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1. INTRODUCTION

The term "market signaling" is not exactly a part of the well-defined, technical vocabulary of the economist. As a part of the preamble, therefore, I feel I owe the reader a word of explanation about the title. I find it difficult, however, to give a coherent and comprehensive explanation of the meaning of the term abstracted from the contents of the essay. In fact, it is part of my purpose to outline a model in which signaling is implicitly defined and to explain why one can, and perhaps should, be interested in it. One might accurately characterize my problem as a signaling one, and that of the reader, who is faced with an investment decision under uncertainty, as that of interpreting signals.

How the reader interprets my report of the content of this essay will depend upon his expectation concerning my stay in the market. If one believes I will be in the essay market repeatedly, then both the reader and I will contemplate the possibility that I might invest in my future ability to communicate by accurately reporting the content of this essay now. On the other hand, if I am to be in the market only once, or relatively infrequently, then the above-mentioned possibility deserves a low probability. This essay is about markets in which signaling takes place and in which the primary signalers are relatively numerous and in the market sufficiently infrequently that they are not expected to (and therefore do not) invest in acquiring signaling reputations.

* The essay is based on the author's doctoral dissertation ("Market Signalling: The Informational Structure of Job Markets and Related Phenomena," Ph.D. thesis, Harvard University, 1972), forthcoming as a book entitled *Market Signaling: Information Transfer in Hiring and Related Screening Processes* in the Harvard Economic Studies Series, Harvard University Press. The aim here is to present the outline of the signaling model and some of its conclusions. Generalizations of the numerical examples used for expositional purposes here are found in *ibid.* and elsewhere.

I owe many people thanks for help in the course of the current study, too many to mention all. However, I should acknowledge explicitly the magnitude of my debts to Kenneth Arrow and Thomas Schelling for persistently directing my attention to new and interesting problems.

I shall argue that the paradigm case of the market with this type of informational structure is the job market and will therefore focus upon it. By the end I hope it will be clear (although space limitations will not permit an extended argument) that a considerable variety of market and quasi-market phenomena like admissions procedures, promotion in organizations, loans and consumer credit, can be usefully viewed through the conceptual lens applied to the job market.

If the incentives for veracity in reporting anything by means of a conventional signaling code are weak, then one must look for other means by which information transfers take place. My aim is to outline a conceptual apparatus within which the signaling power of education, job experience, race, sex, and a host of other observable, personal characteristics can be determined. The question, put crudely, is what in the interactive structure of a market accounts for the informational content, if any, of these potential signals. I have placed primary emphasis upon (i) the definition and properties of signaling equilibria, (ii) the interaction of potential signals, and (iii) the allocative efficiency of the market.

2. Hiring as Investment under Uncertainty

In most job markets the employer is not sure of the productive capabilities of an individual at the time he hires him.[1] Nor will this information necessarily become available to the employer immediately after hiring. The job may take time to learn. Often specific training is required. And there may be a contract period within which no recontracting is allowed. The fact that it takes time to learn an individual's productive capabilities means that hiring is an investment decision. The fact that these capabilities are not known beforehand makes the decision one under uncertainty.

To hire someone, then, is frequently to purchase a lottery.[2] In what follows, I shall assume the employer pays the certain monetary equivalent of the lottery to the individual as wage.[3] If he is

1. There are, of course, other informational gaps in the job market. Just as employers have less than perfect information about applicants, so also will applicants be imperfectly informed about the qualities of jobs and work environments. And in a different vein neither potential employees nor employers know all of the people in the market. The resulting activities are job search and recruiting. For the purpose of this essay I concentrate upon employer uncertainty and the signaling game that results.

2. The term "lottery" is used in the technical sense, imparted to it by decision theory.

3. The certain monetary equivalent of a lottery is the amount the individual would take, with certainty, in lieu of the lottery. It is generally thought to be less than the actuarial value of the lottery.

risk-neutral, the wage is taken to be the individual's marginal contribution to the hiring organization.

Primary interest attaches to how the employer perceives the lottery, for it is these perceptions that determine the wages he offers to pay. We have stipulated that the employer cannot directly observe the marginal product prior to hiring. What he does observe is a plethora of personal data in the form of observable characteristics and attributes of the individual, and it is these that must ultimately determine his assessment of the lottery he is buying. (The image that the individual presents includes education, previous work, race, sex, criminal and service records, and a host of other data.) This essay is about the endogenous market process whereby the employer requires (and the individual transmits) information about the potential employee, which ultimately determines the implicit lottery involved in hiring, the offered wages, and in the end the allocation of jobs to people and people to jobs in the market.

At this point, it is useful to introduce a distinction, the import of which will be clear shortly. Of those observable, personal attributes that collectively constitute the image the job applicant presents, some are immutably fixed, while others are alterable. For example, education is something that the individual can invest in at some cost in terms of time and money. On the other hand, race and sex are not generally thought to be alterable. I shall refer to observable, unalterable attributes as *indices*, reserving the term *signals* for those observable characteristics attached to the individual that are subject to manipulation by him.[4] Some attributes, like age, do change, but not at the discretion of the individual. In my terms, these are indices.

