

Labor Economics, 14.661. Lectures 4 and 5: Externalities and Peer Effects

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Introduction

- General interest over the recent decade or so on various aspects of labor market externalities.
- Two different aspects of externalities:
 - 1 Externalities in (local) labor markets due to production, matching or other market interactions.
 - 2 Externalities in social environments, including schools, friendships, networks etc.
- Both types of externalities may be important in practice and have major welfare consequences.
- Both types of externalities present a range of challenges in estimation.

Labor Market Externalities

- Labor market externalities \approx the productivity of a worker in his or her job affects the productivity of others.
- Three key questions:
 - ① Why will this be the case?
 - ② When will this be an externality?
 - ③ What interactions are important and how does the market deal with the allocation of workers across jobs and firms?

Externalities

- Imagine your coworkers' human capital makes you more productive
 - e.g., academics would like to be together with other high-quality academics
- Imagine your production function is

$$y = f(h, \bar{H})$$

where \bar{H} is the average human capital of your coworkers.

- This is a *technological* spillover of productivity.
- Is it an externality?

Externalities (continued)

- Not necessarily.
- If all of the spillover is within the firm, the firm will internalize it in its hiring decisions and in its compensation of different workers with different amounts of human capital.
- In that case, there is a technological spillover, but no labor market externality.
- Externalities require
 - ① either that productivity spillovers are beyond firm boundaries
 - ② or that firms are unable to compensate workers appropriately for their contribution to their coworkers' productivity (why would this be the case?)
- Let us now focus on externalities.

Nonpecuniary Externalities

- Nonpecuniary externalities \approx technological spillovers of productivity that are not internalized by prices.
- Canonical example due to Jane Jacobs *The Economy of Cities*: managers from different companies exchange ideas.
- Very popular in economics (e.g., Lucas's famous 1986 endogenous growth model)
- What other contexts would this be important in?

Nonpecuniary Externalities (continued)

- A simple model of nonpecuniary externalities:
- Suppose that the output (or marginal product) of a worker, i , is

$$y_i = Ah_i^\nu,$$

where h_i is the human capital (schooling) of the worker, and A is aggregate productivity.

- Assume that labor markets are competitive. So individual earnings are $W_i = Ah_i^\nu$.
- Key idea: the exchange of ideas among workers raises productivity.
- This can be modeled by allowing A to depend on aggregate human capital. In particular, suppose that

$$A = BH^\delta \equiv \mathbb{E} [h_i]^\delta, \quad (1)$$

where H is a measure of aggregate human capital, \mathbb{E} is the expectation operator, B is a constant.

Nonpecuniary Externalities (continued)

- Individual earnings can then be written as

$$W_i = Ah_i^v = BH^\delta h_i^v.$$

- Taking logs:

$$\ln W_i = \ln B + \delta \ln H + v \ln h_i. \quad (2)$$

- If external effects are stronger within a geographical area, as seems likely in a world where human interaction and the exchange of ideas are the main forces behind the externalities, then equation (2) should be estimated using measures of H at the local level.
- This is a theory of non-pecuniary externalities, since the external returns arise from the technological nature of equation (1).
- Nonpecuniary externalities unattractive for a number of reasons:
 - Very reduced form.
 - Do we really expect workers in chemical factories to have a direct productivity effect on retail workers?

Nonpecuniary Externalities (continued)

- Instead, more compelling sources of spillovers:
 - Interactions in the labor market mediated by prices, but externalities might still be at present; *pecuniary externalities*.
 - Interactions in the product market; when computer users become more productive, they can supply cheaper computers to retail companies, again pecuniary externalities.
 - Interactions via R&D and innovation; the semiconductor or the combustion engine have increased the productivity of many workers in many different sectors of the economy.
- The last one may or may not be a pecuniary externality.
- However, except those working in the labor market, the remaining externalities would be economy-wide (sometimes even world-wide), thus difficult to estimate with cross-sectional or panel data variation.
- Thus, let us focus on labor market interactions.

Pecuniary Externalities

- Will pecuniary externalities matter?
- Not in Arrow-Debreu.
- Why not?
- Could they matter in other environments?
- The answer is “perhaps yes”—if we are away from the complete markets benchmark.

