Three Essays on the Effects of Technological Change on Labor Outcomes

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Not all Technological Change is Equal: How the Separability of Tasks Mediates the Effect of Technological Change on Skill Demand

We measure the labor-demand effects of two simultaneous forms of technological change—automation of production processes and consolidation of parts. We collect detailed shop-floor data from four semiconductor firms with different levels of automation and consolidation. Using the O*NET survey instrument, we collect novel task data for operator laborers that contains process-step level skill requirements, including operations and control, near vision, and dexterity requirements. We then use an engineering process model to separate the effects of the distinct technological changes on these process tasks and operator skill requirements. Within an occupation, we show that aggregate measures of technological change can mask the opposing skill biases of multiple simultaneous technological changes. In our empirical context, automation polarizes skill demand as routine, codifiable tasks requiring low and medium skills are executed by machines instead of humans, while the remaining and newly created human tasks tend to require low and high skills. Consolidation converges skill demand as formerly divisible low and high skill tasks are transformed into a single indivisible task with medium skill requirements and higher cost of failure. We conclude by developing a new theory for how the separability of tasks mediates the effect of technology change on skill demand by changing the divisibility of labor.

How It's Made: A General Theory of the Labor Implications of Technological Change

We present a novel theory on the relationship between technology change and skill demand capable of describing the labor impacts of various technology changes from the 19th century to present. Performers (human or machine) face stochastic issues that must be solved in a given time to complete tasks. Firms choose how production tasks are divided into steps (sets of tasks), the rate at which tasks need to be completed, and the type of performer assigned to a step. Performers differ in the breadth of issues they can solve (generality) and in their tolerance for working at higher rates (intensity). Human performers tend to be generalists with low intensity: solving complex steps (variety of issues) at low rates. Machine performers tend to be specialists with high intensity. Central to the theory are the cost of fragmenting tasks into smaller steps, the cost of allocating performers to multiple steps, and the negative relationship between step complexity and the rate of completing that step. With this construction we are able to derive the cost-minimizing division of tasks and level of automation of production and the demand for workers of different skills that those conditions create. We provide empirical counterparts to our theory across three empirical contexts: optoelectronic semiconductors for communications, automotive body assembly, and the Hand-Machine Labor Study covering mechanization and process improvement at the end of the 19th century. Our theory predicts the following: the division of tasks is skill polarizing; automation is skill polarizing at lower production volumes and skill upgrading at higher volumes; and that consolidation increases the demand for mid-level skills. We find that these predictions are supported in our empirical settings.

New Technology, New Hierarchy? Implications of Product and Process Innovations for the Division of Problem Solving

We measure how different technologies alter the structure of problem-solving and the division of labor across occupations, generating technological skill bias across occupations. We focus on automation versus consolidation of parts in the optoelectronic semiconductor industry as examples of innovations that change the inputs to production and the structure of production, respectively. We collect novel data from nine manufacturers in the optoelectronic semiconductor industry on skills, process structure, problem referrals to other occupations, and the distribution of production time per process step for lead operators, technicians, supervisors and engineers involved in more than 90 production steps, and engineers and managers involved in more than 100 process or product design activities. Firms divide problem solving across direct production workers, supervisors and managers and a body of staff (engineers, technicians) intervening "as-needed" with specific problem-solving expertise. Our early insights suggest that in cases of higher automation, skill heterogeneity increases for production supervision roles; in contrast, as designs become more consolidated (so that different strands of development must be more closely coordinated), designers and especially design managers must increase their breadth of skill.