure 3, while an unproductive worker of type $(\underline{\theta}, \overline{\nu})$ is.

A pooling equilibrium can be discarded, as in the case of low heterogeneity in character, by application of the intuitive criterion. A productive worker of type $(\overline{\theta}, \overline{\nu})$ will always be willing to deviate. A partially pooling equilibrium where type $(\underline{\theta}, \underline{\nu})$ worker picks zero education, and all other workers pick a common positive level of education, can be ruled out by similar arguments.

The other logical possibility is a partially pooling equilibrium with the following features. Type $(\underline{\theta}, \underline{\nu})$ picks zero education. Worker types $(\underline{\theta}, \overline{\nu})$ and $(\overline{\theta}, \underline{\upsilon})$ send the same, intermediate,signal. Finally, type $(\overline{\theta}, \overline{\nu})$ picks the highest level of education. Beliefs $\widehat{\theta}$ are thus given by:

$$\begin{aligned} e = 0 \quad &\Rightarrow \quad \widehat{\theta} = \underline{\theta} \\ e = e^i \quad &\Rightarrow \quad \widehat{\theta} = \frac{p_{12}\overline{\theta} + p_{21}\underline{\theta}}{p_{12} + p_{21}} \\ e = e^s \quad &\Rightarrow \quad \widehat{\theta} = \overline{\theta} \end{aligned} \tag{9}$$

For out-of-equilibrium levels of education, we again assume that expected productivity corresponds to the lowest level of education within that interval. The equilibrium with the least-cost signals is represented graphically in Figure 4.

<please insert Figure 4 here>

The least-cost intermediate signal is determined at point D, with education $e = e^i$ and average wage $w = w^i$, that is on the indifference curve of unproductive worker type $(\underline{\theta}, \underline{\nu})$ that goes through point with coordinates $e = 0$ and $w = \underline{\theta}$. As to the least-cost separating signal, it is determined

at point E, where education $e = e^s$ with wage $w = \overline{\theta}$, which for unproductive worker of type $(\underline{\theta},\overline{\nu})$ is just indifferent to point D. Given these levels of expected productivity, firms will be willing to actually pay these wages. Note that this partially pooling equilibrium exists for any set of positive probabilities $\{p_{11},p_{12},p_{21},p_{22}\}$.

However, this partially pooling equilibrium is not unique. Any intermediate signal in the range between point D in Figure 4 and the point where the indifference curve of type $(\overline{\theta},\underline{\nu})$ cuts the intermediate wage line (call it D') will also satisfy (9), as long as the separating signal is now determined at point where the indifference curve of type $(\underline{\theta},\overline{\nu})$ through point D' cuts the high wage line (call this point E'). Just like in the Spence signaling game with three types of productivity, the intuitive criterion is not strong enough to rule out all these other partially pooling equilibria that are less efficient than the undominated partially pooling equilibrium depicted in Figure 4.[2]

Hence,

Proposition 2 *With high heterogeneity in character, there exists a partially pooling equilibrium. Unproductive workers with no taste for study pick low education. Unproductive workers with taste for study and productive workers with no taste for study pick an intermediate education. Productive workers with taste for study pick high education. This equilibrium is not unique. Besides the undominated equilibrium, similar partially pooling equilibria with excess education are possible.*

Proposition 2 implies that extreme signals are still effective to convey a workers type. It is in the middle ground that there may be imperfect revelation of a worker's type.

2.5 Extension from $2x2$ case to NxN case

What happens to the Spence model if we know consider a multiplicity of types of productivity and of taste for study? Assume that the interval between the

[2]The only equilibria that can be ruled out over the D,D' interval are those where the highest possible wage for type $(\underline{\theta},\underline{\nu})$, i.e. $w = \overline{\theta}$, is at an education level that leads to a point below the indifference currve that gives this type its equilibrium payoff. In that case, equilibrium dominance arguments can be used to rule out this type, so expected competency will be above $\underline{\theta}$. However, unless indifference curves of type $(\underline{\theta},\underline{\nu})$ are vertical, there always remains a non-empty interval to the right of D over which equilibrium dominance arguments have no bite.

lowest and highest type in each dimension there are another $N-2$ types that are evenly spaced apart. Since many possible combinations may crop up, we will only look at two polar cases.