Sometime after hiring an individual, the employer will learn the individual's productive capabilities. On the basis of previous experience in the market, the employer will have conditional probability assessments over productive capacity given various combinations of signals and indices. At any point of time when confronted with an individual applicant with certain observable attributes, the employer's subjective assessment of the lottery with which he is confronted is defined by these conditional probability distributions over productivity given the new data.

From one point of view, then, signals and indices are to be re-

4. The terminological distinction is borrowed from Robert Jervis (*The Logic of Images in International Relations* (Princeton, N.J.: Princeton University Press, 1970)). My use of the terms follows that of Jervis sufficiently closely to warrant their transplantation.

garded as parameters in shifting conditional probability distributions that define an employer's beliefs.[5]

3. Applicant Signaling

For simplicity I shall speak as if the employer were risk-neutral. For each set of signals and indices that the employer confronts, he will have an expected marginal product for an individual who has these observable attributes. This is taken to be the offered wage to applicants with those characteristics. Potential employees therefore confront an offered wage schedule whose arguments are signals and indices.

There is not much that the applicant can do about indices. Signals, on the other hand, are alterable and therefore potentially subject to manipulation by the job applicant. Of course, there may be costs of making these adjustments. Education, for example, is costly. We refer to these costs as *signaling costs*. Notice that the individual, in acquiring an education, need not think of himself as signaling. He will invest in education if there is sufficient return as defined by the offered wage schedule.[6] Individuals, then, are assumed to select signals (for the most part, I shall talk in terms of education) so as to maximize the difference between offered wages and signaling costs. Signaling costs play a key role in this type of signaling situation, for they functionally replace the less direct costs and benefits associated with a reputation for signaling reliability acquired by those who are more prominent in their markets than job seekers are in theirs.

A Critical Assumption

It is not difficult to see that a signal will not effectively distinguish one applicant from another, unless the costs of signaling are negatively correlated with productive capability. For if this condition fails to hold, given the offered wage schedule, everyone will invest in the signal in exactly the same way, so that they cannot be distinguished on the basis of the signal. In what follows, we shall make the assumption that signaling costs are negatively correlated with productivity. It is, however, most appropriately viewed as a

5. The shifting of the distributions occurs when new market data are received and conditional probabilities are revised or updated. Hiring in the market is to be regarded as sampling, and revising conditional probabilities as passing from prior to posterior. The whole process is a learning one.

6. There may be other returns to education. It may be a consumption good or serve as a signal of things other than work potential (status for example). These returns should be added to the offered wage schedule.

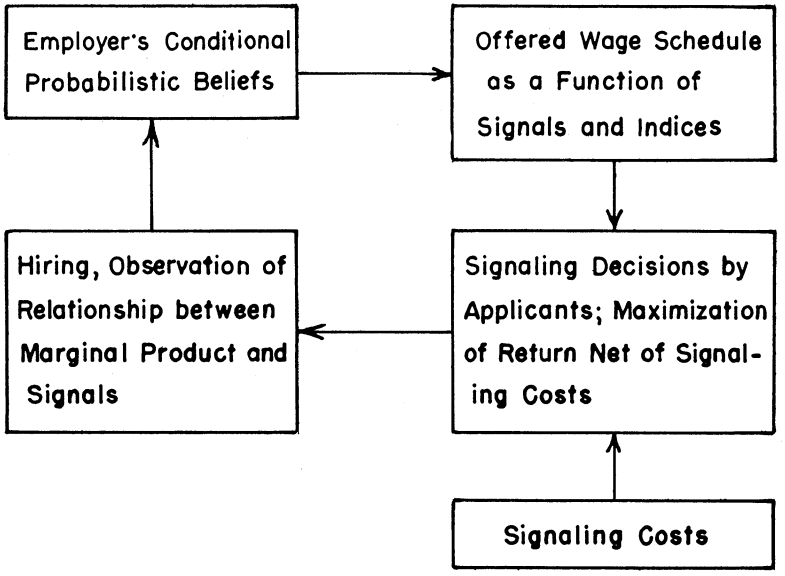

FIGURE I

Informational Feedback in the Job Market

prerequisite for an observable, alterable characteristic to be a persistently informative signal in the market. This means, among other things, that a characteristic may be a signal with respect to some types of jobs but not with respect to others.[7]

Signaling costs are to be interpreted broadly to include psychic and other costs, as well as the direct monetary ones. One element of cost, for example, is time.

4. Information Feedback and the Definition of Equilibrium

At this point it is perhaps clear that there is informational feedback to the employer over time. As new market information comes in to the employer through hiring and subsequent observation of productive capabilities as they relate to signals, the employer's conditional probabilistic beliefs are adjusted, and a new round starts. The wage schedule facing the new entrants in the market generally differs from that facing the previous group. The elements in the feedback loop are shown in Figure I.

It is desirable to find a way to study this feedback loop in the

7. The reason is that signaling costs can be negatively correlated with one type of productive capability but not with another.

market over time. To avoid studying a system in a continual state of flux, it is useful to look for nontransitory configuration of the feedback system. The system will be stationary if the employer starts out with conditional probabilistic beliefs that after one round are not disconfirmed by the incoming data they generated. We shall refer to such beliefs as self-confirming. The sense in which they are self-confirming is defined by the feedback loop in Figure I.