Pecuniary Externalities (continued)

- First suggested in Alfred Marshall's *Principles of Economics* in the context of benefits of geographic concentration of industry.
- A complementary story with labor market imperfections, innovation investment by firms and training by workers developed in Acemoglu (1997).
 - Firms find it profitable to invest in new technologies only when there is a sufficient supply of trained workers to replace employees who quit.
- This is a *nonpecuniary* externality, since it is not built in in the form of technological spillovers, but works through market interactions and results from the fact that prices at which labor is transacted is not equal to its marginal product.
- A related model developed in Acemoglu (1996). Here is simplified version of this model.

Pecuniary Externalities (continued)

- Consider an economy lasting two periods, with production only in the second period, and a continuum of workers normalized to 1.
- Take human capital of each worker i , h_i , as given.
- A continuum of risk-neutral firms.
- In period 1, firms make an irreversible investment decision, k , at cost Rk .
- Workers and firms come together in the second period.
- The labor market is not competitive; instead, firms and workers are matched randomly, and each firm meets a worker.
- The only decision workers and firms make after matching is whether to produce together or not to produce at all (since there are no further periods).

Pecuniary Externalities (continued)

- If firm f and worker i produce together, their output is

$$k_f^\alpha h_i^\nu, \quad (3)$$

where $\alpha < 1$, $\nu \leq 1 - \alpha$.

- Since it is costly for the worker-firm pair to separate and find new partners in this economy, employment relationships generate quasi-rents.
- Wages will therefore be determined by rent-sharing. Here, simply assume that the worker receives a share β of this output as a result of bargaining, while the firm receives the remaining $1 - \beta$ share (a simplified version of Nash bargaining).
- An equilibrium in this economy is a set of schooling choices for workers and a set of physical capital investments for firms.

Pecuniary Externalities (continued)

- Firm f maximizes the following expected profit function:

$$(1 - \beta)k_f^\alpha \mathbb{E}[h_i^v] - Rk_f, \quad (4)$$

with respect to k_f .

- Since firms do not know which worker they will be matched with, their expected profit is an average of profits from different skill levels.
- The function (4) is strictly concave, so all firms choose the same level of capital investment, $k_f = k$, given by

$$k = \left(\frac{(1 - \beta)\alpha H}{R} \right)^{1/(1-\alpha)}, \quad (5)$$

where

$$H \equiv \mathbb{E}[h_i^v]$$

is the measure of aggregate human capital.

Pecuniary Externalities (continued)

- Now the equilibrium is straightforward to characterize.
- Substituting (5) into (3), and using the fact that wages are equal to a fraction β of output, the wage income of individual i is given by

$$W_i = \beta ((1 - \beta)\alpha H)^{\alpha/(1-\alpha)} R^{-\alpha/(1-\alpha)} (h_i)^{\nu}.$$

- Taking logs, this is:

$$\ln W_i = c + \frac{\alpha}{1 - \alpha} \ln H + \nu \ln h_i, \quad (6)$$

where c is a constant and $\alpha/(1 - \alpha)$ and ν are positive coefficients.

- The presence of $\ln H$ on the right hand side corresponds to *positive pecuniary externalities* (in the local labor market).

Pecuniary Externalities (continued)

- Human capital externalities arise here because firms choose their physical capital in anticipation of the average human capital of the workers they will employ in the future.
- Since physical and human capital are complements in this setup, a more educated labor force encourages greater investment in physical capital and to higher wages.
- In the absence of the need for search and matching, firms would immediately hire workers with skills appropriate to their investments, and there would be no human capital externalities.
- Nonpecuniary and pecuniary theories of human capital externalities lead to similar empirical relationships since equation (6) is identical to equation (2), with $c = \ln B$ and $\delta = \alpha / (1 - \alpha)$.
- Again presuming that these interactions exist in local labor markets, we can estimate a version of (2) using differences in schooling across labor markets (cities, states, or even countries).

Signaling and Negative Externalities

- The above models focused on positive externalities to education.
- In contrast, in a world where education plays a signaling role, we might also expect significant *negative externalities*.
- Consider the most extreme world in which education is only a signal—it does not have any productive role.
- Contrast two situations: in the first, all individuals have 12 years of schooling and in the second all individuals have 16 years of schooling.
- Since education has no productive role, and all individuals have the same level of schooling, in both allocations they will earn exactly the same wage (equal to average productivity).

Signaling and Negative Externalities (continued)

- Therefore, here the increase in aggregate schooling does not translate into aggregate increases in wages.
- But in the same world, if one individual obtains more education than the rest, there will be a private return to him, because he would signal that he is of higher ability.
- Therefore, in a world where signaling is important, we might also want to estimate an equation of the form (2), but when signaling issues are important, we would expect δ to be negative.
- The general idea here is that in this world, what determines an individual's wages is his "ranking" in the signaling distribution.
- When others invest more in their education, a given individual's rank in the distribution declines, hence others are creating a negative externality on this individual via their human capital investment.