First, consider the case where heterogeneity in character is so low that the ranking of types is still given by the Spence-Mirrlees condition, i.e. more productive types have flatter indifference curves:

$$\theta_1\nu_1 < ... < \theta_1\nu_N < \theta_2\nu_1 .... < \theta_N\nu_N \tag{10}$$

This case is similar to the case of low heterogeneity in the $2x2$ case: more productive types are always willing to go farther than less productive types, so there always exists a separating equilibrium. By the intuitive criterion, there are no pooling or partially pooling equilibria. However, the intuitive criterion does not allow to rule out inefficient separating equilibria that rely on excess education, because equilibrium dominance arguments have no bite in this setup. Qualitatively, however, the picture is unchanged.

The other polar case is where heterogeneity in character is so high that the ranking of types is basically determined by the taste for study, so the usual Spence-Mirrlees condition fails:

$$\theta_1\nu_1 < ... < \theta_N\nu_1 < \theta_1\nu_2 < .... < \theta_N\nu_N \tag{11}$$

Unlike the case of high heterogeneity in the $2x2$ case, the equilibrium will depend on the distribution of types. To illustrate with a simple example, we make the further assumption that the distribution of types over competency types and over tastes for education is uniform. In this context, a partially pooling equilibrium similar to (9) exists for $N = 3$:

$$\begin{aligned} 0 \square\ e < e_1 \quad &\Rightarrow \quad \widehat{\theta} = \theta_1 \\ e_1 \square\ e < e_2 \quad &\Rightarrow \quad \widehat{\theta} = E(\theta) \\ e_2 \square\ e \Rightarrow \quad &\widehat{\theta} = \theta_N \end{aligned} \tag{12}$$

Case $N = 3$,can be depicted by Figure 4 if point E is now determined by indifference curve of type (θ_2, ν_3). In that equilibrium, only the two extreme types can be told apart: types (θ_1, ν_1) and (θ_3, ν_3) will be characterized

by $e = 0$ and $e = e_2$, respectively. For all the intermediate types, namely set $\{(\theta_2, \nu_1),(\theta_3, \nu_1),(\theta_1, \nu_2),(\theta_2, \nu_2),(\theta_3, \nu_2),(\theta_1, \nu_3),(\theta_2, \nu_3)\}$, expected competency will be exactly $E(\theta)$ with a uniform distribution. Hence, most of the types will be bunched in the middle. No type will have an incentive to deviate, so this is a partially pooling equilibrium (there are also similar, dominated, partially pooling equilibria).

For $N > 3$, all the above-average productivity types ($\theta > E(\theta)$) with the highest level of taste for study ($\nu = \nu_N$) have an incentive to deviate from an equilibrium such as (12), going further than types with lower productivity. Hence, there will be partial revelation of these types. For N odd (for N even, the argument has to be slightly adjusted), we will have:

$$
\begin{aligned}
(13) \qquad 0 \leq e < e_1 \quad &\Rightarrow \quad \widehat{\theta} = \theta_1 \\
e_1 \leq e < e_2 \quad &\Rightarrow \quad \widehat{\theta} \simeq E(\theta) \\
e_j \leq e < e_{j+1} \quad &\Rightarrow \quad \widehat{\theta} = \theta_{(N+1)/2+(j-1)}, \quad \text{where } j = 2, ..., \frac{N+1}{2}
\end{aligned}
$$

This boils down to (12) for $N = 3$. As an example, for $N = 5$, types (θ_4, ν_5) and (θ_5, ν_5) will separate out at the higher end, for $N = 7$ three types will separate out, and so on. The equilibrium can be constructed by analogy to Figure 4. The proportion of types separating out at the high end goes down steadily: 1/9 for $N = 3$, 2/25 for $N = 5$, 3/49 for $N = 7$, etc. The proportion of types in the middle rises from 7/9 for $N = 3$ to 45/49 for $N = 7$, so education is less and less informative about work productivity for a greater proportion of the work force.

