CHAPTER 5

Job Market Signalling

Say employers are recruiting workers. Employers assess the likely productivity of each applicant and offer each a corresponding wage. The problem is – how are employers to know which are the good quality workers? Say, in the extreme, all the applicants 'look alike' (that is, the productivity of the worker is private information). Then if it were left up to the applicants, each would claim to be 'high productivity', and employers would end up paying them all the same wage.

This is another adverse selection problem therefore. But now we shall change the story slightly. Say that the job applicants can, in principle, be distinguished in terms of levels of educational attainment. Some might have left school with no qualifications, some might have A levels, some degrees etc. Good quality job applicants might realise that to get a well paid job they need to 'stand out' in the recruitment process, and hence they invest in a high level of education. Employers might then correctly guess that those applicants with higher attainment are likely to be the more productive workers, and offer them the higher wages.

Why don't *all* the job applicants invest in education to the level required in order to get well paid job offers? The answer to this question, and the reason why the education signal might 'work', lies in the premise that there are costs involved in signalling[1] which are greater for the low ability applicants. (This might be because it is harder in some sense for low ability people to 'make the grade' in education, for example.) As a result, low ability applicants may be deterred from investing in education where the high ability ones are not. The presence of differences in signalling costs for workers of different quality makes the signal of 'education' potentially credible. Thus signalling behaviour may serve to generate information for employers as an endogenous market process.

It is also quite possible, however, for signalling to lead to an equilibemployers end up making expected normal profit from the transaction.[3] 'Confirmation of beliefs' means that employers interpretation of the signal turns out to be true;[4] for example, if an employer believed that an applicant was high productivity on the basis of the observed signal, then in equilibrium (s)he would find after hiring that this was true (if the beliefs were found to be *false*, then the employer would want to change the wage offer).

A signalling equilibrium as set out above is also a Nash equilibrium, in the language of game theory.[5] This is because each of the players in this 'signalling game' is choosing a strategy which is a 'best response' to the other players' strategies. The applicants are choosing education levels which maximize their net return, given the wages on offer and the signalling costs. Each employer chooses wage offers which maximize profits given their beliefs, the strategies of the other employers, and the signalling decisions of the applicants. In equilibrium, none of the players wants to change their decision, given the decisions of the other people.

A Numerical Example

Now we get down to specifics. The following example serves a very similar purpose to the Akerlof (1970) used car market example. That is, it is not (and is not meant to be) realistic as a model of the labour market, but it makes a point very simply and effectively about the sorts of things that can happen in a market where signalling behaviour is prevalent.

Employers and job applicants are taken to be risk neutral. There are two types of job applicants:

type L: productivity = 1, proportion in the population = q,

type H: productivity = 2, proportion in the population = $1 - q$.

That is, it is just worth it to a firm to pay type L (low ability workers) a wage of 1, and type H (high ability) a wage of 2.[6] By the term 'just worth it' we mean that such wage offers would leave firms making normal profit.

Note that the productivity of each worker is assumed to be fixed; the amount of education they receive, for example, does not affect productivity. This helps to keep the numbers simple, and to focus attention on the signalling role of education; it is not difficult, however, to generalize the model to allow for education to affect productivity (see, for example, Spence, 1974; Kreps, 1990*).

We shall also assume that the returns to any worker who did not accept a job of some kind are so low that no worker would voluntarily choose that option (e.g. their productivity if they just stayed at home was zero). The point here is to avoid any 'lemons' problems; if workers could choose not to accept employment, then firms might receive a 'selective sample' of workers. We wish to avoid that issue here to focus attention on the signalling problem.

We now outline two benchmark cases, with which the signalling solutions can be compared.

(A) *Perfect information*: say employers could observe each worker's productivity. Then they would pay each worker their marginal product, so

type L workers would get a wage = type L productivity = 1,

type H workers would get a wage = type H productivity = 2.

This is the classic solution of traditional economic theory, along the lines of perfect competition.

(B) *Imperfect information, no-signalling*: what would happen if employers could not observe productivity and job applicants could not use signals as a way of informing employers? In these circumstances, the only thing employers can do is to give all applicants the same wage (since all applicants 'look alike'). That wage would be given by the (weighted) average level of productivity of the applicants:

$$
\begin{aligned}
w = &\left(\text{productivity of type L}\right)\cdot\left(\text{proportion of type L}\right.\\
&\left.\text{in population}\right)+\left(\text{productivity of type H}\right)\cdot\left(\text{proportion of}\right.\\
&\left.\text{type H in population}\right)\\
&= 1\cdot q + 2\cdot\left(1-q\right)\\
&= 2-q.
\end{aligned}
$$

The more type Ls there are, the nearer is q to 1, and so the nearer is w to 1. Employers make normal expected profits as a result of this wage offer (that is, they make positive profits if the worker turns out to be type H, negative profits if he is type L, and zero profit on average).

