A simple wage–talent curve illustrates several aspects of higher technical education

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Sohoni's wage–talent curve plots wages offered by an employer against the talent of a prospective employee. I use minor extensions and reinterpretations of this curve to study various aspects of higher technical education in India. The curve provides a convenient vocabulary for discussing why our undergraduates often prefer to study engineering over science, and then avoid core engineering jobs; why and how Ph D programmes attract the students they do; why and how conflicts between faculty members arise on the policies that should govern Ph D programmes; and how we might improve our system in ways consistent with stakeholders' motivations.

Keywords: Employer and employee, higher technical education, talent, wage.

THIS article is prompted by an interesting talk and working paper by Sohoni[1]. Here I explore some consequences of a wage versus talent curve that he uses. I call it 'Sohoni's curve' because he uses it, finds it obvious and does not know a source.

Sohoni's curve provides a vocabulary for discussing many questions that interest us in the higher technical education sphere in India. Why do many of our supposedly best undergraduates prefer to study engineering over science, and is there anything we might do about it? Why do those same engineering students then prefer management consulting or finance jobs over core engineering jobs? What can core engineering companies do if they wish to hire such students? How and why are we, in academia, attracting Ph D students – and of what sort? What might lie behind disagreements within a department or an institute on the rules governing its Ph D programme, and can the true concerns of the disagreeing faculty be meaningfully addressed?

The basic curve is shown in Figure 1. It refers to a single employer, and plots wages offered against the employee's talent. The employee's talent is understood to be a single effective scalar measure of suitability for the company (while talent is multidimensional, companies must rank their candidates anyway). Wages can, if we wish, include the equivalent value of non-cash components like flexible hours, job security, intellectual freedom, or a pleasant working environment.

The figure depicts a minimum talent below which the employer will not hire. Beyond that, wages can initially increase with talent but eventually saturate because the employer is not set up to extract profits from higher talent levels. The employer may choose not to hire beyond a certain talent level because, e.g. such employees might get bored and leave. Sohoni suggests that a bit of unused talent may spur useful innovations from employees with extra skills who want to exhibit them; so a nonzero-length flat portion may be good.

Competing employers

Now suppose that there are many employers, each offering a different wage–talent curve, as shown in Figure 2. Assume that employees wish to maximize their wages. Then employer A will only get talent below level 1, and employer B will only get talent between levels 1 and 2. Employer C, despite offering the second best wages, will get nobody.

An employer that gradually starts demanding more from its employees, and pays them more in return, would be moving its curve upward and to the right. This may not always work out well. For example, moving from A to B might increase wages without improving talent levels. To see significant benefits, the curve must rise above D.
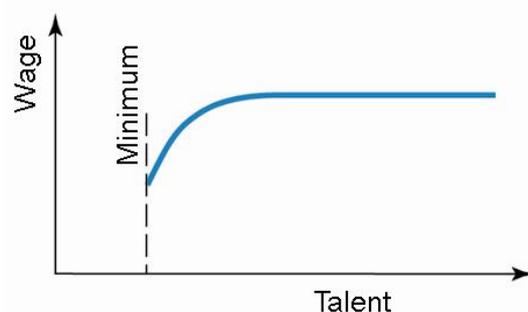
Figure 1. The basic wage–talent curve.

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Moving from *A* to *C* might just be disastrous. The role of government policies can be imagined as well. A protectionist regime wishing to help *C* might impose additional costs on *D* to push it down.

The discussion could also apply to groups of similar employers instead of individual employers. For example, curves that are lower and to the left might represent our domestic core engineering companies, while those to the right and higher might represent international management consulting or finance companies. Thus, one group of companies (e.g. automotive) may not have enough profits to raise its wages beyond a more profitable group (e.g. IT services), leading to mechanical engineers taking IT jobs in large numbers. In such cases, the automotive industry might try to (a) move left, or (b) go away, or (c) extract more from its employees to justify higher wages.

Access is important. For example, the same company may offer curve *D* to domestic employees and *C* to offshore ones. Or company *D* may hire from some colleges and not others. Students of the latter colleges might then accept *C*.

