SCHOOL-TO-WORK PROGRAMS IN THE UNITED STATES: A MULTI-FIRM CASE STUDY OF TRAINING, BENEFITS, AND COSTS

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This paper provides one of the first detailed analyses of the training and finances of school-to-work (STW) programs in the United States. The data are from case studies of seven STW programs sponsored by firms of diverse size, type, and location. In almost every case, the firm paid at least some of the costs of general training. Most firms recoup some of these costs through rents captured by hiring former apprentices, but only in two cases do benefits seem likely to outweigh costs. The findings suggest that certain imperfections in American labor markets—for example, compensation below marginal product for some workers, and a gap between productivity and wages that increases with workers' skill levels—motivate firms to invest in general skills, but these labor market imperfections may not be great enough to allow firms to sustain STW programs over the long run.

Although the United States has enjoyed low levels of unemployment relative to that experienced by most other developed nations, the operation of the U.S. labor market has been less than ideal. Labor productivity has grown slowly in recent times, and the demand for skilled labor has increased substantially while supply has failed to keep pace (Topel 1997). As a result, the wages of less-skilled workers have fallen both absolutely (in real dollars) and relative to those of more highly skilled workers (Murnane and Levy 1996; Blank 1997). These changes have led to an intense focus on policies designed to spur human capital investments.

Of particular interest have been human capital policies targeted toward non-college-bound youth, such as school-to-work (STW) programs. One hope is that STW programs will increase the amount of private training provided by firms, in part because the returns to private training typically exceed those for public programs (Heckman, Lochner, Smith, and Taber

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1997). Yet Becker's (1964) human capital model suggests that both workers and firms may have difficulty financing the kind of general-skills development that is the objective of STW. Unlike the United States, other countries such as Germany and Japan have well-developed labor market or government institutions designed to address potential failures in the market for training. In the absence of policies designed to address these market failures, American firms may confront a fundamental tension between the desire to provide training and the need to cover STW program costs.

Our purpose here is to provide one of the first detailed studies of the training and finances of school-to-work programs in the United States. Our data come from case studies of seven STW programs sponsored by firms with a strong commitment to STW such as Siemens, Eastman-Kodak, and BellSouth. To gather these data, we spent extended periods with multiple employees from each firm. This case study approach should produce more reliable information than one-shot mail or telephone surveys completed by a single employee.

The first objective of our study is to detail the formal and informal ("on-the-job") training that is provided as part of each STW program. Many of the details that distinguish these programs from the part-time jobs already held by many American high school students are difficult to quantify, which makes our case study approach particularly valuable. The second objective is to estimate the costs and benefits of the STW programs from the perspectives of the individual firms, since these programs must have benefits that are at least equal to costs if the programs are to endure. Given the self-selected nature of our sample, we expect this information to highlight the net benefits (or costs) of STW programs under what are likely to be "best case scenarios" given current U.S. labor market and public policies. The final objective of the paper is to relate each program's training component to the net benefits (or costs), to determine whether those programs that involve intensive training can also be cost-effective for firms.

Potential Failures in the Market for Training

Understanding potential failures in the market for training is crucial for understanding whether government intervention is necessary or desirable for meeting some policy objective. The notion of failure in the market for training was challenged by Becker's (1964) seminal work, which argued that firms have incentives to invest in firm-specific skills that are unproductive for the worker at other establishments. Firms will not have incentives to invest in general skills that are equally productive at every workplace, since workers in competitive labor markets will be able to capture as wages the increase in their productivity associated with their increase in general skills. Yet the fact that workers are able to capture the benefits of general training also means that they will have incentives to invest in such skills. Thus the Becker model predicts that students will pay for the general training provided by STW programs by either directly compensating firms or accepting training wages that are below their marginal products.

Despite the incentives to workers or firms to train in the Becker model, several possible market imperfections complicate the prospects for school-to-work training programs in the United States. Imperfect capital markets will limit the ability of workers to borrow in order to finance general training. Similarly, minimum wages and union rules may limit the ability of workers to accept wages below their marginal products to finance training in general skills.

Unlike some other countries, the United States has not developed labor market and government institutions to address these potential market failures. In Germany, training wages are typically 22–33% of the wages of full-time employees (Heckman, Roselius, and Smith 1994). Turnover is lower in Germany than in the United States, perhaps in part because unions seem to help limit poaching of apprentices who have been trained by other firms (Hamilton 1990; Soskice 1994; Cappelli 1996). Turnover rates are also lower in Japan, a country

with a history of implicit lifetime employment and high social costs to firms for poaching workers trained elsewhere (Burtless 1994; Lynch 1994). Countries such as Sweden and France make use of subsidies or "training taxes" to compel firms to invest in training (Lynch 1994).