A Signaling Equilibrium

As successive waves of new applicants come into the market, we can imagine repeated cycles around the loop. Employers' conditional probabilistic beliefs are modified, offered wage schedules are adjusted, applicant behavior with respect to signal choice changes, and after hiring, new data become available to the employer. Each cycle, then, generates the next one. In thinking about it, one can interrupt the cycle at any point. An equilibrium is a set of components in the cycle that regenerate themselves. Thus, we can think of employer beliefs being self-confirming, or offered wage schedules regenerating themselves, or applicant behavior reproducing itself on the next round.[8]

I find it most useful to think in terms of the self-confirming aspect of the employer beliefs because of the continuity provided by the employer's persistent presence in the market.[9] Thus, in these terms an equilibrium can be thought of as a set of employer beliefs that generate offered wage schedules, applicant signaling decisions, hiring, and ultimately new market data over time that are consistent with the initial beliefs.

A further word about the definition of equilibrium is in order. Given an offered wage schedule, one can think of the market as generating, via individual optimizing decisions, an empirical distribution of productive capabilites given observable attributes or signals (and indices). On the other hand, the employer has subjectively held conditional probabilistic beliefs with respect to productivity, given signals. In an equilibrium the subjective distribution and the one implicit in the market mechanism are identical,

8. In pursuing the properties of signaling equilibria, we select as the object for regeneration whatever is analytically convenient, but usually employer beliefs or offered wage schedules.

9. The mathematically oriented will realize that what is at issue here is a fixed point property. A mapping from the space of conditional distributions over productivity given signals into itself is defined by the market response mechanism. An equilibrium can be thought of as a fixed point of this mapping. A mathematical treatment of this subject is contained in Spence, *op. cit.*

over the range of signals that the employer actually observes.[1] Any other subjective beliefs will eventually be disconfirmed in the market because of the employer's persistent presence there.

Indices continue to be relevant. But since they are not a matter of individual choice, they do not figure prominently in the feedback system just described. I shall return to them later.

5. Properties of Informational Equilibria: an Example

I propose to discuss the existence and properties of market signaling equilibria via a specific numerical example.[2] For the time being, indices play no part. The properties of signaling equilibria that we shall encounter in the example are general.[3]

Let us suppose that there are just two productively distinct groups in a population facing one employer. Individuals in Group I have a productivity of 1, while those in Group II have a productivity of 2.[4] Group I is a proportion q_1 of the population; Group II is a proportion of $1-q_1$. There is, in addition, a potential signal, say education, which is available at a cost. We shall assume that education is measured by an index y of level and achievement and is subject to individual choice. Education costs are both monetary and psychic. It is assumed that the cost to a member of Group I of y units of education is y, while the cost to a member of Group II is $y/2$.

We summarize the underlying data of our numerical example in Table I.

TABLE I

Data of the Model

Group	Marginal product	Proportion of population	Cost of education level y
I	1	q_1	y
II	2	$1-q_1$	$y/2$

1. In a multi-market model one faces the possibility that certain types of potential applicants will rationally select themselves out of certain job markets, and hence certain signal configurations may never appear in these markets. When this happens, the beliefs of the employers in the relevant market are not disconfirmed in a degenerate way. No data are forthcoming. This raises the possibility of persistent informationally based discrimination against certain groups. The subject is pursued in detail in *ibid.*

2. Obviously, an example does not prove generality. On the other hand, if the reader will take reasonable generality on faith, the example does illustrate some essential properties of signaling equilibria.

3. See Spence, *op. cit.*

4. For productivity the reader may read "what the individual is worth to the employer." There is no need to rely on marginal productivity here.

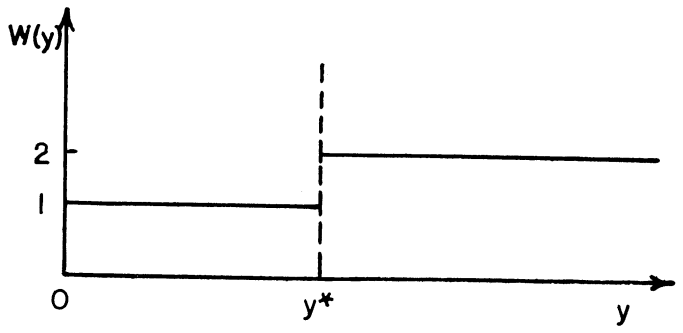

FIGURE II

Offered Wages as a Function of Level of Education

To find an equilibrium in the market, we guess at a set of self-confirming conditional probabilistic beliefs for the employer and then determine whether they are in fact confirmed by the feedback mechanisms described above. Suppose that the employer believes that there is some level of education, say y^* such that if $y<y^*$, then productivity is one with probability one, and that if $y\geqslant y^*$, then productivity will be two with probability one. If these are his conditional beliefs, then his offered wage schedule, $W(y)$, will be as shown in Figure II.