This picture does not reflect limited hirings, e.g. a high-paying company that only takes a fixed number of employees. Such issues can be incorporated if we wish. For example, once the high-paying company leaves, its curve could be removed from the picture (with *D* gone, *C* starts attracting people). Alternatively, we could think of hirings as occurring over a period of time, and consider students' strategies over a month of placement interviews. However, the broad-brush picture above seems enough for topics I want to build on below.

For example, a government which creates and funds institutes meant to train people to serve the nation's technical needs (e.g. power generation or drilling for oil, on curve *C*), might find its efforts derailed by the mere existence of curve *D* (e.g. finance or management consulting). At that point, the government might conceivably try to restrict the access of employer *D*. Alternatively, it might exhort its institutes to produce graduates who are so excellent that they deserve the pay of *D* for the work of *C*. Yet again, it could deliberately broaden its entrance criteria in some way so that the average graduating student remains useful for *C*, but becomes less attractive to employer *D* (see ref. 1). Such broadening might conceivably include extra marks on JEE for having athletic ability, manual workshop skills, classical music training, etc.

Individual motivation

Figure 2 is actually incomplete. It does not allow for people who do things they like for smaller wages than they can earn elsewhere. A modified situation is shown in Figure 3. The thick dashed line marks an employee's line of sufficiency. Such a line frees the employee from wage maximization. A person with talent level 3 can now choose among *B*, *C* and *D*.

Figure 3 seems important for several reasons. First, it represents the best hope of academia, namely talented people consciously rejecting better-paying options to do work they enjoy. Second, it suggests that our schools might teach our children that such choice is possible – that there is more to life than wage maximization. Third, it connects with Maslow's famous hierarchy of needs. It is only when one level of need is met that one can begin to think of the next level. In Maslow's hierarchy, it is commonly agreed that money ranks fairly low (above survival but below love and respect, for example). So it seems useful to suggest that some amount of money can be declared as enough, so that subsequent choices are freed from wage maximization and can address the needs of higher levels.

Admittedly, lines of sufficiency will vary with the individual and may be shifted by extreme offers. Those complications are not addressed here.

A reviewer has pointed out that a developed society has many avenues for individuals to gain esteem and
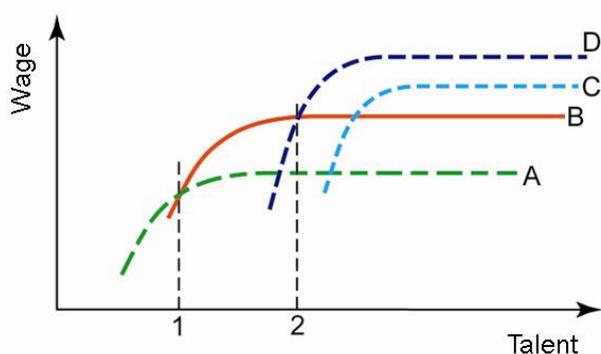
Figure 2. Wage–talent curves of several employers. Here we may refer to both employer *A* and curve *A* (say). In the context of the figure, the employer and the curve are one and the same.
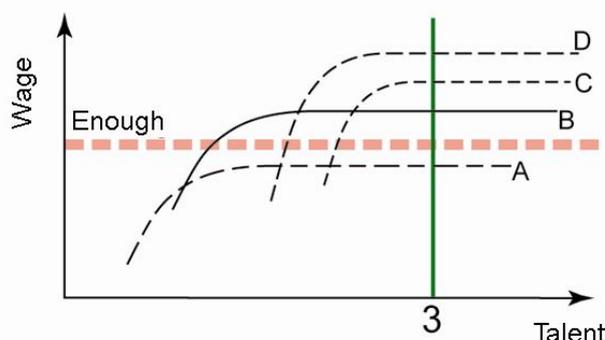

Figure 3. One who sets a level for 'enough' has choices, unlike a purely wage-maximizing employee.

satisfaction, over and above wages. There are regional and community interactions through sports, music and nature clubs, common festivals, folk culture, regional libraries, district planning bodies, and generally speaking, a cultural discourse. Such a society supplies a variety of role models so that people can say 'enough' to money and yet lead a rich and rewarding life. Perhaps a key portion of our society has not recently provided many such role models. In the context of higher technical education, ways to develop such interactions may include a domestic journal that engages directly with our own society, or appreciation for undergraduate thesis projects that demonstrate direct end-users in society.