Yet it is also possible that some labor market imperfections *cause* firms to invest in general training (Acemoglu and Pischke 1998a,b,c). Firms will have incentives to invest in general skills if workers are paid less than their marginal products, and if the differential between productivity and wages increases with the worker's skill level. In this case, the rents the firm extracts from high-skilled workers exceed those it obtains from low-skilled workers, which in turn provides the firm with an incentive to increase the skill levels of its employees. Acemoglu and Pischke (1998b) showed that in this model, the level of general training provided in the economy will be suboptimal.

As an example of how compression in the wage structure may induce firms to invest in general skills, consider a case of asymmetric information in which the worker's current firm has more information than outside firms about the quality or quantity of training the worker has received (Acemoglu and Pischke 1998c). In this case, increases in worker productivity are not fully translated into higher wages. The difference between worker productivity and wages will increase with the worker's skill level, thus giving the firm an incentive to provide general training. Additional labor market imperfections that may achieve the same effect include union rules, search costs, and minimum wages (Heckman, Roselius, and Smith 1994; Harhoff and Kane 1997; Acemoglu and Pischke 1998a,b,c). Evidence that firms in the United States, Germany, and other countries pay for at least some general training is reviewed in Acemoglu and Pischke (1998c).

This discussion suggests that useful information about the prospects for STW in the United States can be derived from some understanding of how STW programs are financed. If labor markets are competitive, student apprentices will pay the full costs of general training and the level of training will be optimal. On the other hand, if labor markets are imperfect, firms will pay for some or all of the costs of general training, and the level of general training will be suboptimal. Even if firms finance some general training through these STW programs, it remains unclear whether labor markets are sufficiently imperfect to finance the level of training that schools and others desire for these programs. The objective of our case studies is to document the training and finances for a sample of STW programs in the United States, and to learn more about whether those programs that provide general training can also be cost-effective for the firms sponsoring them.

Sample and Survey Methods

During the spring of 1997, the National Employer Leadership Council (NELC), a national organization of firms committed to school-to-work, recruited several member firms to participate in this study. Since most NELC members are large firms, NELC also helped us recruit several smaller firms that were known for their involvement in STW. We assume that firms voluntarily participating in STW programs are those for whom the returns to these programs are the highest. Thus, while this sample is not necessarily representative of any well-defined population, the lessons learned from this group help highlight the costs and benefits of STW training programs in what are likely to be best-case scenarios under the current U.S. policy regime.

The firms and sites we examined include four high-technology companies: Autodesk (in the San Francisco Bay area), BellSouth (Atlanta), Eastman-Kodak (Rochester, New York), and Siemens sites in Lake Mary, Florida, and Wendell, North Carolina. We also visited two McDonald's franchises in New Albany, Indiana, and Lady Smith, Wisconsin, and Crown Auto World, a small automotive repair business in Tulsa, Oklahoma. The sample thus represents a diverse set of industries and regions.

Once firms agreed to participate, our

research team first interviewed the coordinator of each firm's STW program. This central contact provided us with background information on the program, identified employees with specific information about different aspects of the program, and helped arrange our field visits. During our site visits in the summer of 1997, members of our research team administered a survey protocol that relied on open-ended questions about the program's objectives, training component, benefits, and costs, as well as lessons learned from the experience. Because our research team was on site for several days in each case, employees had the opportunity to access administrative records and consult with colleagues concerning points about which they were not clear. In a few cases, employees recontacted us by telephone after our field visits to provide supplemental information, or to revise earlier information that they discovered to be in error.

We believe that these case studies should provide more reliable information than would a paper-and-pencil or telephone interview administered to one employee as part of a large-scale survey methodology. Human resource personnel who are asked to complete a written survey are unlikely to have full information about every aspect of their firms' STW programs, and may have few incentives to fill in these informational gaps. Our practice of establishing contact with multiple employees helps address the problem of limited information on the part of individual workers. The relationship our interviewers developed with respondents, and the fact that the firms' STW officers acted as gatekeepers in arranging these interviews, may improve the reliability of these survey reports. Finally, our use of open-ended survey questions allows us to document aspects of the programs that are not easily measured using closed-ended questions.