Given the offered wage schedule, members of each group will select optimal levels for education. Consider the person who will set $y<y^*$. If he does this, we know he will set $y=0$ because education is costly, and until he reaches y^*, there are no benefits to increasing y, given the employer's hypothesized beliefs. Similarly, any individual who sets $y\geqslant y^*$ will in fact set $y=y^*$, since further increases would merely incur costs with no corresponding benefits. Everyone will therefore either set $y=0$ or set $y=y^*$. Given the employer's initial beliefs and the fact just deduced, if the employer's beliefs are to be confirmed, then members of Group I must set $y=0$, while members of Group II set $y=y^*$. Diagrams of the options facing the two groups are shown in Figure III.

Superimposed upon the wage schedule are the cost schedules for the two groups. Each group selects y to maximize the difference between the offered wages and the costs of education. Given the level of y^* in the diagram, it is easy to see that Group I selects $y=0$, and Group II sets $y=y^*$. Thus, in this case the employer's beliefs are confirmed, and we have a signaling equilibrium. We can state the

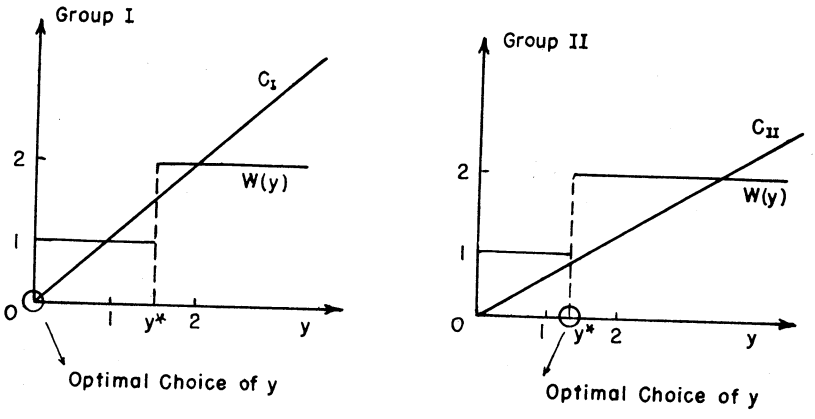

FIGURE III

Optimizing Choice of Education for Both Groups

conditions on behavior by the two groups, in order that the employer's beliefs be confirmed, in algebraic terms. Group I sets $y=0$ if

$$1>2-y^*.$$

Group II will set $y=y^*$ as required, provided that

$$2-y^*/2>1.$$

Putting these two conditions together, we find that the employer's initial beliefs are confirmed by market experience, provided that the parameter y^* satisfies the inequality,

$$1<y^*<2.$$

It is worth pausing at this point to remark upon some striking features of this type of equilibrium. One is that within the class of employer expectations used above, there is an infinite number of possible equilibrium values for y^*. This means that there is an infinite number of equilibria. In any one of the equilibria the employer is able to make perfect point predictions concerning the productivity of any individual, having observed his level of education. The reader will realize that this property is special and depends, at least in part, upon the assumption that education costs are perfectly negatively correlated with productivity. However, even in this case, there are equilibria in which the employer is uncertain, as we shall shortly see.

The equilibria are not equivalent from the point of view of welfare. Increases in the level of y^* hurt Group II, while, at the same time, members of Group I are unaffected. Group I is worse off than it was with no signaling at all. For if no signaling takes place, each

person is paid his unconditional expected marginal product, which is just

$$q_1+2(1-q_1)=2-q_1.$$

Group II may also be worse off than it was with no signaling. Assume that the proportion of people in Group I is 0.5. Since $y^*>1$ and the net return to the member of Group II is $2-y^*/2$, in equilibrium his net return must be below 1.5, the no-signaling wage. Thus, everyone would prefer a situation in which there is no signaling.

No one is acting irrationally as an individual. Coalitions might profitably form and upset the signaling equilibrium.[5] The initial proportions of people in the two groups q_1 and $1-q_1$ have no effect upon the equilibrium. This conclusion depends upon this assumption that the marginal product of a person in a given group does not change with numbers hired.

Given the signaling equilibrium, the education level y^*, which defines the equilibrium, is an entrance requirement or prerequisite for the high-salary job — or so it would appear from the outside. From the point of view of the individual, it is a prerequisite that has its source in a signaling game. Looked at from the outside, education might appear to be productive. It is productive for the individual, but, in this example, it does not increase his real marginal product at all.[6]

A sophisticated objection to the assertion that private and social returns differ might be that, in the context of our example, the social return is not really zero. We have an information problem in the society and the problem of allocating the right people to the right jobs. Education, in its capacity as a signal in the model, is helping us to do this properly. The objection is well founded. To decide how efficient or inefficient this system is, one must consider the realistic alternatives to market sorting procedures in the society.[7] But notice that even within the confines of the market model, there are more or less efficient ways of getting the sorting accomplished. Increases in y^* improve the quality of the sorting not one bit. They simply use up real or psychic resources. This is

5. Coalitions to change the patterns of signaling are discussed in Spence, *op. cit.*

6. I am ignoring external benefits to education here. The assertion is simply that in the example education does not contribute to productivity. One might still claim that the social product is not zero. The signal cost function does, in principle, capture education as a consumption good, an effect that simply reduces the cost of education.

7. This question is pursued in Spence, *op. cit.*

just another way of saying that there are Pareto inferior signaling equilibria in the market.