Science versus engineering

Many of us would like to see bright students in larger numbers studying science as opposed to engineering.

Figure 2, adapted to describe the net wage consequences of studying engineering, becomes Figure 4. Smoothing the curves out (the nationally averaged effect of many companies making many offers in many colleges), the net
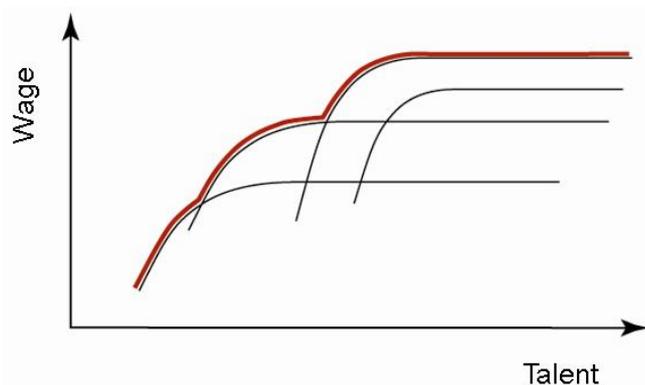
Figure 4. Hypothetical wage consequences of studying engineering (thick line).
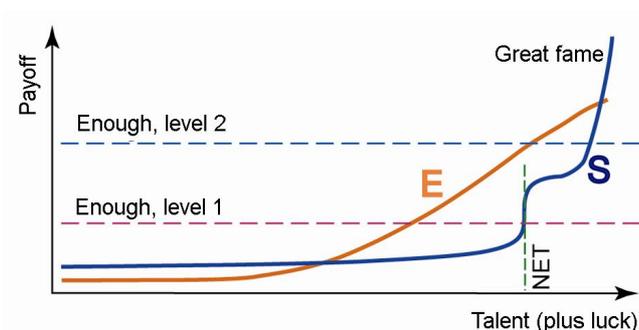
Figure 5. Stylized (and guessed) net payoff curves for engineering (*E*) and science (*S*). The recent move on the part of PSUs to use GATE for hiring has affected the *E* curve and changed the numbers appearing for GATE, but I have not attempted to incorporate it. The key issue here is the relative payoff for engineering and science, for a given level of talent, in the public perception.

payoffs for engineering and science could be compared. I tentatively propose Figure 5. The vertical axis now shows some effective payoffs, as opposed to wages.

At the lowest talent levels, employment prospects consist of various jobs that require only 'graduation', and in such cases the three-year B Sc wins over the four-year B E/B Tech. At intermediate talent levels, average wage prospects for engineers are superior. At some higher talent level, science students can begin to clear some national-level examinations like the NET (http://www.ugcnetonline.in/), which lead to an improvement in professional prospects. However, in the general public perception, I think the payoff does not catch up with engineering at such talent levels. It is only at the highest levels of talent (with some luck thrown in, perhaps) that science offers payoffs well beyond engineering. Such payoffs include magnificent laboratories, great intellectual freedom and international fame for the topmost.

The study of science by talented students therefore seems to rely heavily on their drawing lines of sufficiency, as discussed above. Figure 5 shows two such lines. The lower line (level 1) is what allows Ph D programmes in science to run at all. Those who draw their line at level 2 (or draw no line at all) would hesitate to study science over engineering, unless they were supremely confident of great success.

How can we change this picture? Increasing rewards for the very best scientists, to push the curve up at its rightmost extreme, will not change the middle. Nor will attempts to attract students into science by giving them modest scholarships, because it causes no real upward shift in the payoff. For example, the total KVPY fellowship is negligible compared to a career's worth of salary. If KVPY works, it does so by exposing students to the joys of scientific study and getting them to lower their lines of sufficiency. In contrast, the general payoff for science will probably rise if there is more applied research done by Indian companies, which would then hire science graduates in greater numbers for socially visible scientific R&D roles. Increasing the number of fellowships awarded after the NET may increase the average prior appeal of studying science for those willing to draw a sufficiency line at level 1. A systematic administrative overhaul of our university system could perhaps make them happier, more freedom-giving and more fulfilling places to teach in, increasing the payoffs for studying science.