Measuring Program Training, Benefits, and Costs

While our case study method is likely to produce more reliable results than would the survey techniques associated with a large-scale study, our estimates are nonetheless subject to several potential sources of error. The most important observation is that benefits are typically more difficult to quantify than costs, and as a result our estimates for the benefit/cost ratios of these programs are in most cases probably conservative. When there was uncertainty in estimating costs, we generally made assumptions that led to upper-bound estimates for costs. For example, it can be difficult to estimate the proportion of time mentors spend working with students that produces direct value to the firm. We typically assumed that none of the mentor's time is directly productive, though in reality this was unlikely to be the case.

There are two particular types of uncertainty regarding costs that warrant a brief mention: the choice of an appropriate discount rate, and the treatment of fixed costs. As with most investment projects, many of the costs are incurred up front, while many of the benefits occur in the future, making the choice of discount rate particularly important. We chose a fairly conservative discount rate of 10%, though we replicate all of our analyses for lower rates of 5% and 3%. When a program involved several years of student participation, we discounted all costs and benefits back to the year prior to the student's participation (to properly value the fixed costs incurred to develop the program).[1]

The proper treatment of fixed costs is somewhat complicated because most of the programs we studied tend to be small in scale and operate in areas with limited public sector infrastructures for school-to-work. With larger, more mature programs, the per-student costs for both program development and annual administration would

[1]When programs have fixed development costs, we treat the development of the program as the first year of the intervention, and discount back to this year. When the program does not involve development costs, we discount back to the first year of the program's operation.

presumably be lower. To explore the sensitivity of our results, we handle fixed costs in at least two ways for each case. First, we produce a conservative estimate that distributes fixed costs over only those students who have participated in the program to date. Then we replicate our analysis under the more liberal assumption that the program stays in operation for at least 10 years, and distribute fixed costs over 10 cohorts of students (each assumed to be equal in size to the average of previous cohorts).

In what follows, we present our case studies on each STW program in turn, focusing on the training that firms provide, and the net costs of the program to the firms under alternative assumptions about program benefits and costs. Additional details about each program are available in Bassi, Feeley, Hillmeyer, and Ludwig (1997).

Autodesk

Autodesk is a leading producer of computer-aided design (CAD) and desktop multimedia software, with around 2,200 employees worldwide, most of whom are located in the San Francisco Bay area. In 1992 Autodesk formed a high school internship program after several students inquired about opportunities to work with the firm's software. Autodesk's program is not formally linked to the activities of the area's public school system, given the very limited school-to-work infrastructure in the local schools. The formal structure of Autodesk's program is thus largely limited to the placement of interns with managers. The director of Autodesk's STW program first screens student applicants, and then recruits department managers to participate in the program. Managers then interview students and make hiring decisions for their departments.

By the summer of 1995, 50 students held internships at Autodesk in departments that include human resources, finance, multimedia marketing, technical publications, image archives, desktop services, and the technical assistance center. Interns typically begin working unpaid at Autodesk for 5–12 hours per week. After interns have worked for several months, managers typically begin to pay an hourly wage that starts at $5 to $7 and gradually increases to as much as $15. Most experienced interns work 10 to 20 hours per week during the school year and full-time during the summer months. Many of the managers we interviewed report that high school students are at least as computer literature, and thus trainable, as the adult contract workers whom the firm regularly employs.

The training students received varies across departments within Autodesk, but in all cases training is largely obtained informally from supervisors or by watching other employees. During her first few months on the job, one intern in the Technical Publications department received an average of two hours per week of on-the-job supervision and training in how to write online and hard-copy manuals for Autodesk's Mechanical Desktop software. The amount of supervision and training decreased to less than an hour per week thereafter. In the Information Systems department, one intern was trained to work as a systems administrator to replace full-time employees who are on leave. Her supervisor devoted around five hours per week to training during the first month of the internship.

In the Quality Assurance department, students are not productive during the first two weeks, since they spend around 14 hours per week with supervisors in training. After the first two weeks, interns require 20–30 minutes per week of supervision and training. Interns in the Kinetix Multimedia department work on a four-month project to translate an Autodesk software package into foreign languages. The manager reports that many of the tasks assigned to students, such as file conversions, are things these students already knew how to do and thus require little training. And in the company's Technical Assistance center, interns spend the first six weeks watching other employees assist customers on the company's help lines. Over the next six weeks interns begin to field calls part-time and continue their learning on-the-job. Neither form of training substantially re-

Table 1. Training, Benefits, and Costs of Autodesk's School-to-Work Program.

