

“Computerization and Labor Demand: Agenda for Testing and Forecast of the Future”
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Thank you, Jacques, and good evening to everyone. Let me begin by also thanking the organization committee for putting together a very interesting and stimulating conference. Today we heard a number of presentations which brought new light to the productivity paradox and to skill biased technical change (S? ? T). I owe the committee particular thanks, given the hour, for a day that made the economic importance of our topics completely clear. We won't need to revisit the very difficult social problems posed by the spread out in the rich countries' income distribution, nor the considerable body of statistical evidence for S? ? T driven by information and communication technology. We can go directly to the evening's topic, a story of how computerization changes the demand for labor, shifting it between lower and higher skill workers.

My purposes in telling this story are two. First, to put a more detailed structure on the hypothesis of S? ? T, so that it can be tested in greater detail. Second, to forecast the future. If the story I am telling is correct, then the era of computer-driven S? ? T is unlikely to end soon. The new era of networked computing applications now beginning is likely to lead to further substitution out of low-wage labor and further increases in the demand for more skilled workers. I bring this worrisome prospect to your attention not to suggest it make us anti-technology- far from it!- but to propose appropriate changes in labor supply institutions, so that the impact of this new round of S? ? T an earnings inequality be minimized.

Organizational Computing

Information and Communication Technology (ICT) is varied in its uses and in its economic effects. Contrast this microprocessor-based wristwatch with the computerized reservation systems that helped the airlines bring us all to this lovely place. To tell you my story, I want to narrow the focus considerably, to business information systems in organizations. So the airline reservation system is in the class of applications, but the wrist watch (like most other “embedded” processor devices) is excluded. So, too, are “individual productivity applications” - spreadsheets and word processing running on excluded PCs, computer-aided design on workstations, and so on. I want to focus our attention entirely on organizational computing(OC).¹ Organizational computing is a new technology for white collar bureaucracies. In sectors like finance, banking, brokerage, and insurance, OC is the technology of production. In much of the rest of the service sector, OC is a key control technology. (Computers didn't bring us to Nice, people and airplanes did. Yet the CRS systems are critical to operational and marketing functions.) In the manufacturing sector, OC underlies the buying of inputs and selling of outputs. Transacting, allocating, budgeting planning, and managing are now the tasks of organizational computing.

The spread out in the income distribution is widespread, pervasive and large. To explain

¹See my paper with Shane Greenstein at <http://timb.stanford.edu/papers/techcomp.pdf/> for a classification of applications of computing.

it, a S??T must be correspondingly powerful and general. So you may have been surprised that I threw out so much of ICT, keeping only OC for my story. The reasons are simple. First, I can tell you a story of how OC changes labor demand that is largely the same across this class of applications. So this is very much a unitary theory. Second, a very large fraction of modern employment is in white collar bureaucracies. I offer a simple story of S??T in that portion of employment. This is a “one big thing” story in the way it explains economy wide labor market outcomes.² OC is old enough, widespread enough, and linked closely enough to work to be the basis of a plausible theory.³

Limited Substitution in OC

The first element of the theory of OC as an S??T comes from limited substitution. Many of the tasks once performed by clerks handling paper have been automated using computers. This includes not only handling the paper, but a great deal of remembering, recording and deciding. Is it time for a letter to a customer, reminding them their account is overdue? That task was once the province of Accounts Receivable (AR) clerks, now of AR software. There are many such tasks in white collar bureaucracies. They are not very demanding in terms of human thinking. And they are, at least in part, amenable to implementation by computer. Does the computer do the thinking that the person once did? No, but a task once carried out by people with some education and other cognitive-skills training is now carried out by the computer.

It is rare that the computer literally replaces the clerk. Instead, the work comes to be shared between people and computers in a wide variety of complex ways. The computer system is better at remembering small things, like how many times customer X has been late with its bill. The computer is cheaper making the same decision (late 30 days, send letter) over and over. Slowly, the computer is given more and more complex decision rules, and comes to make decisions that were once made with common sense. It is not that computer can learn common sense. Rather, a routinized, regularized, rule-based system with excellent recall can come to decide as well, on average, as a system using modest amounts of human intelligence and human cognitive skills.

This substitution has been limited in two senses. First, it has been much more effective substituting for modest bundles of human cognitive skills than for large bundles. The work of the highly educated is more supported than automated by OC. Second, noncognitive human skills are hard to substitute by computer. Much clerical work has been changed into being the eyes, ear, voice and fingers of the computer. The computer cannot call the customer on the telephone to find out why the payment is late, nor can computers handle such a difficult situation as both getting the money and leaving the customer feeling better off.

The main purpose of OC has been to improve customer satisfaction, make new services,

²The quantitative argument is made more completely, and the story is stated more carefully, in my paper at <http://timb.stanford.edu/papers/c&w.pdf/>.

³Of course, there way other elements of technical change which contribute to S??T, and there are many nontechnical forces that contribute to earnings inequality growth. This theory can't explain it all - it has that in common with all abstract economic theory. It is vastly more testable than theories which treat ?T as a residual, and much more testable than theories which treat ICT as an aggregate.

and make bureaucracies more responsive. This interacts strongly with the “human skills” limitation. While the demand for people with modest cognitive skills has declined, the demand for people with good attitudes, good communication skills, etc. - at all levels of education - has flourished. Thus we see the relative wages of the less educated falling, but non-cognitive skills (people skills) also getting a higher reward.

There is an important question about these changes in lower-paid while collar work that remains unresolved. Should we think of this work as (cognitively) deskilled and machine-paced? Certainly sitting before a screen wearing a telephone headset and saying what the computer tells you to say has that flavor. Yet there are important examples in which the superior monitoring and measurement inherent in computer-based work permits upskilling: more autonomy, more teamwork, less hierarchy.⁴ The limited substitution story goes through either way, yet the distinction matters enormously.