Evidence

- Ordinary Least Squares (OLS) estimation of equations like (2) using city or state-level data yield very significant and positive estimates of δ , indicating substantial positive human capital externalities; e.g., Jim Rauch's paper in the *Journal of Urban Economics*.
- There are at least two problems with this type OLS estimates.
- **First problem:** high-wage cities or states may attract a large number of high education workers or give strong support to education.
 - Rauch uses a cross-section of cities.
 - Including city or state fixed affects ameliorates this problem, but does not solve it, since states' attitudes towards education and the demand for labor may comove. The ideal approach would be to find a source of quasi-exogenous variation in average schooling across labor markets.
- Acemoglu and Angrist (2000): exploit exogenous sources of variation due to cross-state differences in compulsory schooling laws. The advantage is that these laws not only affect individual schooling but average schooling in a given area.

Evidence (continued)

- **Second problem:** even if we have an instrument for average schooling in the aggregate, estimates of labor market externalities might be spurious.
- In particular, if individual schooling is measured with error (or for some other reason OLS returns to individual schooling are not the causal effect), some of this discrepancy between the OLS returns and the causal return may load on average schooling, even when average schooling is instrumented.
- This suggests that we may need to instrument for individual schooling as well (so as to get to the correct return to individual schooling).

Evidence (continued)

- To elaborate on the second problem, let Y_{ijt} be the log weekly wage, then the estimating equation is

$$Y_{ijt} = X_{ij}'\mu + \delta_j + \delta_t + \gamma_1 \bar{S}_{jt} + \gamma_2 s_i + u_{jt} + \varepsilon_i, \quad (7)$$

- To illustrate the main issues, ignore time dependence, and consider the population regression of Y_i on s_i :

$$Y_{ij} = \mu_0 + \rho_0 s_i + \varepsilon_{0i}; \text{ where } \mathbb{E}[\varepsilon_{0i}s_i] \equiv 0. \quad (8)$$

- Next consider the IV population regression using a full set of state dummies. This is equivalent to

$$Y_{ij} = \mu_1 + \rho_1 \bar{S}_j + \varepsilon_{1i}; \text{ where } \mathbb{E}[\varepsilon_{1i}\bar{S}_j] \equiv 0, \quad (9)$$

since the projection of individual schooling on a set of state dummies is simply average schooling in each state.

Evidence (continued)

- Now consider the estimation of the empirical analogue of equation (2):

$$Y_{ij} = \mu^* + \pi_0 s_i + \pi_1 \bar{S}_j + \xi_i; \text{ where } \mathbb{E}[\xi_i s_i] = \mathbb{E}[\xi_i \bar{S}_j] \equiv 0. \quad (10)$$

- Then, we have

$$\begin{aligned} \pi_0 &= \rho_1 + \phi(\rho_0 - \rho_1) \\ \pi_1 &= \phi(\rho_1 - \rho_0) \end{aligned} \quad (11)$$

where

$$\phi = 1/1 - R^2 > 1,$$

and R^2 is the first-stage R-squared for the 2SLS estimates in (9).

- Therefore, when $\rho_1 > \rho_0$, for example because there is measurement error in individual schooling, we may find positive external returns even when there are none.

Evidence (continued)

- What can be done?
- Instrument for both individual and average schooling, we would solve this problem.
- But what type of instrument?
- Consider the relationship of interest:

$$Y_{ij} = \mu + \gamma_1 \bar{S}_j + \gamma_{2i} s_i + u_j + \varepsilon_i, \quad (12)$$

which could be estimated by OLS or instrumental variables, to obtain an estimate of γ_1 as well as an average estimate of γ_{2i} , say γ_2^* .