Program Description: 40 high school students hold internships with Autodesk each year.

Training: Informal on-the-job training, as students intern in Autodesk departments such as Technical Publications, Information Systems, Quality Assurance, Kinetix Multimedia, and Technical Assistance Center.

Program Costs (per student):

Department	*Administration*	*Student labor (wage, hours)*	*Supervision/Training*
Technical Publications	$1,815	$4,400 ($8/hour, 550 hours)	$2,220 ($85/week first 8 weeks, $35/week next 44 weeks)
Information Systems	$1,815	$7,600 ($10/hour, 760 hours)	$800 ($200/week first 4 weeks)
Quality Assurance	$1,815	$5,824 ($8/hour, 728 hours)	$2,675 ($712/week first 2 weeks, $25/week next 50 weeks)
Kinetix Multimedia	$1,815	$2,100 ($7/hour, 300 hours)	Marginal
Technical Assistance	$3,465[a]	$24,855[b]	Marginal

Program Benefits (per student):

Department	*Benefits (productive hours, shadow wage[c])*	*Benefits/Costs*
Technical Publications	$13,750 (550, $25)	1.63
Information Systems	$24,320 (760, $32[d])	2.38
Quality Assurance	$23,520 (560,[e] $42)	2.28
Kinetix Multimedia	$4,500 (300, $15)	1.15
Technical Assistance	$78,014[f] (2,735,[g] $30)	2.75 (10% discount rate; 2.70 at 5% rate, and 3.59 at 3% rate)

[a]First year fixed costs are $1,815. Second year fixed costs of $1,815 are discounted back to first year at 10% rate, to equal $1,650. At a 5% rate, second year fixed costs equal $1,729, and at 3% rate, they equal $1,762.

[b]First year, students work 1,480 hours at $5 per hour, for total labor costs of $7,400. In second year, students work their first 600 hours at wage rate of $10 per hour, and an additional 880 hours at wage rate of $15 per hour. Present-value of second year student labor costs equal to $17,455 at preferred 10% discount rate, and are equal to $18,286 at 5% rate, and $18,640 at 3% rate.

[c]Wage of employee who would have completed work in absence of intern.

[d]This is the average wage of the two groups of employees for whom interns typically substitute: full-time employees with salaries of $27.50 to $30 per hour, and contract employees with hourly costs of $50.

[e]Apprentices are not productive for first two weeks, and thereafter are estimated by Autodesk managers to attain 80% of the productivity rate of full-time employees, for the equivalent of (50*14*.8) = 560 hours of productive work by full-time employees.

[f]Present value of second year productivity of (1,480 hours * $30/hour) is equal to $40,364 at preferred 10% discount rate, $42,286 at 5% rate, and $43,107 at 3% rate.

[g]During first six weeks, interns are not productive as they learn by watching full-time employees. During next six weeks, interns attain 50% productivity rate, for a total first-year productivity of 1,255 hours.

duces the productivity of other employees.

Since the Autodesk program involves little formal training, costs consist primarily of intern salaries, the overhead costs of operating the program, and supervision and other informal training (Table 1). The program benefits come primarily from the value of student labor, since to date few interns have transitioned into full-time Autodesk employees. In the Quality Assurance department, after the first two weeks interns are 80% as productive as full-time employees. In the Technical Assistance department, interns are unproductive for the first six weeks, and work at 50% productivity (relative to a full-time worker) during the next six weeks. After the first two months, interns are as productive as other employees in handling basic calls, which frees up other members of the department to focus on more complex calls. In the other departments, managers report that trained interns are as productive as other workers.

In sum, interns at Autodesk seem to bear the full costs of informal training in what

appear to be fairly general computer skills, by accepting wages below their marginal products. As seen in Table 1, the benefit/cost ratios range from a low of 1.15 to a high of 2.75 in the five departments we studied. In the one department in which interns consistently work for more than one year (Technical Assistance), the benefit/cost ratio of 2.75 calculated using a conservative 10% discount rate is at least as large using lower discount rates.

BellSouth

Headquartered in Atlanta, Georgia, BellSouth serves as a holding company for telecommunications companies in nine states in the southeastern United States, with operations in 17 countries on five continents. BellSouth's involvement in STW was motivated by concern over the company's current and future staffing needs, as well as a sense of corporate citizenship. BellSouth's involvement with STW includes student "job shadowing," partnerships with local schools to modify curricula, and apprenticeships. We focus on the company's apprenticeship program. While specific cost and benefit figures for this defunct program are not available, the program's story illustrates the potential problems of financing such training programs.