Ph D programmes

Ph D students are the lifeblood of our academic research programmes. While undergraduate teaching is rewarding in the connection it provides with the next generation, Ph D programmes provide more extended and intellectually fulfilling interactions with students who often, at least

ideally, end up as friends and perhaps colleagues. For these reasons, we need to think consciously about our Ph D programmes. Who joins them? What do they want from us, and are they getting it? And what do we want from them?

In Figure 6, the vertical axis plots the desirability (in a Ph D student's mind) of the outcome: some combination of learning, publications, time taken and subsequent employment opportunities. The horizontal axis shows some suitable combination of talent and interest. Each curve represents a potential Ph D advisor. By this figure, advisor *A* will attract only the weakest students, advisor *D* will attract the best students and so on. Incidentally, curves *B* and *D* suggest a possible argument against hiring one's own Ph D students as faculty members in one's own department. All other things held equal, the senior faculty member usually offers better outcomes due to better contacts (curve *D* compared to *B*). The younger faculty member may then get no students.

On adapting Sohoni's curve to Ph D programmes, we find two key differences with the wage–talent discussion under 'Competing employers'.

(a) There, an employer can pay a higher wage if it wishes. Paying a higher wage is procedurally easy (write a bigger cheque), though it may be profit-reducing.
(b) The employer's main goal is to maximize profits.

Let us consider these two issues in turn.

(a) Compared to simply writing a bigger cheque, an advisor cannot easily improve the outcome of a student's Ph D. The outcome is largely decided by the subject area (e.g., fluid dynamics as opposed to materials science), the problem taken up, and the ability and reputation of the advisor to begin with. Additional improvements might require much effort and dedication: better publications, more rapid completion and greater attention to subsequent employment prospects.
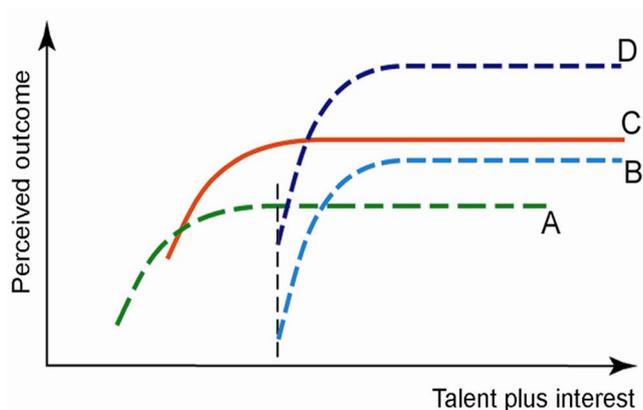

Figure 6. Ph D programmes.

(b) The Ph D advisor usually has no commercial profits. His/her gains are academic (shared credit with the student) and bureaucratic (when the institute asks for the number of Ph D students guided). In either case, the student's outcome is mostly not in conflict with the advisor's goals.

To summarize: Ph D advisors cannot easily raise their curves of outcomes; yet they have a strong incentive to acquire Ph D students. The consequences are interesting. In particular, the incentives in place for various faculty members on various curves are almost guaranteed to produce conflicts.

First, rationing of students seems unavoidable. Even in the best institutes, some advisors will have curves that lie lower than others. Many departments agree on a ceiling strength per advisor (e.g. 'no more than four'). Without such a ceiling, a brilliant advisor joining a department could starve all others, to the department's overall detriment.

Second, some faculty members will have a direct incentive to lower quality. One whose outcome curve is already low will be tempted to shift left and pick up a few more students. This is not a reflection on that faculty member's absolute standards and ethics, but a consequence of the incentive structure: how many of us can be trusted to be player and referee in the same match? The institute or department must therefore collectively watch overall standards.