- An alternative way of expressing this relationship is to adjust for the effect of individual schooling by directly rewriting (12):

$$\begin{aligned} Y_{ij} - \gamma_2^* s_i &\equiv \tilde{Y}_{ij} \\ &= \mu + \gamma_1 \bar{S}_j + [u_j + \varepsilon_i + (\gamma_{2i} - \gamma_2^*) s_i]. \end{aligned} \quad (13)$$

Evidence (continued)

- In this case, instrumental variables estimate of external returns is equivalent to the Wald formula

$$\begin{aligned}
 \gamma_1^{IV} &= \frac{\mathbb{E}[\tilde{Y}_{ij}|z_i = 1] - \mathbb{E}[\tilde{Y}_{ij}|z_i = 0]}{\mathbb{E}[\bar{S}_j|z_i = 1] - \mathbb{E}[\bar{S}_j|z_i = 0]} \\
 &= \gamma_1 + \left[\frac{\mathbb{E}[\gamma_{2i}s_i|z_i = 1] - \mathbb{E}[\gamma_{2i}s_i|z_i = 0]}{\mathbb{E}[s_i|z_i = 1] - \mathbb{E}[s_i|z_i = 0]} - \gamma_2^* \right] \\
 &\quad \times \left[\frac{\mathbb{E}[s_i|z_i = 1] - \mathbb{E}[s_i|z_i = 0]}{\mathbb{E}[\bar{S}_j|z_i = 1] - \mathbb{E}[\bar{S}_j|z_i = 0]} \right].
 \end{aligned}$$

Evidence (continued)

- This shows that to obtain consistent estimates of external returns to schooling we should set

$$\begin{aligned} \gamma_2^* &= \frac{\mathbb{E}[\gamma_{2i}s_i|z_i = 1] - \mathbb{E}[\gamma_{2i}s_i|z_i = 0]}{\mathbb{E}[s_i|z_i = 1] - \mathbb{E}[s_i|z_i = 0]} \\ &= \frac{\mathbb{E}[(Y_{ij} - \gamma_1\bar{S}_j)|z_i = 1] - \mathbb{E}[(Y_{ij} - \gamma_1\bar{S}_j)|z_i = 0]}{\mathbb{E}[s_i|z_i = 1] - \mathbb{E}[s_i|z_i = 0]} \end{aligned} \quad (14)$$

- This is typically not the OLS estimator of the private return, and we should be using some instrument to simultaneously estimate the private return to schooling. The ideal instrument would be one affecting exactly the same people as the compulsory schooling laws.

Evidence (continued)

- Quarter of birth instruments might come close to this.
- Since quarter of birth instruments are likely to affect the same people as compulsory schooling laws, adjusting with the quarter of birth estimate, or using quarter of birth dummies as instrument for individual schooling, is the right strategy.
- So the strategy is to estimate an equation similar to (2) or (10) using compulsory schooling laws for average schooling and quarter of birth dummies for individual schooling.
- The estimation results from using this strategy in Acemoglu and Angrist (2000) suggest that there are no significant external returns.
- The estimates are typically around 1 or 2 percent, and statistically not different from zero.
- They also suggest that in the aggregate signaling considerations are unlikely to be very important (at the very least, they do not dominate positive externalities).

Peer Effects

- Issues of school quality are also intimately linked to those of externalities.
- An important type of externality, different from the external returns to education discussed above, arises in the context of education is peer group effects, or generally social effects in the process of education.
- The fact that children growing up in different areas may choose different role models will lead to this type of externalities/peer group effects.
- This is intuitive: to the extent that schooling and learning are group activities, there could be this type of peer group effects.
- But important theoretical and empirical challenges in understanding and estimating peer effects.

Segregation and Mixing

- An important question is whether the presence of peer group effects has any particular implications for the organization of schools, and in particular, whether children who provide positive externalities on other children should be put together in a separate school or classroom.
- The basic issue here is equivalent to an *assignment problem*.
- The general principle in assignment problems, such as Becker's famous model of marriage, is that if inputs from the two parties are complementary, there should be assortative matching, that is the highest quality individuals should be matched together.

Segregation and Mixing (continued)

- In the context of schooling, this implies that children with better characteristics, who are likely to create more positive externalities and be better role models, should be segregated in their own schools, and children with worse characteristics, who will tend to create negative externalities will, should go to separate schools.
- This practically means segregation along income lines, since often children with “better characteristics” are those from better parental backgrounds, while children with worse characteristics are often from lower socioeconomic backgrounds

Segregation and Mixing (continued)

- However a potential confusion in the literature: deducing complementarity from the fact that in equilibrium we do observe segregation;
 - e.g., rich parents sending their children to private schools with other children from rich parents, or living in suburbs and sending their children to suburban schools, while poor parents live in ghettos and children from disadvantaged backgrounds go to school with other disadvantaged children in inner cities.
- This reasoning is often used in discussions of *Tiebout competition*, together with the argument that allowing parents with different characteristics/tastes to sort into different neighborhoods will often be efficient.

