With What Skills Are Computers a Complement?

By FRANK LEVY AND RICHARD J. MURNANE*

A central fact of U.S. labor markets in the 1980's was the declining demand for semi-skilled and unskilled labor. A central explanation for this fact was skill-biased technical change (John Bound and George Johnson, 1995). In most studies, skill-biased technical change is inferred rather than observed directly. It remains a plausible explanation in part because of the rapid spread of computers. But the role of computers is equally speculative since computers also "de-skill" jobs—witness the electronic cash register with scanner that calculates change and keeps inventory records.

In this paper we examine the impact of computers on skill demands in the custodian unit of "Tammany Bank." To accumulate the details we needed, we ignored Tammany Bank's other units—its large retail banking and international-lending operations. We begin by briefly reviewing the relationship between computers and skill demands. Following Kenneth I. Spenner (1990) we then discuss two channels by which computers influenced the bank's skill demands: changes in the numbers of different occupations and changes in the content of individual occupations.

I. Computers and Technical Change

A networked personal computer can increase an individual's ability to do a number of tasks. A nonexhaustive list includes preparing text and charts, designing three-dimensional objects, performing calculations, transferring data among locations, classifying data into user-established categories, and maintaining and manipulating data bases. Beyond this, a computer can augment *management's* ability to control employee behavior by, for example, requiring an employee to execute a specific sequence of steps when a particular error occurs.

With this list in mind, it is useful to think of an employee's work as containing two kinds of tasks. The first—"routine tasks"—are those that computers perform at economically feasible costs. The second—"exceptions"—are tasks that computers perform at much higher costs (if at all). The exceptions shape the postcomputer demand for labor.

In some cases, dealing with exceptions requires skills that are in large supply. An example is human contact. In McDonald's, with its rigid menu, virtually all transactions between customers and counter persons fit the cash register's programmed format, and so counter transactions could be fully computerized.[1] But many customers (including us) would be uneasy getting hamburgers from a change-making machine with a touch screen. Thus, live counter persons provide the human contact that machines cannot provide. While providing human contact is an important skill, it is a skill in large supply and so cannot, by itself, command high wages in the current economy.

More typically, dealing with the exceptions requires skills in short supply: the ability to design appealing objects, to classify "fuzzy" data ("making judgment calls"), and so on. In many situations, computers also demand sophisticated error-detection skills in which individuals monitor dimensions of the computer's output quality that cannot be measured by software.

* Department of Urban Studies, Massachusetts Institute of Technology, Cambridge, MA 02139, and Graduate School of Education, Harvard University, Cambridge, MA 02138, respectively. Support for this paper came from a grant by the Alfred P. Sloan Foundation to MIT's Industrial Performance Center and from the Daniel Rose Chair in Urban Economics. We thank the many persons at Tammany Bank for the time they spent with us.

[1] A counter person in a diner would expect many more exceptions, (e.g., the BLT without bacon frequently ordered by Marin Levy). The exceptions at a McDonald's will occur at the management level: how to handle a late delivery truck or an employee who does not arrive for a shift.

How do exceptions influence the demand for labor? In a given organization, it is plausible that computers generate two opposing effects:

(i) by changing skill requirements, computerization increases the optimal ratio of skilled to unskilled labor per unit of output.
(ii) by improving labor productivity, computerization nonetheless reduces the quantity of skilled labor per unit of output.

In this case, the firm's absolute demand for skilled labor will be determined by changes in demand for the firm's product, a change driven either by the firm's ability to charge a lower price or by other, exogenous circumstances.

II. Changes in the Custodian Unit's Occupations

Through the late 1970's Tammany Bank concentrated on consumer and commercial banking. As a sideline the bank provided custodian services (''keeping the books'') for a limited number of mutual and pension funds. The bank's activities were typical for the industry, but Tammany had a strong reputation for its mainframe computer systems.

Relying on these systems, Tammany made a strategic decision in the early 1980's to expand its custodian services. The timing was outstanding. Between 1980 and 1994 the number of mutual funds grew from about 550 to 5,400, and assets grew correspondingly. The result was a rapidly growing demand for custodian services. Demand was stimulated further by the passage of ERISA (the Employee Retirement Income Security Act) and its increased reporting requirements for pension funds.