Following the passage of the School-to-Work Opportunities Act of 1994, BellSouth implemented four pilot apprenticeship programs designed to integrate skills training into school curricula and place selected students into paid employment with the company. Two programs worked with high school students, and two focused on community college students. The occupations for which intern training was geared varied by site: consumer service representatives (Columbia, Tennessee); network service technicians (Key West, Florida); and field engineers and graphic artists (both in Atlanta). Most of these occupations require some post-secondary training but not a four-year college degree.

After working with 30 students for several years, the company decided that the program was not meeting its objectives and terminated it. The primary problem was that BellSouth's human resources policies made it difficult for the company to retain apprentices. As employment opportunities open up at particular locations, senior employees throughout the company are given preference in filling these vacancies. As a result, local sites were unable to recruit apprentices following their completion of the STW program. Because the program's substantial supervision and administrative costs were not covered by the difference between apprentice productivity and wages, the program was eventually dropped.

Crown Auto World

Crown Auto World is an independently owned Jeep, Buick, and BMW dealer in Tulsa, Oklahoma, with annual sales of $80 million. Crown's participation in STW was motivated by an industry-wide shortage in skilled automotive technicians. In 1992, Crown decided to recruit and train recent junior college and vocational-technical-school students, rather than lure experienced mechanics away from other dealers with promises of higher salaries. Crown's success in training and retaining technicians prompted the company's 1994 decision to participate in the General Motors Automotive and Automotive Services Advanced Programs (ASAP).[2] ASAP is a two-year program in which students alternate every nine weeks between full-time school at a local community college and full-time work at Crown.

Crown now works with an average of five students per year. When students first arrive at Crown, training is provided by a foreman who dedicates 30–50% of his time to this task. Once students have mastered a set of basic skills, they are assigned to work with a technician who serves as a mentor.

[2]Crown Auto World actually participates in both a vo-tech program and a junior college program, but for simplicity we focus our discussion and cost-benefit estimates on the latter.

Table 2. Training, Benefits, and Costs of Crown Auto World's School-to-Work Program.

Program Description: Five students per year participate in on-the-job training. Junior college students take classes in a local junior college and have on-the-job learning at Crown through General Motors' Automotive Services Advantaged Programs (ASAP).

Program Costs (per student):	
Cost Category	*Costs and Sensitivity Analysis*
Fixed Costs	$800 if assume program operates for 10 years with average cohort size of 5 students ($4,444 if fixed costs distributed only across students who have participated in program to date)
Tools	$900
Program Admin.	$2,727 first year at 10% discount rate ($2,857 at 5%, $2,913 at 3%) $2,479 second year at 10% discount rate ($2,721 at 5%, $2,828 at 3%)
Training Mechanics to Become Mentors	$448 (8 hours, $56/hour)
Supervision/Training	$8,182 first year at 10% discount rate ($8,571 at 5%, $8,738 at 3%)
Student Wages[a]	$33,079 over two years at 10% discount rate ($35,440 at 5%, $36,470 at 3%)
Program Benefits (per student):	
Benefit Category	*Benefits and Sensitivity Analysis*
Student Productivity	$11,580 first year at 10% discount rate ($12,133 at 5%, $12,369 at 3%) $16,846 second year at 10% discount rate ($18,488 at 5%, $19,214 at 3%)
Increased Profits from Hiring Apprentices as Technicians	$59,522 (firm hires 100% of apprentices, average tenure is eight years, 10% discount rate)[b]
Benefit/Cost Ratio:	*Assumptions*
0.88	10% discount rate, firm hires only 50% of apprentices, avg. tenure four years, upper-bound fixed costs
1.81	10% discount rate, firm hires 100% of apprentices, avg. tenure eight years, distribute fixed costs over 10 cohorts
2.28	3% discount rate, firm hires 100% of apprentices, avg. tenure eight years, distribute fixed costs over 10 cohorts

[a]Student wages include retirement and health insurance benefits.