Segregation and Mixing (continued)

- The underlying idea can be given by the following simple model.
- Suppose that schools consist of two kids, and denote the parental background (e.g., home education or parental expenditure on non-school inputs) of kids by e , and the resulting human capitals by h .
- Suppose

$$\begin{aligned}h_1 &= e_1^\alpha e_2^{1-\alpha} \\h_2 &= e_1^{1-\alpha} e_2^\alpha\end{aligned}\tag{15}$$

where $\alpha > 1/2$.

- This implies that parental backgrounds are complementary, and each kid's human capital will depend mostly on his own parent's background, but also on that of the other kid in the school.
- For example, it may be easier to learn or be motivated when other children in the class are also motivated. This explains why we have

$$\partial h_1 / \partial e_2 > 0 \text{ and } \partial h_2 / \partial e_1 > 0.$$

Segregation and Mixing (continued)

- More important than the positive first derivatives are the *cross-partial derivatives*.
- The human capital production function (15) implies that

$$\partial^2 h_1 / \partial e_2 \partial e_1 > 0 \text{ and } \partial^2 h_2 / \partial e_1 \partial e_2 > 0.$$

- This implies that the backgrounds of the two kids are complementary.
- This implies that a classmate with a good background is especially useful to another kid with a good background.
- We can think of this as the “bad apple” theory of classroom: one bad kid in the classroom brings down everybody.

Segregation and Mixing: Digression

- Notice an important feature of the way we wrote (15) linking the outcome variables, h_1 and h_2 , to predetermined characteristics of children e_1 and e_2 , which creates a direct analogy with the human capital externalities discussed above.
- However, this may simply be the reduced form of that somewhat different model, for example,

$$\begin{aligned}h_1 &= H_1(e_1, h_2) \\ h_2 &= H_2(e_2, h_1)\end{aligned}\tag{16}$$

whereby each individual's human capital depends on his own background and the human capital choice of the other individual.

- Although in reduced form (15) and (16) are very similar, they provide different interpretations of peer group effects, and econometrically they pose different challenges, which we will discuss below.

Segregation and Mixing (continued)

The complementarity in the human capital production function (15) has two implications:

- 1 It is socially efficient, in the sense of maximizing the sum of human capitals, to have parents with good backgrounds to send their children to school with other parents with good backgrounds.
 - This follows simply from the definition of complementarity, positive cross-partial derivative, which is clearly verified by the production functions in (15).
- 2 It will also be an equilibrium outcome that parents will do so.

Segregation and Mixing (continued)

- To see that segregation is an equilibrium, suppose that we have a situation in which there are two sets of parents with background e_l and $e_h > e_l$.
- Suppose that there is mixing.
- Now the marginal willingness to pay of a parent with the high background to be in the same school with the child of another high-background parent, rather than a low-background student, is

$$e_h - e_h^\alpha e_l^{1-\alpha}.$$

Segregation and Mixing (continued)

- Instead, the marginal willingness to pay of a low background parent to stay in the school with the high background parents is

$$e_l^\alpha e_h^{1-\alpha} - e_l.$$

- The complementarity between e_h and e_l in (15) implies that $e_h - e_h^\alpha e_l^{1-\alpha} > e_l^\alpha e_h^{1-\alpha} - e_l$.
- Therefore, the high-background parent can always outbid the low-background parent for the privilege of sending his children to school with other high-background parents.
- Thus with profit maximizing schools, segregation will arise as the outcome.

Segregation and Mixing (continued)

- The results are very different when the human capital production function features negative cross-partial derivatives, i.e., “substitutes”.
- For example,

$$\begin{aligned} h_1 &= \phi e_1 + e_2 - \lambda e_1^{1/2} e_2^{1/2} \\ h_2 &= e_1 + \phi e_2 - \lambda e_1^{1/2} e_2^{1/2} \end{aligned} \quad (17)$$

where $\phi > 1$ and $\lambda > 0$ but small, so that human capital is increasing in parental background.

- With this production function, we again have $\partial h_1 / \partial e_2 > 0$ and $\partial h_2 / \partial e_1 > 0$, but now in contrast to (15), we now have

$$\frac{\partial^2 h_1}{\partial e_2 \partial e_1} \text{ and } \frac{\partial^2 h_2}{\partial e_1 \partial e_2} < 0.$$

- This can be thought as corresponding to the “good apple” theory of the classroom, where the kids with the best characteristics and attitudes bring the rest of the class up.