Each working day, a mutual fund's custodian updates the books and calculates two key statistics. By 10:30 A.M. the custodian provides the fund's managers with the day's cash balance, the amount of money initially available for investing. By 5:40 P.M. the custodian must report the fund's net asset value (NAV), the value of a fund's share, which is published daily in newspaper stock tables across the country. Day-to-day changes in a fund's NAV depend on the number of new fund shares sold and redeemed, the fund's purchase and sale of assets, the payment of interest and dividends, changes in the market prices of fund assets, and so on. The work involves strict deadlines and requires accuracy; Tammany is liable for losses due to its errors.

Throughout this expansion, the ''NAV accountants''[2] who kept the books were four-year-college graduates. The reasons why are not as obvious as they appear.

For his or her job an NAV accountant must know a particular slice of accounting: how to record each trade, how to record the interest or expense that is realized over several periods, how to notify the settlement house where the trade will be consummated, how to record share purchases and redemptions, and ultimately, how to calculate the morning cash balance and NAV. A more recent skill is the ability to find valuations for derivatives and other thinly traded instruments held by fixed-income mutual funds.

This list is long, but it omits many topics taught to accounting majors (e.g., tax or managerial accounting). Correspondingly Tammany uses its location in a big city with many colleges to recruit NAV accountants from among ''the 'B' students in second-tier colleges and the 'A' students in third-tier colleges.'' Some have majored in business; others have one or two accounting courses; a few have no accounting. With respect to computers, a few know spreadsheets, but most know nothing beyond word processing.

As the reader now suspects, the Tammany custodian unit's demand for labor during the 1980's exceeded even the national shift toward college graduates. Employment levels are proprietary, but between 1982 and 1993 the custodian unit's employment grew by almost a factor of four, and eight of every ten net new positions involved someone with four or more years of college. Two-thirds of the employment increase involved NAV accountants or related positions like auditors.

On the surface, the trend has a simple explanation: Tammany's custodian business

[2] This is our term for the three slightly different occupational titles held by individuals who performed the calculations.

expanded rapidly; custodian services require NAV accountants; and Tammany's NAV accountants have always had a college education. Viewed more closely, NAV accountants know only a slice of accounting, and Tammany does much of its own training. Thus the question arises: why do NAV accountants have to be college graduates in the first place?

The answer involves two issues: the skills required and the most efficient way to search for those skills. Bank staff generally agree on the skills required. They are in less agreement on how to recruit the skills.

Current recruiting centers on the first-line managers (FLM), men and women in their late 20's and early 30's who entered the bank as NAV accountants and who now supervise 4–7 accountants. Every applicant is interviewed by one or more FLM, and their opinions play a key role in hiring decisions.

One group of bank staff believes that the FLM's hire college graduates because college signals that a person has the requisite skills: intelligence, an ability to absorb abstract material, maturity, and so forth. In this view, few high-school graduates have these skills (if they did they would go to college), and the good junior-college graduates all matriculate to four-year colleges.

A second group of bank staff believes the FLM's simply hire in their own image (most of the FLM's are college graduates). The FLM's have high-tension jobs; they want to minimize problems. And so they hire people exactly like themselves—people they know they can manage. In this view, the bank does not really know about high-school or junior-college graduates, because these sources have been excluded by the path of least resistance.

Whichever group is correct, the fact remains that the custodian unit created substantial demand for college graduates. Most discussions of computers' impacts on skill demands focus on changes in the skills required for a particular job. Tammany's changing demand was driven by a more macroeconomic channel: the growth of both volume and complexity in the securities industry which itself was made possible by computers' lowering transaction costs. For perspective note that, in the 1960's the New York Stock Exchange would occasionally close early because its back offices could not handle the paperwork generated by the trading of 10 million shares. Today 10 million shares are traded in the first few minutes of the exchange's business day. This increased volume drives the derived demand for Tammany's NAV accountants.

III. Computerization and Occupational Content

To determine how computers have affected skill demands within occupations, we begin by describing the NAV accountant's job. Before computerization, a list of tasks and their underlying skills would include five items:

(i) *Keeping Ledgers*.—Generic skills include data transfer and data classification (into appropriate ledgers).

(ii) *Data Rework*.—Locating and recording missing information on transaction slips, for example the ID number of the trade's settlement location. Without full information, the transaction cannot be entered. Generic skills include developing search routines and reasoning by analogy. The process is also helped by curiosity, an interest in the problems encountered by coworkers, which increases the stock of analogies. Data rework may also require communication skills to extract the data from the harried broker on the other end of the line.