Signalling equilibria: separating solutions

Now we allow workers to signal ability via education. As hinted earlier, there are different kinds of signalling equilibrium. Here we deal with the most famous kind, called separating equilibria for reasons that will become apparent. The equilibrium loosely sketched out in the introduction to this chapter was of this kind.

Suppose educational attainment is measured by some number y. For type L workers, the costs of acquiring education rise one-for-one with the level of attainment, that is $c_L = y$. For type H, signalling costs are $c_H = y/2$, that is it costs type H workers half as much to reach any given level of education as it costs type L. Crucially then, it costs more for low ability workers to send the signal than it costs high ability workers. This is called the 'single crossing property' in the literature, and is a precondition for informative signalling, as noted in the introduction.[7]

Costs to education may be monetary and/or psychic. To calculate the monetary *benefits* to education we turn next to an important part of the signalling equilibrium, concerning employers beliefs. Say employers believed that only applicants with some *particular* level of educational attainment (which we will call y^*) or more are high productivity, and the rest are low productivity. That is, if employers observed an applicant with level of education y which had value $y < y^*$ then they would believe that person to be type L and offer him/her a wage $w = 1$; if they observed an applicant with education y which had a value $y \geq y^*$ then they would believe that person to be type H and offer him/her a wage $w = 2$.

These beliefs generate a wage offer schedule of the kind drawn in figure 5.1. Wage offers vary with education hence we write $w(y)$, that is 'wages as a function of education', where in this case we can see $w(y)$ is a 'step function' (jumping from $w = 1$ to $w = 2$ as education reaches y^*). Superimposed on this wage schedule, we have drawn the signalling cost functions $c_L = y$ for type L, and $c_H = y/2$ for type H.

Remember that the first 'move' or decision to be made in this signalling model comes from the job applicant. He/she must choose an education level given the incentive of a higher wage for higher education on the one hand, and the disincentive of the signalling cost on the other. For both type L and type H individuals there is no point in setting their education at any level other than 0 or y^*; signalling $y = 0$ elicits a wage

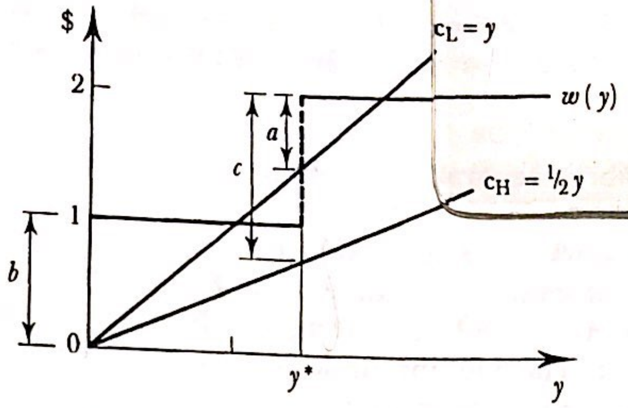

Figure 5.1 A separating equilibrium

offer of $w = 1$; signalling $y = y^*$ elicits a wage offer of $w = 2$. Any other level of the education signal would merely incur signalling costs without any corresponding increase in the wage offer. Both type L and type H workers therefore choose between setting $y = 0$ and setting $y = y^*$ in order to maximize their net return (w – signalling costs).

Consider the situation for type L in the diagram. As we have drawn it, setting education y at the level $y = 0$ yields net return given by distance 'b', whereas setting $y = y^*$ yields net return given by distance 'a'. Since 'a' is less than 'b' we can conclude that it is best for type L people to set $y = 0$, i.e. they do not invest in education. For type H people, however, setting $y = y^*$ yields net return given by distance 'c' (since their signalling costs are lower), whilst $y = 0$ still only yields 'b'. Since 'c' is greater than 'b', it is best for type H people to set $y = y^*$.

Say job applicants signal along these lines, and employers respond with job offers in accordance with their beliefs. Will those beliefs turn out to be confirmed? Employers believed that applicants with $y < y^*$ would all be type L and indeed that is true – the only applicants who have $y < y^*$ actually set $y = 0$, and these are all type L. Employers also believed that applicants with $y \geq y^*$ would all be type H and indeed that is true also – the only applicants who have $y \geq y^*$ actually set $y = y^*$, and these are indeed all type H.[8]

Hence we have satisfied all the conditions for an equilibrium; job applicants are choosing their optimal signal, wages are set at a level equal to expected productivity (implying normal profits), and employers' beliefs are confirmed. This equilibrium holds given the way the diagram is drawn, but in general what are the circumstances under which an equilibrium of this kind holds? To answer this we must find out under what circumstances type L people set $y = 0$, and under what circumstances type separate out the two types of applicants, given the imperfect information in the market.