Third, a faculty member who is doing very well (e.g. *D*) may be tempted to exhort less successful colleagues (e.g. *A*) to raise their standards. If they do, then the department's reputation improves, and a small associated rise occurs for all (including for *D*, in return for no additional work). Asking for improvement is not a bad thing, perhaps; but all it might achieve here is ill will.

Fourth, some faculty members might try to reduce mandatory course requirements. If their research projects draw little from broad course work, and students' completion times can be shortened by reducing course work, then their outcome curves would thereby be raised. Here again, the institute or department must collectively decide how much minimum course work is to be prescribed.

Fifth, in Figure 6, it appears that faculty member *A* would benefit if faculty member *C*'s acceptance criteria were raised. To see how this might be approached in an interview format, see Figure 7. Let two faculty members be working on (say) nuts and bolts. Let incoming Ph D students favour nuts over bolts. Then the professor of bolts may start asking hard questions about nuts during the interview. Such a strategy would be hard to detect and prove.

Before concluding this section, let us revisit Figure 6 for the case where the different curves represent different institutes. For example, internationally famous universities would be high and to the right, while lower quality
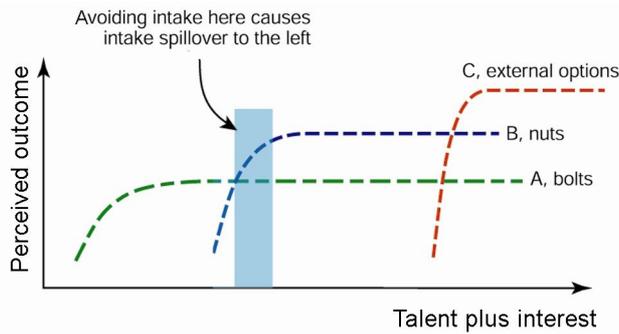
Figure 7. Imagine that a department offers curves *A* and *B*. More attractive external options, like a Ph D from an internationally renowned university, are depicted by curve *C*. Elimination of intake from the mid-range can cause spillover to the left if total intake is limited.

institutes with poorer reputations would be low and to the left. Perhaps the IITs would be somewhere in the middle. Considering the five possibilities mentioned above, the first one (rationing) is in place within Indian government-funded institutions through seat restrictions. The second (lower-ranked institutes shifting left) probably does occur: readers who have reviewed Ph D dissertations from many institutes in the country could comment on this better. The remaining three possibilities seem unlikely on the whole. Higher-ranked institutes do not exhort lower-ranked institutes to raise their Ph D-granting standards; institutes that wish to lower Ph D course-work requirements just go ahead and lower them; and lower-ranked institutes have not yet (as far as I know) collaborated in any way to raise the Ph D admission standards of higher-ranked ones.

Conscious improvement

We all wish to improve our educational system. We want our undergraduates to learn our subjects well, and use what they learn. We want our Ph D students to be enthusiastic, able and numerous; and their subsequent careers to be satisfying. However, the previous sections suggest that conflicts of interest are unavoidable, and improvement may not be easy.

Perhaps the logic of the foregoing sections can lead to useful suggestions.

For our undergraduate engineering programmes, if we want our students to remain in the core fields we teach, we must make our subjects more attractive and hope that our students set lower lines of sufficiency. Or we might try to upgrade our training to make our students worth more. Both options are difficult, and it is not as if we are not trying. Another conceivable option is to broaden entrance criteria as discussed previously. Finally, we might simply increase the number of students and colleges nationwide so that there are enough engineers for every employer at all points on the talent axis (this angle seems well covered).

Happily for our Ph D programmes, improvement seems possible through more appealing methods.

For one thing, if we think of the Ph D not in terms of research quality alone but in terms of perceived student outcomes, then it becomes clear that individual faculty members can evolve personal strategies toward improving those outcomes. Strategies might include greater help with publications, a sustained focus on shorter completion times, a clearer orientation towards subsequent employment, and advisors' attention to student-specific issues (possibly encouraging each student to work in the style, or on the problem, that best suits him/her).