(iii) *Valuation*.—In certain circumstances, the NAV accountant may have to search for the value of a lightly traded or untraded asset. Generic skills include communication skills to obtain estimates from brokers or originators and reasoning by analogy to know when to reject the broker's valuation.

(iv) *Morning Cash Calculation*, NAV *Calculation, and Report-Writing*.—Generic skills involve arithmetic calculations.

(v) *Analysis*.—The bank's term for the constant scanning for incorrect data that nonetheless passes computer checks. Generic skills include reasoning by analogy and curiosity to build up a context of what a number "should be."

Twenty years ago, many of these activities were done manually with an adding machine.

Ledgers were kept in batch-process mainframes or, in some cases, on paper. Data-entry tasks were sufficiently time-consuming that an NAV accountant would usually handle only one mutual fund.

Over time, computerization has eliminated most data transfer, much of the data entry, and almost all computations. What is left includes data rework, valuation, and analysis—jobs that require the ability to build a base of analogies, to reason by analogy, to conduct searches, and to communicate (and negotiate) with other persons. Computerization has *not* eliminated the need for much of the knowledge that underlies the routine work. To the contrary, the FLM's fear that accountants will only learn to operate the computer in rote fashion and will have no theory to fall back on when an error occurs.

At a conversational level, bank staff describe this computerization as freeing the NAV accountant to do more analysis and higher-level problem-solving. The reality is more complex. Computers have sharply reduced the time spent doing manual data entry and transfer. But the bank has adjusted by assigning the typical accountant more funds. As one FLM said, "When I began here, we would handle one, single-class fund. Now, an accountant can handle three to four multi-class funds." In the process NAV accountants are not really thinking more deeply. Rather they are doing what always were the more difficult parts of their job (data rework, valuation, analysis) at the same level of intensity for a greater number of funds.[3]

IV. Training and Managing Skilled Workers

The difference between perceived and actual skill changes has affected training and, in turn, has led to a dilemma. Until recently, Tammany Bank put new NAV accountants directly "on the floor." They would shadow another employee for several days and then begin to work under supervision. The bank also had a well-developed training curriculum built around modules running from several days to a week. FLM's were expected periodically to release the new hires from daily work to take these modules according to a general schedule that ran over a year.

By the mid-1990's the bank concluded the system was not working. The pressure on the floor was so great that FLM's often did not release the new hires for scheduled training. The pressure was also causing new hires to focus on immediate techniques—learning the keystrokes without learning the underlying accounting. This raised the fear discussed earlier: accountants with this outlook could not deal with errors when they arose (if indeed, they could detect the error). As one FLM was reported to have said, "If we wanted data-entry clerks, we would have hired data-entry clerks, not college graduates."

The bank responded by instituting a new training program, an eight-week, all-day program that trained new hires *before* they went on the floor. The new program represented a considerable investment—approximately $9,000–$10,000 per trainee "including instructor time, wages, training materials, cookies, everything."

The dilemma arises because the NAV accountant job has always had high turnover—in excess of one-third during the first year. The work involves lots of repetition, and slack periods alternating with tense deadlines. It is not a pace to everyone's liking, and it is a pace computerization has not changed.

The earlier, modular training was slower to impart skills but focused resources on employees who were likely to stay with the bank long enough to recoup training costs. The new program has increased the new hires' skill levels, but also, we believe, their expectations. The FLM's appear to be pleased, but many of the new hires find the jobs disappointing. Of 16 new hires we followed through training, 15 completed the training program in May 1995. Of these 15, four had left the bank by November 1995. Given training costs, these quits are very expensive.

V. Conclusion

To this point the evidence seems clear-cut that computerization has increased Tammany

[3] Shoshana Zuboff (1988) finds similar differences between job skill changes and management's perception of those changes.

bank's demand for college graduates. The increase, however, has been driven more by computers' impact in increasing the size of the financial industry than on changing skill requirements within the bank. But a close look at Tammany Bank suggests the development of computerization, the design of jobs, and the recruitment of college graduates—"three sides of the same coin"—are not fully played out. As with all banks providing custodian services, Tammany Bank's profit margins are under pressure from competition. In this cost-sensitive environment the bank may begin to reevaluate the practice of putting new hires through an expensive eight-week training program and then placing them in jobs which one in four leaves within the first six months.

Tammany's experience suggests that an increased demand for skilled labor means more than just a change in recruiting or training. It means redesigning the jobs themselves to maintain the interest of higher-skilled workers. Organizations sometimes assume that computerizing a job redesigns it automatically. In our example that does not appear to be true.

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