[b]The initial assumption that Crown hires 100% of its apprentices as full-time technicians is based on the fact that each of the nine vo-tech high school graduates hired and trained by Crown in 1992 are still with the firm. At a 100% hiring rate and average tenure of eight years (the average tenure of Crown's current technician stock), the firm earns $79,141 at a 5% discount rate and $89,325 at a 3% rate. If the average tenure is four years and the firm hires 100% of apprentices, the firm earns $35,366 per apprentice at a 10% rate, $43,420 at a 5% rate, and $47,300 at a 3% rate.

Technicians who are interested in serving as mentors must first complete an eight-hour training program, in which they are taught how to manage students and to document the students' proficiencies in a "passport" that is periodically reviewed by the junior college instructors. Crown technicians have a strong incentive to serve as mentors and provide substantial informal training, since Crown pays the intern salaries, interns improve mentor productivity, and the technician-mentors are paid on a piece-rate basis. Technicians report that they experience very modest reductions in productivity during the initial phase of working with a student, since students have already received basic training from the foreman. Students graduate from the ASAP program with an Associate's of Science degree, and then have the option of joining Crown and earning $40,000 per year or more within two years on the job.

Table 2 reviews the program costs and benefits to Crown. A large share of the costs come from the student labor: students start at an hourly wage of $5.50 and can eventually earn up to $12 an hour, and become eligible for health insurance ben-

efits when they work more than 30 hours per week. Taken together, at a 10% discount rate the student labor costs average around $33,000 for the two-year period. Given recent cohort sizes and the foreman's annual salary and benefit costs, Crown spends around $9,000 per student for training from one of the shop foremen. The program also costs an additional $3,000 per year per student to administer. Finally, Crown has contributed a total of $45,000 to the local schools and community colleges as part of the program. If we distribute these fixed costs across only those students who have participated in the program to date and use a conservative discount rate of 10%, the per-student fixed costs are $4,444. Alternatively, we can use a 10% discount rate and assume that these fixed costs cover program operations for ten years with an average cohort size of five students, which implies a cost of $800 per student.

Among the other benefits of the program, during their first year at Crown students can increase technician productivity by 10% and produce an additional $11,580 in revenue for the company (discounted at 10% after subtracting the additional payments the technician-mentor receives). More advanced students can produce $16,800 of additional revenue for Crown. Our discussions with Crown technicians and managers also suggest that the quality of the repair work has increased since the firm began the apprentice program: the company's average customer satisfaction ranking has increased from a 2.9 in 1992 to a 3.7 in 1997 (on a 4.0 scale). Unfortunately, we are unable to quantify the benefits from these quality improvements.

Finally, Crown estimates that it will earn appreciable rents for each apprentice who is hired on as a full-time technician. While the program is too young to estimate an apprentice retention rate, this rate could plausibly be as high as 100%, given that Crown still employs each of the nine votech graduates the company hired and trained in 1992. Crown estimates that it receives $13,500 in profits for each additional technician the firm hires, under the assumption that the firm can increase output at current retail prices. Despite these considerable gains, Crown is generally hesitant to hire additional technicians away from other firms at higher salaries, because this may require wage hikes for its current technicians. If Crown manages to hire each of its apprentices as full-time employees at the prevailing wage, and these apprentices have the same average tenure with the firm as current technicians (eight years), the firm will earn $59,500 per apprentice at a 10% discount rate. If the firm manages to hire only half of its apprentices and the average tenure is as low as four years, it earns $17,700 per apprentice (at a 10% rate).

As seen in Table 2, the students do not appear to pay for any of the apprenticeship training regardless of the discount rate that is used. For example, with a 10% discount rate students receive salary and benefits during the training period equal to $33,079, while the (quantifiable) value of student labor during training is only around $28,500. Crown thus seems to pay for automotive training despite the fact that the auto-repair skills used at any given shop appear to be quite general. But on net the substantial rents Crown receives from hiring apprentices as full-time technicians offset most or all of these costs. Our preferred estimate of the benefit/cost ratio is equal to 1.81, which assumes a 10% discount rate, a 100% retention rate, an average tenure among apprentices hired as full-time technicians of eight years, and fixed costs that are distributed across 10 cohorts of students. Under the lowest reasonable estimate, which assumes a far lower retention rate and average employee tenure, the program still nearly pays for itself with a benefit cost ratio of 0.88.