It is not always the case that all groups lose due to the existence of signaling. For example, if, in the signaling equilibrium, $y^* < 2q_1$, then Group II would be better off when education is functioning effectively as a signal than it would be otherwise. Thus, in our example if $q_1 > \frac{1}{2}$ so that Group II is a minority, then there exists a signaling equilibrium in which the members of Group II improve their position over the no-signaling case. Recall that the wage in the no-signaling case was a uniform $2-q_1$ over all groups.

We may generalize this bit of analysis slightly. Suppose that the signaling cost schedule for Group I was given by $a_1 y$ and that for Group II by $a_2 y$.[8] Then with a small amount of calculation, we can show that there is a signaling equilibrium in which Group II is better off than with no signaling,[9] provided that

$$q_1 > a_2/a_1.$$

How small a "minority" Group II has to be to have the possibility of benefiting from signaling depends upon the ratio of the marginal signaling costs of the two groups.[1]

Before leaving our education signaling model, it is worth noting that there are other equilibria in the system with quite different properties. Suppose that the employer's expectations are of the following form:

If $y < y^*$: Group I with probability q_1,
Group II with probability $1-q_1$;
if $y \geqslant y^*$: Group II with probability 1.

As before, the only levels of y that could conceivably be selected are

8. It is assumed that $a_2 < a_1$.

9. Notice that the statement is that there exists a signaling equilibrium in which Group II is better off. It turns out that there always exists a signaling equilibrium in which Group II is worse off as well.

1. The calculation is straightforward. Given these signaling costs groups will make the requisite choice to confirm the employer's beliefs provided that

$$1 > 2 - a_1 y^*$$

and

$$2 - a_2 y^* > 1.$$

These translate easily into the following condition on y^*:

$$\frac{1}{a_2} < y^* < \frac{1}{a_1}.$$

Now, if Group II is to be better off for some signaling equilibrium, then

$$2 - \frac{a_2}{a_1} > 2 - q_1,$$

or

$$q_1 > \frac{a_2}{a_1}.$$

This is what we set out to show.

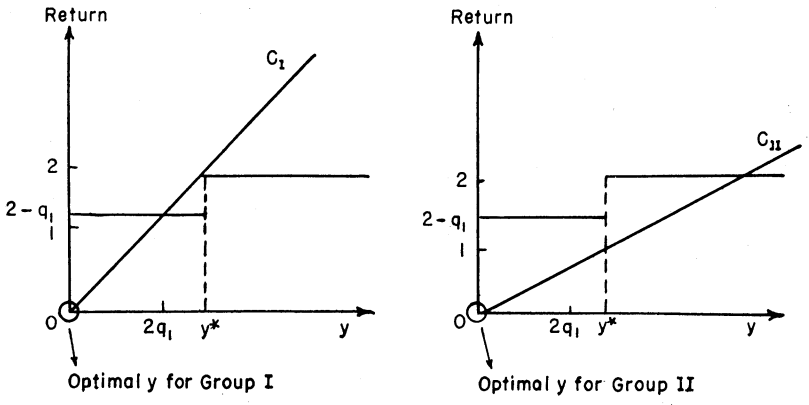

FIGURE IV

Optimal Signaling Decisions for the Two Groups

$y=0$ and $y=y^*$. The wage for $y=0$ is $2-q_1$, while the wage for $y=y^*$ is simply 2. From Figure IV it is easy to see that both groups rationally set $y=0$, provided that $y^*>2q_1$. If they both do this, then the employer's beliefs are confirmed, and we have an equilibrium.

It should be noted that the employer's beliefs about the relationship between productivity and education for $y\geqslant y^*$ are confirmed in a somewhat degenerate, but perfectly acceptable, sense. There are no data relating to these levels of education and hence, by logic, no disconfirming data. This is an example of a phenomenon of much wider potential importance. The employer's beliefs may drive certain groups from the market and into another labor market. We cannot capture this situation in a simple one-employer, one-market model. But when it happens, there is no experience forthcoming to the employer to cause him to alter his beliefs.[2]

Education conveys no information in this type of equilibrium. In fact, we have reproduced the wages and information state of the employer in the no-signaling model, as a signaling equilibrium.

Just as there exists a signaling equilibrium in which everyone sets $y=0$, there is also an equilibrium in which everyone sets $y=y^*$ for some positive y^*. The requisite employer beliefs are as follows:

If $y<y^*$: Group I with probability 1;
if $y\geqslant y^*$: Group I with probability q_1,
Group II with probability $1-q_1$.

2. This is discussed in detail in Spence, *op. cit.*

Following our familiar mode of analysis, one finds that these beliefs are self-confirming in the market, provided that

$$y^* < 1 - q_1.$$

Again, the education level conveys no useful information, but in this instance individuals are rationally investing in education. If they as individuals did not invest, they would incur lower wages, and the loss would exceed the gain from not making the educational investment. The implication of this version of the signaling equilibrium is that there can be stable prerequisites for jobs that convey no information by virtue of their existence and hence serve no function.