Segregation and Mixing (continued)

- In this case, because the cross-partial derivative is negative, the marginal willingness to pay of low-background parents to have their kid together with high-background parents is higher than that of high-background parents.
- With perfect markets, we will observe mixing, and in equilibrium schools will consist of a mixture of children from high- and low-background parents.
- Now combining the outcomes of these two models, many people jump to the conclusion that since we do observe segregation of schooling in practice, parental backgrounds must be complementary, so segregation is in fact efficient.
- Again the conclusion is that allowing Tiebout competition and parental sorting will most likely achieve efficient outcomes.
- However, this conclusion is not correct; even if the correct production function was (17), segregation would arise in the presence of credit market problems.

Segregation and Mixing (continued)

- The way that mixing is supposed to occur with (17) is that low-background parents make a payment to high-background parents so that the latter send their children to a mixed school.
- To see why such payments are necessary, recall that even with (17) we have that the first derivatives are positive, that is

$$\frac{\partial h_1}{\partial e_2} > 0 \text{ and } \frac{\partial h_2}{\partial e_1} > 0.$$

- This means that everything else being equal all children benefit from being in the same class with other children with good backgrounds. With (17), however, children from better backgrounds benefit *less* than children from less good backgrounds. This implies that there has to be payments from parents of less good backgrounds to high-background parents.

Segregation and Mixing (continued)

- Payments from poor background families to better off families to ensure mixing are both difficult to implement in practice, and practically impossible taking into account the credit market problems facing parents from poor socioeconomic status.
- Therefore, if the true production function is (17) but there are credit market problems, we will observe segregation in equilibrium, and the segregation will be inefficient.
- This implies that we cannot simply appeal to Tiebout competition, or deduce efficiency from the equilibrium patterns of sorting.
- Another implication of this analysis is that in the absence of credit market problems (and with complete markets), cross-partials determine the allocation of students to schools.
- With credit market problems, first there of it has become important.
- This is a general result, with a range of implications for empirical work.

The Benabou Model

- A similar point is developed by Benabou even in the absence of credit market problems, but relying on other missing markets.
- His model has competitive labor markets, and local externalities (externalities in schooling in the local area).
- All agents are assumed to be ex ante homogeneous, and will ultimately end up either low skill or high skill.
- Utility of agent i is assumed to be

$$U^i = w^i - c^i - r^i$$

where w is the wage, c is the cost of education, which is necessary to become both low skill or high skill, and r is rent.

The Benabou Model (continued)

- The cost of education is assumed to depend on the fraction of the agents in the neighborhood, denoted by x , who become high skill. In particular, we have $c_H(x)$ and $c_L(x)$ as the costs of becoming high skill and low skill.
- Both costs are decreasing in x , meaning that when there are more individuals acquiring high skill, becoming high skill is cheaper (positive peer group effects).
- In addition,

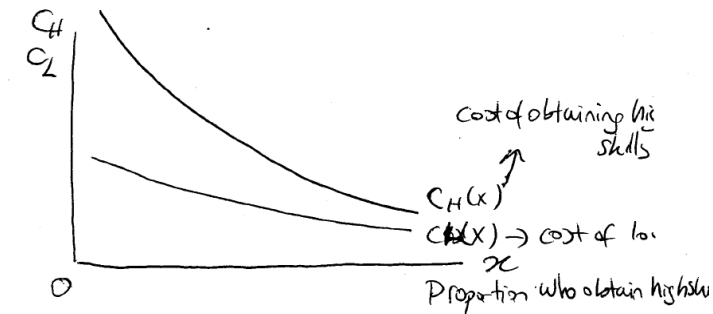
$$c_H(x) > c_L(x)$$

so that becoming high skill is always more expensive.

The Benabou Model (continued)

- More importantly, the effect of increase in the fraction of high skill individuals in the neighborhood is bigger on the cost of becoming high skill.

$$c'_H(x) < c'_L(x),$$



The Benabou Model (continued)

- Since all agents are ex ante identical, in equilibrium we must have

$$U(L) = U(H)$$

that is, the utility of becoming high skill and low skill must be the same.

- Assume that the labor market in the economy is global, and takes the constant returns to scale form $F(H, L)$.
- The important implication here is that irrespective of where the worker obtains his education, he will receive the same wage as a function of his skill level.
- Also assume that there are two neighborhoods of fixed size, and individuals will compete in the housing market to locate in one neighborhood or the other.