We have only given an example with the uniform distribution. My conjecture is that with other distribution, one must still get in equilibrium a distribution of types such that expected productivity is increasing in education (otherwise, some types will prefer to deviate to lower levels of education to get higher wages).

As to cases between the two polar types, for some of the types in between it will not be possible to tell types apart unequivocally. Viewed in this light of a multiplicity of types that come closer and closer together, it becomes less likely that one is ever in the setup with low heterogeneity where education satisfies the Spence-Mirrlees condition.

2.6 Relation to other papers

In the economics literature, the differences in character have been analyzed in various contexts. For example, Levine (1998) considers how heterogeneity in character (specifically, whether an individual is nice to others or not) can help explain anomalous results in experimental economics. Weinschelbaum (1998) considers how heterogeneity in both competency and in character affects the issue of corruption.

In a signaling framework, Streb (2002) considers the consequences of two-dimensional asymmetric information in the context of the Rogoff (1990) equilibrium budget cycle model, developing more fully an idea introduced in Stein and Streb (2002). However, the analysis in the Rogoff signaling model gets very involved because the indifference curves of types with different degrees of competence may cross more than once if there is high heterogeneity in character (given there by differences in the degree of opportunism).

The paper that is closest to this, Riley (2001), considers an extension of the original Spence model when there is "noise". There are four types of agents, because some unproductive workers have relatively low signaling costs in terms of education. This resembles our two-dimensional asymmetric information framework in which there also are four types of agents, productive and unproductive, which can have a taste for study or not. From the viewpoint of firms in our model, tastes for education just introduce noise into the signal. In this sense, our model can also be said to be concerned with the consequences of noise in the Spence model.

However, Riley's focus is completely different. He is not concerned about asymmetric information on other dimensions of a workers characteristics. He is concerned about what happens to equilibrium refinements, in particular the intuitive criterion, when there is noise. Riley shows that in his setup there is a partially pooling equilibrium with either low education (unproductive workers with high signaling costs in terms of years of formal education), or high education (productive workers, or the two types of unproductive workers with low signaling costs). His main point is that the intuitive criterion no longer selects a single partially pooling equilibrium, since inefficient equilibria can not be ruled out (much like what happens in our setup in Section 2). He also analyzes other equilibrium refinements to define out-of-equilibrium events, emphasizing that the distribution of types is key in determining the existence of a unique equilibrium (much like what happens in screening models).

3 Work experience as a sign

If the issue of heterogeneity in character is empirically relevant, signaling via education will lead to a partially pooling equilibrium. One would then expect firms to use other types of information to sort productive and unproductive workers. Work experience seems particularly relevant information. Firms get to know a worker better through day to day contact at work. This generates private information that allows to assess a worker's type better. The process of revelation of productivity at work takes time, so to incorporate this feature requires a minimum of dynamics.

We extend as follows the setup in the previous section to incorporate this feature. After the first period has elapsed, firms observe the worker's true productivity. This information may or not become public afterwards. We first analyze the case were this information becomes public, and then we look at the case where this information remains private.

3.1 Public information

Suppose the decision rule that firms follow is that workers whose wage is equal to or larger than their productivity are offered a renewal of their contracts. On the other hand, workers whose contract stipulates a wage larger than their productivity are fired (the job market may work like this because wage reductions may be seen as unfair, cf. Akerlof and Yellen 1988). To not enter into the issue of the duration of unemployment spells, we will simply assume that workers that are fired have a discontinuous job experience, while workers that are not fired have a continuous job experience.

In our simple $2x2$ setup, the renewal decision rule will provoke a total revelation of types. Types with low or high education will get their contracts renewed, since in the first-period equilibrium their wages equaled productivity. As to types with intermediate education, those with low productivity will be fired, while those with high productivity will get a renewal offer. If these decisions become public information, i.e. workers that are fired become visibly unemployed, this reveals information to other firms.