4 The results do not depend on the proportion of low productivity workers in the population (i.e. q). There could be just a handful of poor workers (q small) and the vast majority of good workers would still incur signalling costs to distinguish themselves from that handful, in this equilibrium.

5 The full information solution outlined above (case (A)) Pareto-dominates all the imperfect information separating equilibria. This is because the wages received by each worker are the same under full information as under (imperfect information) separation; but in the former case no signalling costs are incurred at all (equivalent to everyone setting $y = 0$), whereas in the latter case type H workers must set education at least to level $y = 1$.

6 The 'no-signalling' benchmark case outlined above (case (B)) can also Pareto-dominate some of the separating equilibria. To see this, note the following.

Type L workers are better off with no-signalling: recall that with no-signalling, all applicants get wage $w = 2 - q$. By comparison, in the separating equilibria identified above, type L applicants get $w = 1$ and pay no signalling cost. Clearly, as long as $q < 1$ (there are some type Ls in the population) then the no-signalling wage $w = 2 - q$ is better than a wage of 1, and hence we can conclude that type L would prefer the no-signalling outcome. The reason for this is that in the separating equilibria they get paid their marginal product of 1, but with no-signalling they get a bit more than that because employers think they might be type H (high ability).

Type H workers can be better off with no-signalling: in the separating equilibrium, type H workers' net return (wage minus signalling cost) is $2 - y^*/2$. For them to be better off with no-signalling means the following has to hold:

$$2 - q > 2 - y^*/2$$

which rearranges to yield

$$y^* > 2q$$

For example, say q (the proportion of type Ls in the population) is equal to $\frac{1}{2}$; then if $y^* > 1$, so high ability workers would prefer the no-signalling equilibrium. The intuition for this is that although high ability workers get a higher wage in the separating equilibria, they also pay signalling costs which can outweigh the higher wage.

Employers are indifferent: they make expected profit of zero (normal profit) in all equilibria.

Thus we can conclude that the no-signalling outcome Pareto-dominates many separating equilibria. Once the players are *in* a separating equilibria, however, there is nothing any one person can do unilaterally to 'get back' to the no-signalling case.

7 Education results in negative externalities, in the sense that the marginal private benefit may be positive (that is why type H people invest in it), but the marginal social benefit is always zero since it does not affect the total output of the goods produced in the economy. Education is unproductive, but people still invest in it.

Signalling equilibria: pooling solutions

So far, we have dealt with situations in which the two types of workers end up getting 'separated'. There is a further logical possibility, however, that the workers end up getting 'pooled' – i.e. they send the same signal and get the same wage offer.[10] Can job market signalling generate equilibria in which the workers get pooled in this way? We show here that the answer to this question is 'yes'.

Consider the following example. Say employers held the following probabilistic beliefs:

(i) If a job applicant has education below y^*
(s)he is type L for certain.

(ii) If a job applicant has education at level y^* or above,
(s)he is type L with probability q, and
(s)he is type H with probability $1 - q$.

That is, employers think that low education means low ability for sure, but when an applicant with high education arrives they think it is possible that applicant is high ability, but they might still be low ability. Given competition amongst employers for workers, the belief (i) above means that all workers with $y < y^*$ get offered a wage $w(y < y^*) = 1$; the belief (ii) means that all workers with $y \geq y^*$ get offered a wage $w(y \geq y^*) = 1q + 2(1 - q) = 2 - q$.

The initial move comes from the workers, who must decide whether to set $y = 0$ or set $y = y^*$ (there is no point in setting education at any other level). Say y^* happened to be rather low (we will be precise in a moment), so that all workers decided to set $y = y^*$. That is, for all workers the following is true:[11]

net return from setting $y = y^* \geq$ net return from setting $y = 0$.

For type L workers, this means:

$$w(y = y^*) - c_L(y^*) \geq w(y = 0)$$

that is

$$2 - q - y^* \geq 1$$

and so

$$1 - q \geq y^*. \tag{5.3}$$

For type H workers, it means:

$$w(y = y^*) - c_H(y^*) \geq w(y = 0)$$

that is

$$2 - q - \tfrac{1}{2}y^* \geq 1$$

and so

$$1 - q \geq \tfrac{1}{2}y^*. \tag{5.4}$$

In fact, if we look at these inequalities we see that inequality (5.4) is redundant – if (5.3) is satisfied then (5.4) will automatically be satisfied also (since y cannot be negative). As long as employers' beliefs are such that the former inequality is satisfied ($1 - q \geq y^*$), then both type L and type H job applicants will set $y = y^*$. This situation is captured in figure 5.2. The wage offer would be 1 for all education levels below y^*, jumping to $2 - q$ for $y \geq y^*$, consistent with employers' beliefs. The distance '*a*' gives the net return to type L workers at $y = y^*$, and this is clearly more than distance '*b*' which is the net return at $y = 0$. The distance '*c*' gives the net return to type H workers at $y = y^*$, and this is also more than '*b*'.