The Benabou Model (continued)

- There can be two types of equilibria:
- ① Integrated city equilibrium, where in both neighborhoods there is a fraction \hat{x} of individual obtaining high education.

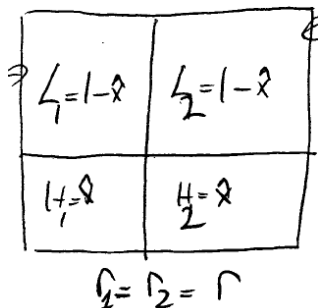


Figure: Integrated City Equilibrium

The Benabou Model (continued)

2. Segregated city equilibrium, where one of the neighborhoods is homogeneous. For example, we could have a situation where one neighborhood has $x = 1$ and the other has $\tilde{x} < 1$, or one neighborhood has $x = 0$ and the other has $\bar{x} > 0$.

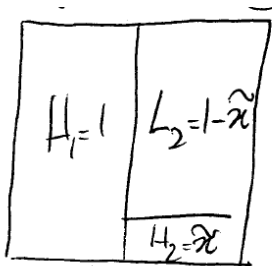


Figure: Segregated City Equilibrium

The Benabou Model (continued)

- The important observation here is that only segregated city equilibria are “stable”.
- To see this consider an integrated city equilibrium, and imagine relocating a fraction ε of the high-skill individuals (that is individuals getting high skills) from neighborhood 1 to neighborhood 2.
- This will reduce the cost of education in neighborhood 2, both for high and low skill individuals.
- But by assumption, it reduces it more for high skill individuals, so all high skill individuals now will pay higher rents to be in that city, and they will outbid low-skill individuals, taking the economy toward the segregated city equilibrium.

The Benabou Model (continued)

- In contrast, the segregated city equilibrium is always stable.
- Thus segregation arises as the equilibrium (stable equilibrium) outcome, because of “complementarities”.
- As in the previous model with spillovers between students within the school, high-skill individuals can outbid the low-skill individuals because they benefit more from the peer group effects of high skill individuals.
- But crucially there are again *missing markets* in this economy.
- In particular, rather than paying high skill individuals for the positive externalities that they create, as would be the case in complete markets, agents transact simply through the housing market.
- In the housing market, there is only one rent level, which both high and low skill individuals pay.
- In contrast, with complete markets, housing prices would be such that high skill individuals pay a lower rent (to be compensated for the positive externality that they are creating on the other individuals).

The Benabou Model (continued)

- This discussion implies that there are missing markets, and efficiency is not guaranteed.
- Is the allocation with segregation efficient?
- It turns out that it may or may not.
- To see this consider the problem of a utilitarian social planner maximizing total output minus costs of education for workers.
- This implies that the social planner will maximize

$$F(H, L) - H_1 c_H(x_1) - H_2 c_H(x_2) - L_1 c_L(x_1) - L_2 c_L(x_2)$$

where

$$x_1 = \frac{H_1}{L_1 + H_1} \text{ and } x_2 = \frac{H_2}{L_2 + H_2}$$

The Benabou Model (continued)

- This problem can be broken into two parts:
 - 1 the planner will choose the aggregate amount of skilled individuals, and then she will choose how to actually allocate them between the two neighborhoods.
 - 2 then, there is simple cost minimization, and the solution depends on whether

$$\Phi(x) = xc_H(x) + (1-x)c_L(x)$$

is concave or convex.

This function is simply the cost of giving high skills to a fraction x of the population.

When it is convex, it means that it is best to choose the same level of x in both neighborhoods, and when it is concave, the social planner minimizes costs by choosing two extreme values of x in the two neighborhoods.

The Benabou Model (continued)

- It turns out that this function can be convex, i.e. $\Phi''(x) > 0$. More specifically, we have:

$$\Phi''(x) = 2(c'_H(x) - c'_L(x)) + x(c''_H(x) - c''_L(x)) + c''_L(x)$$

We can have $\Phi''(x) > 0$ when the second and third terms are large. Intuitively, this can happen because although a high skill individual benefits more from being together with other high skill individuals, he is also creating a positive externality on low skill individuals when he mixes with them.

- This externality is not internalized, potentially leading to inefficiency.
- This model gives another example of why equilibrium segregation does not imply efficient segregation.