It is interesting to note that this last possibility does not depend upon costs being correlated with productivity at all. Suppose that the signaling costs *for both groups* were given by the one schedule y. And suppose further that employer beliefs were as described above. Then everyone will rationally select $y = y^*$, provided that

$$y^* < 1 - q_1.$$

The outcome is the same. But the interesting thing is that, because of the absence of any correlation between educational costs and productivity, education could *never* be an effective signal, in the sense of conveying useful information, in an equilibrium in this market.

We have dwelt enough upon the specifics of this model to have observed some of the effects the signaling game may have upon the allocational functioning of the market. The numerical example is not important. The potential effects and patterns of signaling are.

An alterable characteristic like education, which is a potential signal, becomes an actual signal if the signaling costs are negatively correlated with the individual's unknown productivity. Actually, the negative correlation is a necessary but not sufficient condition for signaling to take place. To see this in the context of our model, assume that the only values y can have are one and three. That is to say, one can only get units of education in lumps. If this is true, then there is no feasible value of y^* that will make it worthwhile for Group II to acquire an education. Three units is too much, and one unit will not distinguish Group II from Group I. Therefore, effective signaling depends not only upon the negative correlation of costs and productivities, but also upon there being a "sufficient" number of signals within the appropriate cost range.[3]

3. In *ibid.* it is argued that many potential signals in credit and loan

An equilibrium is defined in the context of a feedback loop, in which employer expectations lead to offered wages to various levels of education, which in turn lead to investment in education by individuals. After hiring, the discovery of the actual relationships between education and productivity in the sample leads to revised expectations or beliefs. Here the cycle starts again. An equilibrium is best thought of as a set of beliefs that are confirmed or at least not contradicted by the new data at the end of the loop just described. Such beliefs will tend to persist over time as new entrants into the market flow through.

Multiple equilibria are a distinct possibility. Some may be Pareto inferior to others. Private and social returns to education diverge. Sometimes everyone loses as a result of the existence of signaling. In other situations some gain, while others lose. Systematic overinvestment in education is a distinct possibility because of the element of arbitrariness in the equilibrium configuration of the market. In the context of atomistic behavior (which we have assumed thus far) everyone is reacting rationally to the market situation. Information is passed to the employer through the educational signal. In some of our examples it was perfect information. In other cases this is not so. There will be random variation in signaling costs that prevent the employer from distinguishing perfectly among individuals of varying productive capabilities.

In our examples, education was measured by a scalar quantity. With no basic adjustment in the conceptual apparatus, we can think of education as a multidimensional quantity: years of education, institution attended, grades, recommendations and so on. Similarly, it is not necessary to think in terms of two groups of people. There may be many groups, or even a continuum of people: some suited to certain kinds of work, others suited to other kinds. Nor need education be strictly unproductive. However, if it is too productive relative to the costs, everyone will invest heavily in education, and education may cease to have a signaling function.

6. The Informational Impact of Indices

In the educational signaling model we avoided considering any observable characteristics other than education. In that model education was a signal. Here we consider what role, if any, is played

markets effectively become indices because the "signaling" costs swamp the gains, so that characteristics that could be manipulated in fact are not. House ownership is an example of a potential signal that, in the context of the loan market, fails on this criterion and hence becomes an index.

by indices. For concreteness I shall use sex as the example. But just as education can stand for any set of observable, alterable characteristics in the first model, sex can stand for observable, unalterable ones here. The reader may wish to think in terms of race, nationality, size, or in terms of criminal or police records and service records. The latter is potentially public information about a person's history and is, of course, unalterable when viewed retrospectively from the present.[4]

Let us assume that there are two groups, men and women. I shall refer to these groups as W and M. Within each group the distribution of productive capabilities and the incidence of signaling costs are the same. Thus, within M the proportion of people with productivity one and signaling (education) costs of y is q_1. The remainder have productivity two and signaling costs $y/2$. The same is true for group W. Here m is the proportion of men in the overall population of job applicants.

TABLE IV

DATA OF THE MODEL

Race	Productivity	Education costs	Proportion within group	Proportion of total population
W	1	y	q_1	$q_1(1-m)$
W	2	$y/2$	$1-q_1$	$(1-q_1)(1-m)$
M	1	y	q_1	$q_1 m$
M	2	$y/2$	$1-q_1$	$(1-q_1)m$

Given the assumptions the central question is, "how could sex have an informational impact on the market?" The next few paragraphs are devoted to arguing that indices do have a potential impact and to explaining why this is true. We begin by noting that, under the assumptions, the conditional probability that a person drawn at random from the population has a productivity of two, given that he is a man (or she is a woman), is the same as the unconditional probability that his productivity is two. Sex and productivity are uncorrelated in the population. Therefore, *by itself*, sex could never tell the employer anything about productivity.

We are forced to the conclusion that if sex is to have any informational impact, it must be through its interaction with the educational signaling mechanism. But here again we run up against an initially puzzling symmetry. Under the assumptions, men and women of equal productivity have the same signaling (education)

4. It is, or ought to be, the subject of policy decisions as well.

costs. It is a general maxim in economics that people with the same preferences and opportunity sets will make similar decisions and end up in similar situations. We may assume that people maximize their income net of signaling costs so that their preferences are the same. And since signaling costs are the same, it would appear that their opportunity sets are the same. Hence, again we appear to be driven to the conclusion that sex can have no informational impact. But the conclusion is wrong, for an interesting reason.