In a competitive environment, the wages of the workers with intermediate education that get a renewal offer will be bid up (note that this argument does not work in just one round with $N > 2$: workers with average or above average productivity get a renewal offer, so only the average productivity of this group of workers is revealed). On the contrary, the wages of the workers

that are discontinued will be bid down. In this environment, one can hence expect that high productivity workers will be paid in equilibrium a high wage, regardless of their level of education, while low productivity workers will be paid a low wage, regardless of their level of education.

This setup implies there will still be a positive correlation between education and wages, and between job experience (or job continuity) and wages. In the second period, more highly educated workers on average get higher wages. Workers with no unemployment spell will also tend to get higher wages.

<please insert Table 2>

As to the first period equilibrium, the key issue is that in the second period wages are independent of education. This implies that the equilibrium in the first period are just as described in Section 2 above, where the costs of education have to be compared to the benefits in that period.

3.2 Private information

Alternatively, one can analyze what happens if firms reduce wages of employees who are found to have low productivity. In that case, outside firms would not be able to distinguish high and low productivity workers by their employment record.[3]

The difference with the previous case of public information is that now the firm will have an informational monopoly, and will be under no pressure to raise the wage of productive workers with intermediate education. If this is so, then wages in the second period will not be independent of education. This implies that the first and second period games cannot be analyzed separately: if a workers invests in more education in the first period, it might be able to earn higher wages not only in the first but also in the second period.

To analyze the impact on the first period equilibrium, one has to incorporate the fact that education not only leads to higher wages in the first period, but also in the second period for productive workers (for unproductive workers, it only leads to higher wages in the first period). This will mean that indifference curves of productive workers become flatter (since their prize is multiplied by 2, if we ignore any discount factors). Hence, it is more likely

[3]Other firms might be able to recognize higher productivity workers despite this if higher productivity workers are assigned more complicated jobs, or jobs with higher responsibility, i.e. if some kind of promotion in job hierarchies is visible to outside firms.

to be in the low heterogeneity case. More generally, one can say that education becomes more revealing. However, a partially pooling equilibrium is not ruled out even in this case.

3.3 Indices, signals and signs

We have seen that if there is two-dimensional asymmetric information, one would expect firms to use other pieces of information to sort workers. The previous work record is an obvious candidate, since empirically it is a key factor in determining which job applicants an employer will interview (Behrenz 2001). Formal education is important as a signal, but this information may be specially relevant to determine entry requirements (again, we are abstracting from the role of education in the buildup of human capital, that enhances productivity by itself).

As to the informational status of the employment record, Spence (1973) distinguishes between "indices" and "signals". Indices are fixed attributes of job applicants, (mostly) unalterable observable attributes such as race and sex. Since age does not change at the discretion of the individual, Spence also considers it an index. Signals are observable characteristics that are subject to the manipulation by the individual, of which education was singled out by Spence.

The continuity or discontinuity of work experience, because an individual may have been fired, is neither a fixed characteristic, nor is it usually subject to the direct manipulation of the worker. Since it can reveal characteristics of the worker that are very similar to signals, it might be termed as a "sign".

Work continuity in the job market is comparable as an informational sign to credit availability in the credit market. The creditworthiness of small firms or individuals may only be privately known to the bank or lender that has carried out transactions with them and developed a relationship. This relationship generates private information. However, the very existence of a relationship, if it is observable, can act as a public sign to third parties of who is a good credit or not. Being a bank client or getting a credit card can act as a good sign, and other financial intermediaries will try to get these clients.[4] The same happens with people that have continuing employment.

[4] When I arrived to the US in 1987 to do my Ph.D. at Berkeley, my credit card applications were turned down by commercial banks because I had no previous credit history. After Amex gave me a card (in a promotion for university students which said that was the only guarrantee they needed), I started to receive many offers from commercial banks.

4 Conclusions

This signaling model implies a variant of Spence (1973). Differences in character imply that the taste for study (or the desire to achieve social recognition) vary. In our 2x2 case, this parameter can be either high or low. This trait is independent from the fact that highly competent individuals have lower costs of completing formal education.