Complementarities with Skill at the Firm Level

Routinization and regularization of the low-paid part of white collar work have had very different effects on the high-paid parts of white collar work. More directable production processes result. Also, those production processes create databases which may be analyzed. These offer new opportunities for managing and analyzing. The widespread change in all bureaucracies in this direction has meant a widespread increase in the demand for large bundles of cognitive skills. This is a complementarity between computers and analytical management. It has raised the demand curve for highly educated labor.⁵

As managerial work grows more analytical, the demand for managers with excellent human skills paradoxically grows as well. More distant relations to subordinates -- perhaps mediated through explicit monitoring and rule-based incentives or promotion -- make it harder to do the human part of motivating, leading, counseling and mentoring. The demand for human skills is shifted up across the board. The demand for cognitive skills is down shifted for those who have modest skills and up for those who have more training and education.

Some Exceptions and Open Questions

Some have suggested a direct effect on the productivity of those individual workers who use computers. In my story, this effect is unimportant, with organizational computing at the center. Of course, there are some other complementarities between literal computer use and technical skills. Programmers, graphic designers, and other highly computer-intensive workers are up in demand. But that is a small portion of literal computer use, suggesting a very different

⁴Erik Brynjolfsson’s work, both that at this conference and in earlier papers, has emphasized the latter. See <http://ccs.mit.edu/erik/itod/> Erik and my joint work emphasizes this part, as does the brilliant essay by Kathryn Shaw we saw this afternoon. Yet I believe Nathalie Greenan was right to emphasize the other view in her penetrating remarks.

⁵Here my story parallels that of Reich and of Krueger, though the specifics are very different. I put no emphasis on individual use of computers at all. Instead, it is the managers and professionals in computer-using organizations whose demand is raised by this mechanism.

empirical strategy than that found in the literature.⁶

Between limited substitution and complementarities to analytical and human skills, there is clearly enough in this theory to explain the skill bias in the OC part of ICT. Whether it is true or not, I do not know. Certainly the anecdotal literature is encouraging. And the tests that Erik Brynjolfsson, Lorin Hitt and I have put forward are very encouraging.⁷ Yet if you look at the thoughtful survey of the statistical literature by Lucy Chennels and John Van Reenan we saw this afternoon, you will see that the vast bulk of the empirical work is not detailed enough to address the theory raised here. It is highly encouraging, in that there is definitely a shift in skills demand associated with ICT. Yet only a little work ever begins to address the flows of causation.

One flow of causation that may be very important in the aggregate is missed by all the studies. The regularization and routinization of specific production processes permits, in many cases, efficient redrawing of the boundaries of the firm. Firms, markets, and clusters of sellers of complements are reorganized as a result. High wage or low wage workers may be shifted out of an industry, for example, into a new specialized service supplying industry. So far, our measurement frames (firm, establishment, industry) have failed to capture this.

I am completely convinced that IT investments are productive, but if you are not, please do not doubt my labor market story for that reason. There are only two plausible stories of the productivity of organizational computing investments:

CThe social return has been large, but not visible in the aggregate productivity statistics because of unmeasured outputs.

CThe social return has been modest, and the hidden costs of computer systems in changing organizations have eaten it all up.

In both theories, there is the substantial labor market impact. I believe the first theory, but the second is not impossible.⁸

Forecast the Future.

George Stigler, one of the best economists of a good century, advocated more forecasts of the future by economists. He was, as often, right.

Let me begin with a forecast of the direction of technical change. We are at the beginning of a new wave of organizational computing. This time, the relevant organization is bigger than the firm. It includes suppliers, customers, contractors, and workers. We might call this interorganizational computing. These expanded applications have a solid technical basis in networked computing. And while it may be hard to predict the timing and the exact nature of interorganizational applications, there are some very reliable facts. (1) There remains a great deal of un-automated or partially automated white collar bureaucracy that buys, sells, and co-ordinates across company boundaries. (2) Much of the low skill work in this bureaucracy is suitable for

⁶ Individual computer use in the most common application, word processing, is of a different character in its effect on labor demand than individual computer use in graphics design, CAD, or programming.

⁷[http://timb.stanford.edu/papers/it org and labor demand.pdf/](http://timb.stanford.edu/papers/it%20org%20and%20labor%20demand.pdf/)

⁸A third story in which there is trivially little impact because the “share of ICT in the capital stock is small” really is too silly to pay any attention to.

some form or another of substitution through ICT. (3) Interorganizational applications are more complex than intra-organizational ones. They call for even more analysis. (4) Negotiating and managing across firm boundaries has at least as many human traps and pitfalls as that within.

These features convince me that limited substitution, increased demand for “people” skills, and complementarity with analytical management will continue. IOC is coming and that its labor demand impact will be like OC. The impact of ICT on the demand for cognitive and human skills will continue in the same direction. Obviously, public and private efforts to change labor supply institutions anticipating changes in the demand for skills -cognitive and human - in time to supply them will be highly valuable.

One open research task is understanding the implications of IOC for labor demand in detail. The introduction of information technology changes the information economics of firms and markets. But how? Which of the many exciting implications of the new theory of the firm is a first-order effect? We have a glorious opportunity as researchers to follow IOC from its present early state. We missed this opportunity with computing in general and OC in particular a generation ago. We at Stanford are going to pursue this question with new data and new energy. It would be fabulous if there were a parallel European effort. So let this talk here serve two purposes. Not only did it provide a little diversion for those German soccer fans over there, but let it also serve as an advertisement for transatlantic research collaborations.