Eastman-Kodak

Eastman-Kodak is one of the world's largest producers of photographic film, paper, and chemicals. Kodak's skilled-trades youth apprenticeship program was initiated by the Capital and Maintenance Organization (CandMO) division at company headquarters in Rochester, New York. The program

was developed in conjunction with the Rochester City School District and the Rochester Business Education Alliance (RBEA) as part of an area-wide STW initiative. The program began five years ago, and each year 10th-grade students from Edison Technical High School enroll as apprentices in the CandMO division. To be selected, students must have completed all core courses and must have a 90% attendance record, a 2.0 GPA, and no serious disciplinary suspensions. Typically, 25 or more students apply for five or six positions.

Students who are selected for the program work 16 to 20 hours per week while in school, and 40 hours per week during summers and holidays. During the program, students are required to maintain a 2.5 GPA in high school, keep a 95% attendance rate at both school and work, and complete a minimum of 1,200 hours of work at Kodak. These hours are evenly distributed across five skilled-trade areas: automatic equipment; electrical/instrumentation; machine/tool; pipe fitting/welding; and sheet metal. In each rotation, students spend approximately 75% of their time on activities that produce value for Kodak, and receive on-the-job training and supervision by coaches who have knowledge of the specific skilled trade. Students also have one mentor for the duration of the program, who monitors the students' progress.

In order to receive their certificate of completion, students are required to complete a final project that includes an outline of the skills learned in the program, a discussion of the relationship between these skills and the student's academic work, and an oral presentation to a review board. Graduates are invited to join Kodak's regular apprenticeship program, in which they are paid an hourly wage of $11.50 plus benefits and given advanced credit for certain areas.

Unfortunately, Kodak did not retain information on the fixed costs associated with designing and developing the apprenticeship program, though our interviews suggested that these costs are not trivial. As seen in Table 3, Kodak estimates that the program's operating costs equal $1,527 for administration per student over two years (discounted at a 10% rate), and an additional $400 for supplemental training by an outside organization. Student compensation averages $8.50 per hour for salary and benefits. The costs of the student labor thus range between $9,700 and $14,600, depending on whether they work 600 or 900 hours per year. Kodak also incurs costs of $3,500 per student for the time spent by mentors and coaches on informal training; this is an upper-bound estimate, since it assumes that mentors do not accomplish any productive work while spending time with apprentices.

To date, the key benefits come from the value of student labor. Seventy-five percent of the students' time at Kodak is devoted to productive activities that would otherwise have been completed by regular employees who earn $16–20 an hour. We value the work that would have been completed by full-time workers at an intermediate rate of $18 per hour. We also assume that interns are 70% as productive as experienced workers, which is about equal to the average efficiency of welders-in-training during their first two years at a U.S. shipyard (Ryan 1980). Depending on whether students work 600 or 900 hours per year, at a 10% discount rate this labor will be worth no less than $10,825 and no more than $16,763. To date, 10 of the 16 graduates have joined Kodak's regular apprenticeship program, which they complete in three months less time than regular trainees at an estimated savings to Kodak of $2,583.

Taking all these factors into consideration, it appears that students pay for some of the training they receive in the Kodak program. At a 10% discount rate, the value of students' labor exceeds their wages by $1,100 to $2,100 over two years, depending on whether they work 600 or 900 hours per year. (At lower discount rates, the amounts paid by students are slightly lower.) Yet Kodak also pays for what appears to be general training. Kodak's costs are only partially offset by the savings the company receives when teens graduate from STW

Table 3. Training, Benefits, and Costs of Eastman-Kodak's School-to-Work Program.

Program Description: Two-year program for high school students who gain work experience and develop skill proficiencies in five different Kodak departments. In exchange for a certificate of completion, students are required to complete a final project. Graduates are then invited to join Kodak's regular apprentice program.

Program Costs (per student):	
Cost Category	*Costs and Sensitivity Analysis*
Fixed Costs	Not available
Program Administration	$1,527 over two years at 10% discount rate ($1,561 at 5%, $1,577 at 3%)
Student Labor	$9,736 for 600 hours per year over two years at 10% discount rate ($9,957 at 5%, $10,051 at 3%); $14,605 if students work 900 hours per year, 10% discount rate ($14,936 at 5%, $15,077 at 3%)
Supervision/Training	$3,500 in first year[a]
Additional Training	$400
Supplies	$325
Program Benefits (per student):	
Benefit Category	*Benefits and Sensitivity Analysis*
Value of student labor	$10,825 for 600 hrs./yr., two years[b] at 10% disc. rate ($11,070 at 5%, $11,175 at 3%) $16,237 for 900 hrs./yr., two years at 10% disc. rate ($16,605 at 5%, $16,763 at 3%)
Reduced Training Costs for Retained Apprentices	$2,583 at 10% disc. rate, assuming firm hires 62.5% of apprentices[c] ($2,835 at 5%, $2,946 at 3%)
Benefit/Cost Ratio:	*Assumptions*
0.94	Upper bound estimate (3% disc. rate, 900 hours of work)
0.87	Lower bound estimate (10% disc. rate, 600 hours of work)