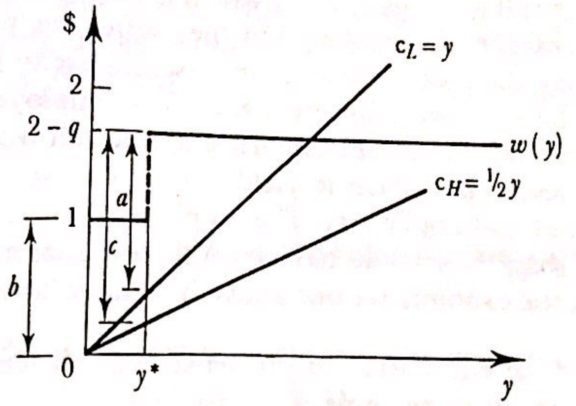

Figure 5.2 A pooling equilibrium

It is in the interests of both worker types to signal $y = y^*$ in this situation. Employers respond by offering all applicants a wage of $2 - q$, consistent with their prior probabilistic beliefs. Are the beliefs confirmed? Belief (i) above is never wrong, since no workers set $y < y^*$ and hence this belief is never tested. Belief (ii) above is shown to be right at least in so far as observing applicants with $y = y^*$ employers will find that such workers are type L with probability q, as expected. This is because all workers set $y = y^*$ so the probability that any individual worker will turn out to be type L is the same as that from a random draw from the population, and the proportion of type L workers in the population is exactly q. Employers beliefs are confirmed. Furthermore, they make normal expected profits since wage offers equal productivity on average. Hence, we can conclude that we have an equilibrium in which workers are pooled, each sending the same signal (y^*) and receiving the same wage $2 - q$.

We said earlier that y^* had to be 'low' for this to work. By this we meant that inequality (5.3) above

$$1 - q \geq y^*$$

had to hold. So if $q = \frac{1}{2}$ for example (half the population is type L, the other half is type H), then y^* would have to be no more than a half.

Say y^* was actually fixed at a value of $y^* = 0$ (which trivially satisfies $1 - q \geq y^*$). Then the outcome would exactly reproduce the 'no signalling benchmark' case – all workers receive the same wage $w = 2 - q$, and no signalling costs are incurred. However, it is also possible to have $y^* > 0$ and still satisfy the condition $1 - q \geq y^*$. In this event, it is individually rational for workers to pay the signalling costs, and yet overall no one benefits. Workers still get a wage $2 - q$ which is exactly what they would have got in the absence of signalling, but they suffer the 'pain' of getting education (i.e. pay the costs). And in this case, no useful information is transmitted to the employers by the signal. The employers' beliefs are confirmed but the signal is completely useless, since all workers invest in it to the same level and hence it yields no power for distinguishing between good and bad applicants. The employers are quite literally no better informed than they would have been if the signal had not existed.

Overall then, the example set out above has the following properties:

1 It yields 'pooling equilibria', in the sense that all workers send the same signal y^* and get the same wage ($w = 2 - q$). Type L workers successfully mimic the behaviour of the type Hs by sending the same signal, degrading the information content of the signal until it is as worthless as the verbal assurance of the used car seller who says his car is good quality. The signal is uninformative.

2 The equilibria are not unique. Any value of y^* between 0 and $1 - q$ will do to sustain the solution, given the employers' beliefs. Thus there are an infinite number of these pooling equilibrium, as well as the infinite number of separating equilibria identified earlier.

3 The different equilibria are once again not equivalent from a welfare point of view. Higher values of y^* impose costs on both types of workers, without making anyone better off – hence equilibria with y^* closer to $1 - q$ are Pareto-inferior to those with y^* closer to 0.

4 The equilibrium does depend on the proportion of low productivity workers in the population (q). For example, the pooling wage w will be higher, the fewer such workers there are in the population. However, for any value of q such that $0 < q < 1$, a set of pooling equilibria can be found.

5 The full information solution (case (A)) does *not* Pareto-dominate the (imperfect information) pooling equilibria, and vice versa. Type L workers are better off under pooling; they get $2 - q - y^*$ which is at least as much as their full information return of 1 (given that $1 - q \geq y^*$). Type H workers are worse off under pooling; they get $2 - q - \frac{1}{2}y^*$ which is less than their full information return of 2.

6 The no-signalling benchmark (case (B)) (quite obviously) Pareto-dominates the pooling equilibria for any $y^* > 0$. Workers get the same wage $w = 2 - q$ in either case, but with pooling equilibria they have to pay signalling costs and if these are positive ($y^* > 0$) that leaves them worse off than with no-signalling.