Signaling can be said to be quite resilient to the introduction of asymmetric information in two dimensions. We analyzed the $2x2$ case in detail. With low heterogeneity in character, the equilibrium is separating. On the other hand, high heterogeneity in character leads to a partially pooling equilibrium. Very competent individuals who are highly motivated will stand out from the rest. At the other extreme will be types with low competency and low motivation. In the middle, the mix of competent individuals who do not have a taste for education, and of incompetent individuals that do, will be difficult to tell apart. Extreme types still send unequivocal signals. Furthermore, average competency will be increasing in the degree of education.

This analysis can be extended to consider more types of competency and of character. When one goes form the $2x2$ case to the NxN case, the results will depend on the distribution of types. In an example with high heterogeneity and an uniform distribution, we show that it becomes more likely that almost all types become bunched in the middle. More generally, as long as the Spence-Mirrlees condition is violated, there will be some intermediate types that cannot be perfectly told apart using education as a signal.

If heterogeneity in character is indeed important, education will be an imperfect proxy for a worker's productivity, and other information will be used by firms. Education –as a signal– will still have an import impact on entry level wages, in contrast to wages later on in the work cycle. For additional information, the work record is singled out in this paper. In a dynamic setting, interaction in the work place gives firms direct information on worker productivity. Though on-the-job experience generates private information to the employer, the continuity of working relationships can also act as a sign of high productivity to other firms. If this becomes public information because, e.g., higher productivity workers are more likely to keep their job, this would be consistent with the finding that wages are increasing with on-the-job experience in empirical wage equations.

The present framework shows how to incorporate other dimensions of a person's personality into the analysis. It might be applied to consider

the closely related issue of the influence of emotional intelligence on work productivity. Formal education may capture basically what has to do with formal intelligence, but labor productivity depends on other traits that are not (even imperfectly) evaluated by the educational system. This will be the subject of subsequent work.

The present framework completely ignores that work productivity in part is a matter of matching the right person to the right job, which of course greatly complicates the process of getting an efficient outcome.

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Table 1

Types of individuals - probability distribution -		
	Competency θ	
	Low (θ_1)	High (θ_2)
Taste ν Low (ν_1)	p_{11}	p_{12}
High (ν_2)	p_{21}	p_{22}

Table 2

Wage in second period - conditional on signal -	
Education:	
None	θ_1
Positive	$\frac{p_{21}\theta_1+(p_{12}+p_{22})\theta_2}{p_{21}+p_{12}+p_{22}}$
Job experience:	
Discontinuous	θ_1
Continuous	$\frac{p_{11}\theta_1+(p_{12}+p_{22})\theta_2}{p_{11}+p_{12}+p_{22}}$