The opportunity sets of men and women of comparable productivity are *not* necessarily the same. To see this, let us step back to the simple educational signaling model. There are externalities in that model. One person's signaling strategy or decision affects the market data obtained by the employer, which in turn affect the employer's conditional probabilities. These determine the offered wages to various levels of education and hence of rates of return on education for the next group in the job market. The same mechanism applies here, with a notable modification. If employers' distributions are conditional on sex as well as education, then the external impacts of a man's signaling decision are felt only by other men. The same holds for women.

If at some point in time men and women are not investing in education in the same ways, then the returns to education for men and women will be different in the next round. In short, their opportunity sets differ. In what follows, we demonstrate rigorously that this sort of situation can persist in an equilibrium. The important point, however, is that there are externalities implicit in the fact that an individual is treated as the average member of the group of people who look the same and that, as a result, and in spite of an apparent sameness the opportunity sets facing two or more groups that are visibly distinguishable may in fact be different.

The employer now has two potential signals to consider: education and sex. At the start he does not know whether either education or sex will be correlated with productivity. Uninformative potential signals or indices are discarded in the course of reaching an equilibrium. As before we must guess at an equilibrium form for the employer's expectations and then verify that these beliefs can be self-confirming via the market informational feedback mechanisms. We will try beliefs on the following form.

If W and $y < y^*_W$, productivity $= 1$ with probability 1.
If W and $y \geq y^*_W$, productivity $= 2$ with probability 1.
If M and $y < y^*_M$, productivity $= 1$ with probability 1.
If M and $y \geq y^*_M$, productivity $= 2$ with probability 1.

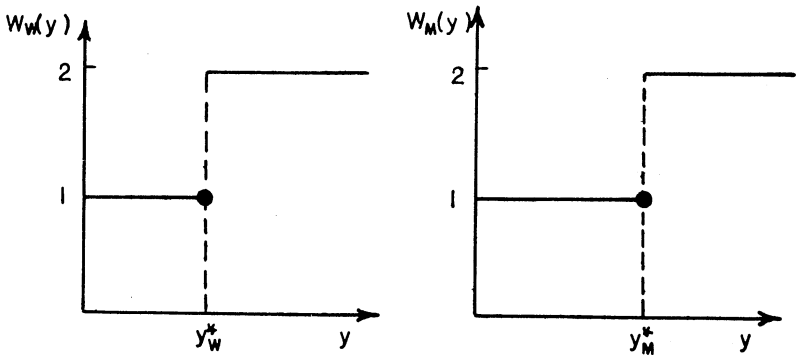

FIGURE V

Offered Wages to W and M

These lead to offered wage schedules $W_W(y)$ and $W_M(y)$ as shown in Figure V.

Because groups W and M are distinguishable to the employer, their offered wages are not connected at the level of employer expectations. Applying the reasoning used in the straightforward educational signaling model, we find that the required equilibrium conditions on y^*_W and y^*_M are

$$1 < y^*_W < 2$$

and

$$1 < y^*_M < 2.$$

No logical condition requires that y^*_W equals y^*_M in an equilibrium.

Essentially we simply have the educational signaling model iterated twice. Because sex is observable, the employer can make his conditional probability assessments depend upon sex as well as education. This has the effect of making signaling interdependencies between two groups, W and M, nonexistent. They settle into signaling equilibrium configurations in the market independently of each other. But in the first model there was not one equilibrium, there were many. Therefore, there is at least the logical possibility that men and women will settle into *different* stable signaling equilibria in the market and stay there.

As we noted earlier, the signaling equilibria are not equivalent from the point of view of social welfare. The higher that y^*_W (or y^*_M) is, the worse off is the relevant group or, more accurately, the high-productivity portion of the group. One example of an asymmetrical equilibrium would be given by $y^*_M = 1.1$ and $y^*_M = 1.9$. In this case high-productivity women have to spend more on education

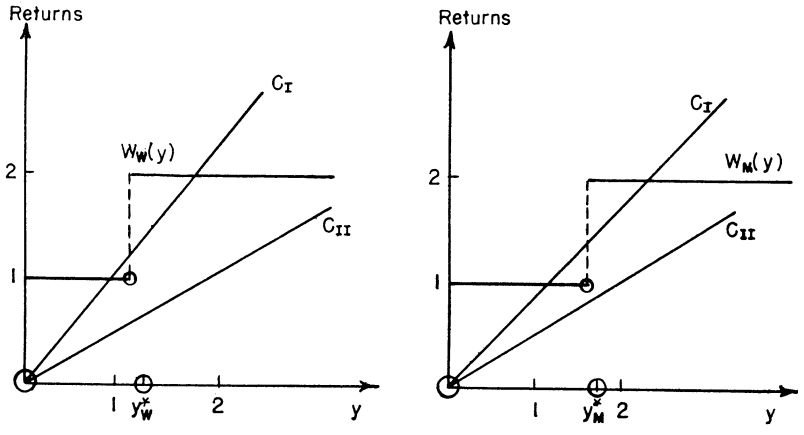

FIGURE VI
Market Equilibrium with Sex as an Index

and have less left over to consume in order to convince the employer that they are in the high-productivity group.