Again, since its horizontal axis represents some combination of talent and interest, Figure 6 is really a two-dimensional projection that we need not take at face value. Thus, in Figure 6, the faculty member on curve *B* need not be permanently overshadowed by curve *D*. Instead, he can redefine his research. For example, if curve *D* represents a fancy laboratory with a focus on (say) metals, then a viable alternative for some potential students may well be a humbler laboratory for ceramics. A small tree growing under a bigger one may well get no Sun until one of them dies. In academia, we can move out of the shade if we decide to.

Third, while the outcomes of some faculty members might be measured mostly in publications and impact factors, other faculty members might like to offer Ph D experiences that provide greater social contact and contribution, recognition from the community, and other scientometrically irrelevant outcomes that build personal satisfaction. Such possibilities might lead to Ph D students drawing their own lines of sufficiency as far as high impact journal publications are concerned.

Finally, the multidimensional possibilities hidden by the planar projection of Figure 6 indicate the positive role that can be played by friendly counselling from disinterested senior faculty members. Junior faculty members can then develop their research approach to their greatest individual advantage.

Who is the customer?

Any business that produces anything needs customers. Without customers, it goes bankrupt. Sohoni's curve assumes that there is a company willing to hire the students we produce. The company is our customer.

The IIT system has been mass producing engineers for many decades (see refs 2 and 3 for a sobering view on the matter). These engineers have become famous for achievements more outside than within core Indian engineering. That was a happy accident, perhaps. The wage–talent curves offered by non-core Indian options have provided customers for the students we have produced. Over the years, the popular alternatives have varied. In my time, it was going abroad for higher studies. Later, it

was software. More recently, it has been finance and consulting. Bright and young people tend to be flexible, and one hopes there will always be such customers for them.

But what about more mature, specialized, dedicatedly technical and older people? Our administrations want us to produce more Ph Ds. The Kakodkar Committee[4], for example, suggests that we must go from an annual Ph D production rate of 1000 to 10,000. But for which customer? Granted, some of those Ph Ds would become faculty members, thereby increasing further the rate of production. But this cannot be the main customer, any more than a steel plant can indefinitely use all its output to keep enhancing its own production capacity.

What will help our Ph Ds find good careers? Should we simply follow research trends in the West, which in turn follow their governments' funding patterns, in turn guided by advisory committees whose motivations we may not share? Should we make up our own thrust areas? Or stick with the thrust areas of a few decades ago, whence the pioneers have moved on?

Should we produce a large number of Ph Ds on topics that lead at best to a sequence of postdoctoral positions in the West, with nothing permanent emerging either there or back home? Can we risk overproducing Ph Ds trained in advanced academic skills for which there is no domestic, social or industrial market; Ph Ds then left to slowly filter down into lower ranked colleges, there to repeat the process on a more modest scale, and so on all the way down and out?

In this light, it is interesting that the Kakodkar Committee report has a section titled 'Where will the Ph D students come from?', but none titled 'Where will the graduating Ph Ds go?'

The issue can be stated selfishly or idealistically, but comes to the same thing. Put selfishly: if our Ph Ds do not find jobs they like, our outcome curves (Figure 6) may collapse and our Ph D programmes may dry up. Put idealistically: it seems unethical to attract students into our academic world if we do not try to make their career prospects as appealing as our own.

1. Sohoni, M. and Kathuria, V., The Elite University: are we being too selective? An analysis of placements at IIT Bombay as a case study. Working paper, 2014; www.cse.iitb.ac.in/~sohoni/sel.pdf; www.youtube.com/watch?v=fc5WsQBJqcs
2. Sohoni, M., Knowledge and practice for India as a developing country; www.cse.iitb.ac.in/~sohoni/kpidc.pdf; http://www.india-seminar.com/semframe.html
3. Sohoni, M., Engineering teaching and research in IITs and its impact on India. *Curr. Sci.*, 2012, **102**(11), 1510–1515.
4. Taking IITs to greater excellence and relevance, Report of Dr Anil Kakodkar Committee, April 2011; mhrd.gov.in/sites/upload_files/mhrd/files/KakodkarCommitteeReport-05132011_0.pdf