Figure 1

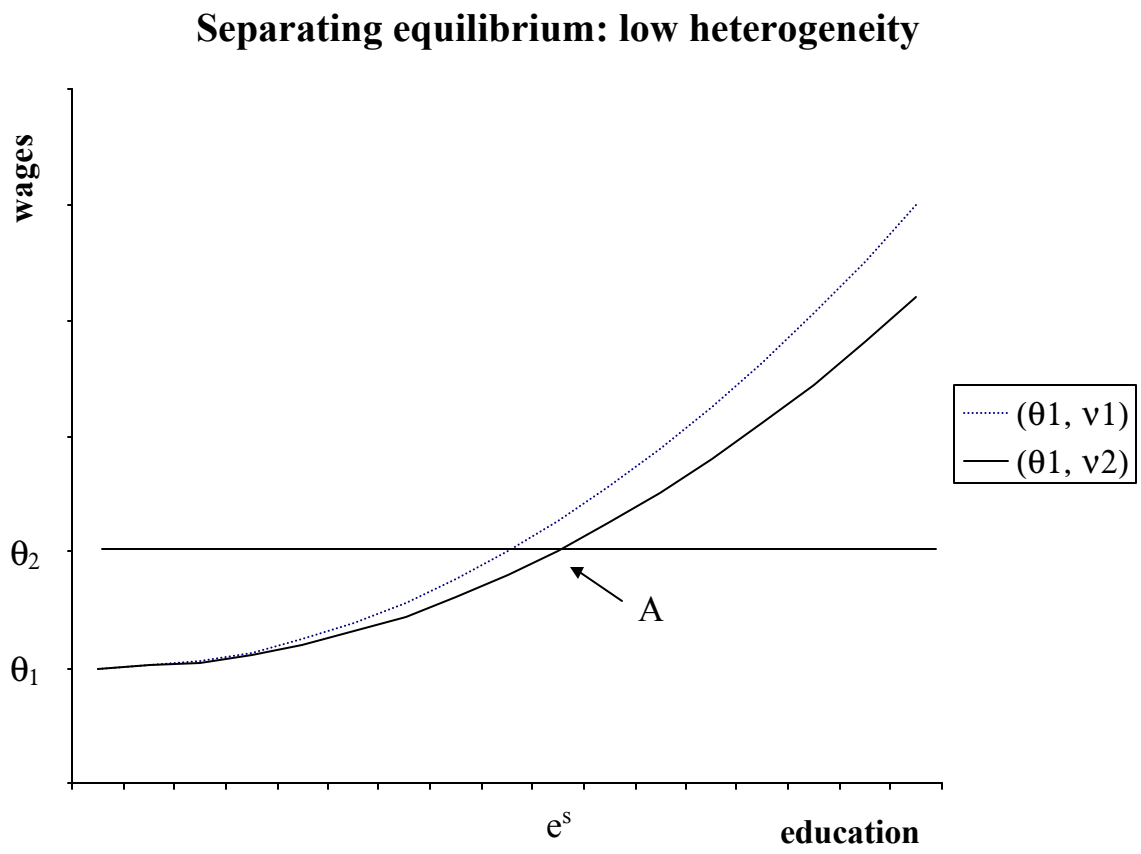

Separating equilibrium: low heterogeneity
wages
θ2
θ1
A
e^s
education
(θ1, ν1)
(θ1, ν2)