Notice that the proportions of high- and low-productivity people in each group do not affect the signaling equilibrium in the market. Hence, our initial assumption that the groups were identical with respect to the distribution of productive characteristics and the incidence of signaling costs was superfluous. More accurately, it was superfluous with respect to this type of equilibrium. As we saw in the educational signaling model, there are other types of equilibrium in which the proportions matter.

Since from an equilibrium point of view men and women really are independent, they might settle into different types of equilibrium. Thus, we might have men signaling $y=y^*_M=1.1$ if they are also in the higher productivity group, while other men set $y=0$. On the other hand, we may find that all women set $y=0$. In this case all women would be paid $2-q_1$, and the upper signaling cutoff point y^*_M would have to be greater than $2q_1$. Notice that all women, including lower productivity women, would be paid more than low-productivity men in this situation.[5] High-productivity women would, of course, be hurt in terms of wages received. It is conceivable, however, that returns net of signaling would be higher for women with productivity of two. In other words, it is possible that

$$2-q_1>w-y^*_{M/2}.$$

5. I have not assumed that employers are prejudiced. If they are, this differential could be wiped out. Perhaps more interestingly laws prohibiting wage discrimination, if enforced, would also wipe it out.

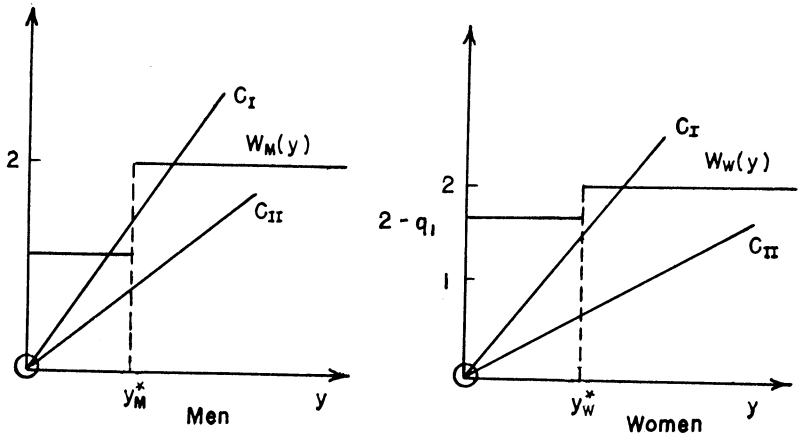

FIGURE VII

Another Equilibrium Configuration in the Market

This will occur when

$$2q_1 < y^*_M.$$

Looking at this situation from outside, one might conclude that women receive lower wages than some men because of a lack of education, which keeps their productivity down. One might then go looking outside the job market for the explanation for the lack of education. In this model the analysis just suggested would be wrong. The source of the signaling and wage differentials is in the informational structure of the market itself.[6]

Because of the independence of the two groups, M and W, at the level of signaling, we can generate many different possible equilibrium configurations by taking any of the educational signaling equilibria in our first model and assigning it to W and then taking any education equilibrium and assigning it to M. However, an exhaustive listing of the possibilities seems pointless at this stage.

We have here the possibility of arbitrary differences in the equilibrium signaling configurations of two or more distinct groups. Some of them may be at a disadvantage relative to the others. Subsets of one may be at a disadvantage to comparable subsets of the others. Since the mechanism that generates the equilibrium is a feedback loop, we might, following Myrdal and others, wish to refer to the situation of the disadvantaged group as a vicious cycle, albeit it an informationally based one. I prefer to refer to the situ-

6. Differential signaling costs over groups are an important possibility pursued in Spence, *op. cit.*

ation of the disadvantaged group as a lower level equilibrium trap, which conveys the notion of a situation that, once achieved, persists for reasons endogenous to the model. The multiple equilibria of the education model translate into arbitrary differences in the equilibrium configuration and status of two groups, as defined as observable, unalterable characteristics.

Conclusions

We have looked at the characteristics of a basic equilibrium signaling model and at one possible type of interaction of signals and indices. There remains a host of questions, which can be posed and partially answered within the conceptual framework outlined here. Among them are the following:

1. What is the effect of cooperative behavior on the signaling game?

2. What is the informational impact of randomness in signaling costs?

3. What is the effect of signaling costs that differ systematically with indices?

4. How general are the properties of the examples considered here?

5. In a multiple-market setting, does the indeterminateness of the equilibrium remain?

6. Do signaling equilibria exist in general?

7. What kinds of discriminatory mechanisms are implicit in, or interact with, the informational structure of the market, and what policies are effective or ineffective in dealing with them?

I would argue further that a range of phenomena from selective admissions procedures through promotion, loans and consumer credit, and signaling status via conspicuous consumption lends itself to analysis with the same basic conceptual apparatus. Moreover, it may be as important to explain the absence of effective signaling as its presence, and here the prerequisites for effective signaling are of some use.

On the other hand, it is well to remember that the property of relative infrequency of appearance by signalers in the market, which defines the class signaling phenomena under scrutiny here, is not characteristic of many markets, like those for consumer durables, and that, as a result, the informational structures of these latter are likely to be quite different.

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