Econometric Issues

- Peer group effects are generally difficult to identify. In addition, we can think of two alternative formulations where one is practically impossible to identify satisfactorily.
- To discuss these issues, let us go back to the previous discussion, and recall that the two “structural” formulations, (15) and (16), have very similar reduced forms, but the peer group effects work quite differently, and have different interpretations.
- In (15), it is the (predetermined) characteristics of my peers that determine my outcomes, whereas in (16), it is the outcomes of my peers that matter.
- Above we saw how to identify externalities in human capital, which is in essence similar to the structural form in (15).

Econometric Issues (continued)

- To develop this point further, consider

$$y_{ij} = \theta x_{ij} + \alpha \bar{X}_j + \varepsilon_{ij} \quad (18)$$

where \bar{X} is average characteristic (e.g., average schooling) and y_{ij} is the outcome of the i th individual in group j .

- Here, for identification all we need is exogenous variation in \bar{X} .
- The alternative is

$$y_{ij} = \theta x_{ij} + \alpha \bar{Y}_j + \varepsilon_{ij} \quad (19)$$

where \bar{Y} is the average of the outcomes.

- The parameter α is now practically impossible to identify (why?).

Econometric Issues (continued)

- Since \bar{Y}_j does not vary by individual, this regression amounts to one of \bar{Y}_j on itself at the group level.
- This is a serious econometric problem.
- One imperfect way to solve this problem is to replace \bar{Y}_j on the right hand side by \bar{Y}_j^{-i} which is the average excluding individual i .
- Another approach is to impose some timing structure.
- For example:

$$y_{ijt} = \theta x_{ijt} + \alpha \bar{Y}_{j,t-1} + \varepsilon_{ijt}$$

- There are still some serious problems irrespective of the approach taken;
 - 1 the timing structure is arbitrary, and
 - 2 there is no way of distinguishing peer group effects from “common shocks”.

Econometric Issues and Evidence

- As a concrete example of these problems, consider the paper by Sacerdote (2001), which uses random assignment of roommates in Dartmouth.
- He finds that the GPAs of randomly assigned roommates are correlated, and interprets this as evidence for peer group effects.
- Despite the very nice nature of the experiment, the conclusion is problematic, because Sacerdote attempts to identify (19) rather than (18).
- For example, to the extent that there are common shocks to both roommates;
 - e.g., they are in a noisier dorm), this may not reflect peer group effects.
- This identification problem would not have arisen if the right-hand side regressor was some predetermined characteristic of the roommate
 - in this case, we would be estimating something similar to (18) rather than (19).

Peer Effects in Workplaces

- A recent literature empirically estimates peer effects in workplaces.
- Idea: if your coworkers are more productive or work harder, you will be more productive.
- Examples: Mas and Moretti; Bandiera, Barankay and Rasul. But see also Guryan, Kroft, and Notowidigdo.

Peer Effects in Social Interactions

- A large social networks literature focusing on social interactions.
- Examples:
 - Crime: e.g., Glaeser, Sacerdote and Scheinkman
 - New controversial (and popular) book by Christakis and Fowler: social networks and friends → diet, health, happiness, and everything else.

Policy on the Basis of Peer Effects

- If nonlinear peer facts can be estimated, then one could think of “policy interventions” to estimate these nonlinearities.
 - Recall that if peer effects are purely additive and group size is fixed, no room for doing so.
- Recent creative paper by Carrell, Sacerdote and West (2001), “From Natural Variation to Optimal Policy? The Lucas Critique Meets Peer Effects”.
- Based on an earlier paper by Carrell, Fullerton and West (2009) (and methodological work by Graham, Imbens and Ridder, 2009) which finds nonlinear peer effects that the U.S. Air Force Academy, they have convinced U.S. Air Force to change the composition of squadrons.
- The results in the earlier study, using random assignment resulting from the existing policy of the U.S. Air Force, show that “low ability” cadets (students) benefit most from high ability peers in their squadron.

Endogenous Group Formation?

- Carrell, Sacerdote and West (2001) then design a new assignment (based on a simple optimization approach to have maximum impact on low ability students).
- They then leave some of the squadrons with the old assignment policy to create a control group.
- Essentially, this involves maximizing the number of low ability students assigned to squadrons with high average ability, which means putting many low ability students with the highest ability students in the treatment.
- Their results are surprising: in contrast to their expectations, they find that low ability students in the treatment squadrons do significantly *worse*.
- Why? It seems that endogenous formation of the relevant social groups within squadrons has responded to the bimodal distribution of ability within the squadron!