Figure 2

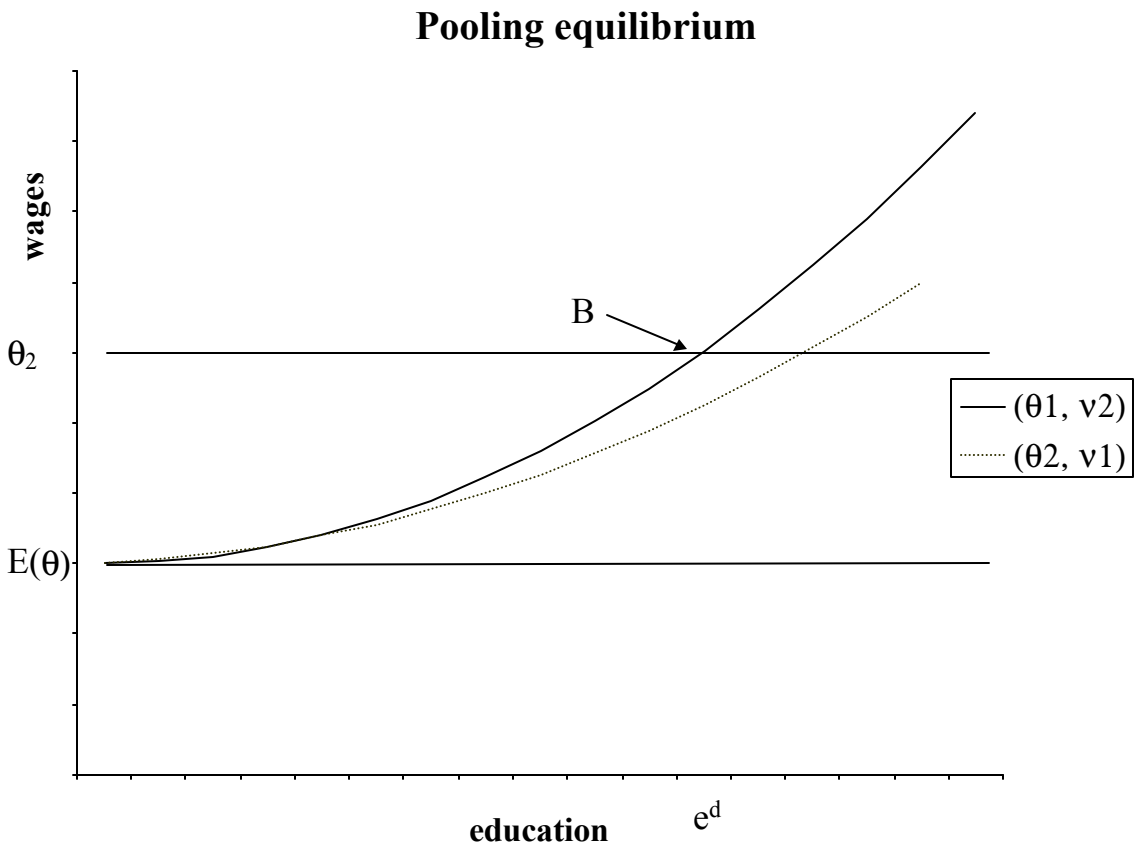


Figure 3

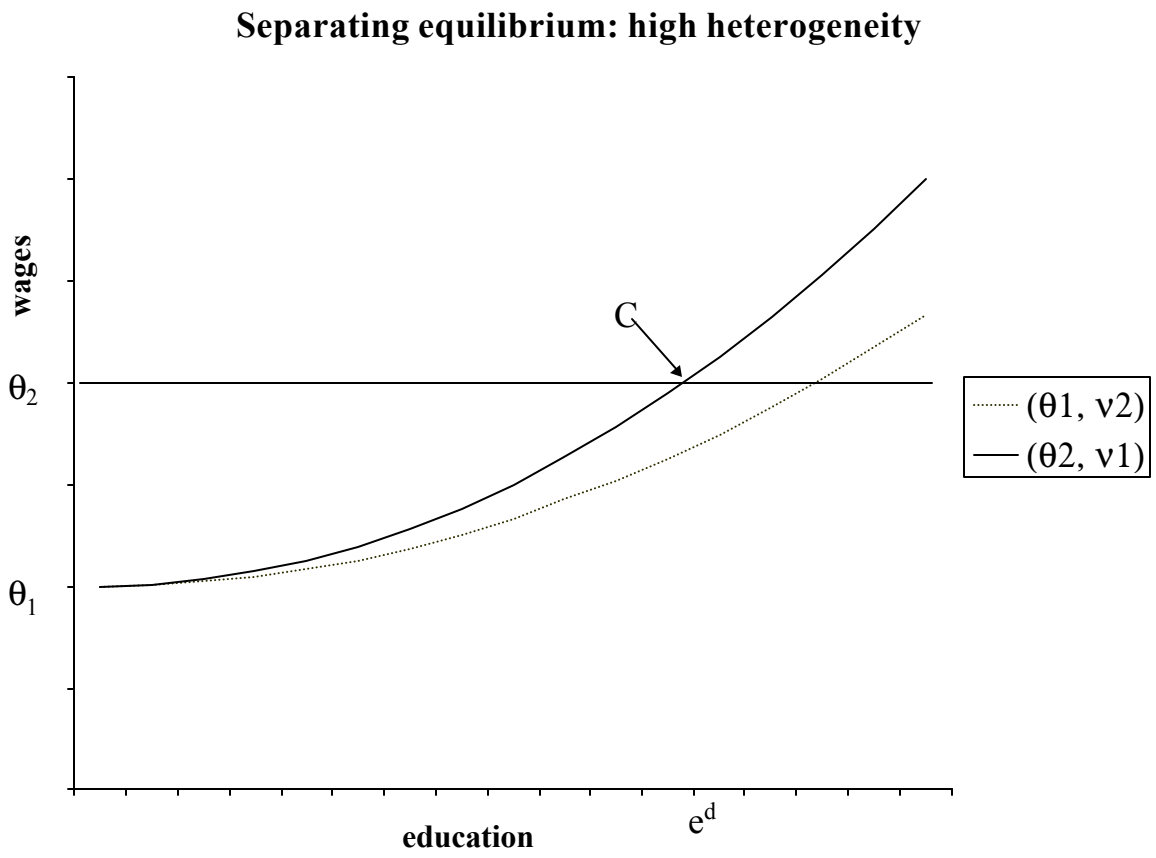
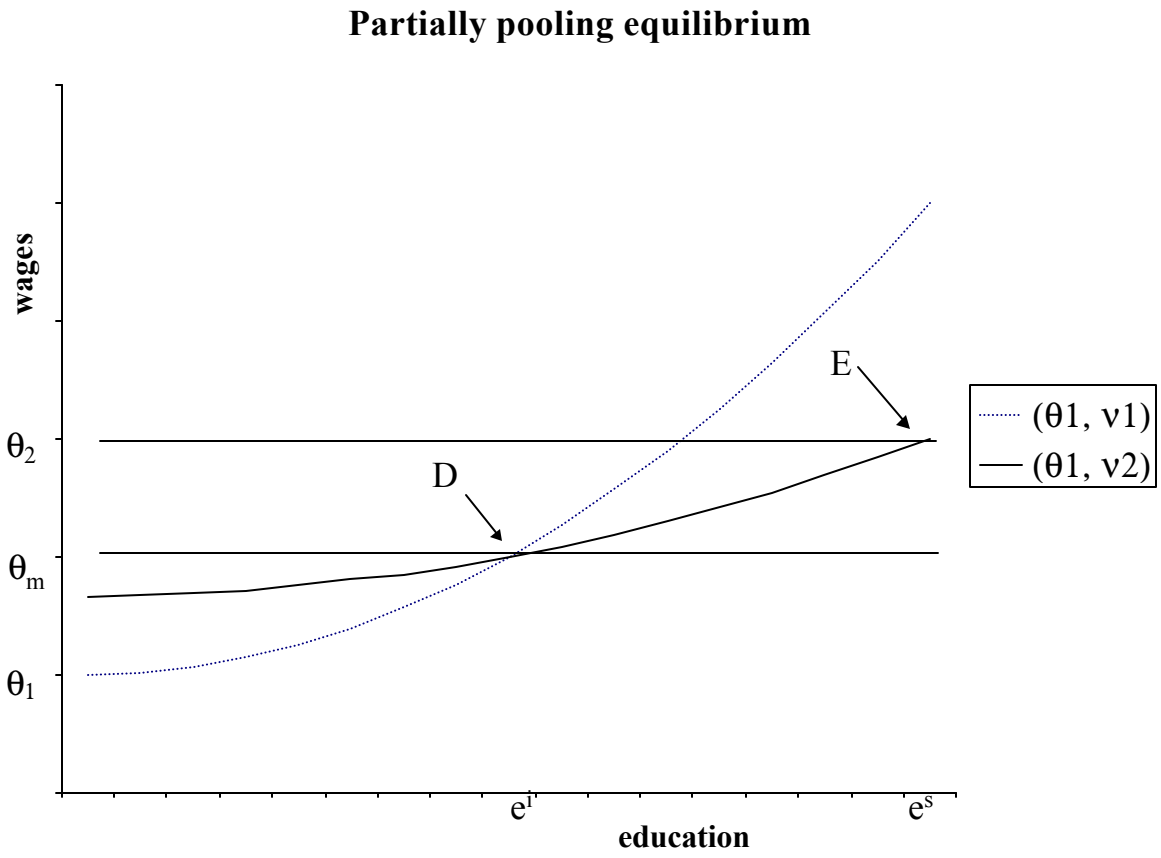

Separating equilibrium: high heterogeneity
wages
C
θ2
θ1
(θ1, ν2)
(θ2, ν1)
education
e^d

Figure 4


Partially pooling equilibrium
wages
θ2
θm
θ1
D
E
(θ1, ν1)
(θ1, ν2)
e^I
e^S
education