[a]Supervision and training costs are conservative for two reasons. First, in the absence of direct data on how these supervision and training costs are distributed across each student's two years in the program, we assume that all costs are incurred during the first year. Second, we assume that all of the time that mentors spend working with apprentices is unproductive, in the sense that this time does not produce output of value to Kodak.

[b]Students spend 75% of their 600 hours of work per year on productive activities. We assume that students average a 70% productivity rate compared with full-time employees during their apprenticeships, the two-year average productivity rate for new shipyard welders estimated by Ryan (1980). Employees who would have performed this work are compensated at rates of $16 to $20 per hour.

[c]To date, Kodak has hired 10 of the 16 apprentices who have completed the program (62.5%). These graduates complete the regular Kodak apprenticeship program in three months' less time than other new hires, at a savings of $5,000 (which is then discounted back to the first year of the program).

and enter the regular apprenticeship program. We estimate that the benefit/cost ratio of the Kodak program is no higher than 0.94, obtained using a discount rate of 3% and assuming students work 900 hours per year. Given the benefits and costs we were able to measure, our lower bound estimate is 0.87, derived by using a 10% discount rate and assuming students only work 600 hours per year. The true benefit/cost ratios are likely to be lower than these figures, because our estimates do not account for the fixed costs associated with developing the program.

McDonald's of Lady Smith, Wisconsin

Lady Smith (population 3,939) is a rural farming community in northwestern Wisconsin. The surrounding county has the lowest per capita income level in the state, and a 1997 unemployment rate of 11%. The Lady Smith store is owned and operated by the Courtesy Corporation, which has 22 stores in western Wisconsin and northern Iowa. The student apprenticeship program began in December 1995 as a collaboration between Courtesy and Flambeau High School. The original intention

was for Flambeau to incorporate into the curriculum a series of business management courses developed as part of the National Youth Apprenticeship in Consumer Service Management (NYACSM) program. The NYACSM program was developed by the McDonald's Corporation, Northern Illinois University, and Walgreen's, and focuses on fundamental mathematics, team building, basic management skills, and interpersonal skills. Students also work part-time at McDonald's in conjunction with the NYACSM coursework. New skills are certified at each step of the program. The ultimate objective is for students to complete the NYACSM courses and become front-line managers following high school graduation. After two years of post-secondary education and management training, participants can become consumer service managers.

In practice, the NYACSM courses could not be scheduled as part of the regular curriculum at Flambeau High. Students were instead offered the opportunity to work through the self-guided course during study periods in exchange for a half credit on their academic reports, and to work part-time at McDonald's. Of the 12 students who applied from the 9th through 11th grades, all were accepted. In April 1997, the 9 juniors and seniors among the group of 12 began to work for 20 hours per week at the Lady Smith restaurant, at a starting hourly wage of $4.75 (roughly $5,000 per year). The local franchise has also spent $5,460 for a manager to spend 420 hours to work with students in the NYACSM courses, $400 on materials, and between $5,000 and $6,600 to organize and establish the program in Lady Smith.

The primary benefits of the program so far come from the value of the student labor. While the hourly productivity of apprentices is equal to that of other front-line workers, apprentices have lower turnover rates. The Lady Smith franchise estimates that each turnover costs the firm between $500 and $550. While the annual turnover rate in Lady Smith among front-line workers is 90%, of the nine apprentices who started work at McDonald's only one left as of the summer of 1997. The difference in turnover implies annual savings to Courtesy of $3,500 from this cohort of students. (See Table 4.)

The results of our case study thus suggest that the relatively modest training costs associated with the McDonald's program are borne largely by the firm. The primary benefit the firm has received to date comes from the lower turnover rates among apprentices relative to other employees, though these benefits may increase over time as apprentices join the local franchise's full-time work force. We estimate that the benefit/cost ratio in this program is probably no lower than 0.90 and no higher than 0.98; the difference between the two estimates is due to different decisions about how to allocate fixed costs. Despite the uncertain returns to Courtesy to date, our interviews suggest that social norms may play a role in motivating the firm's participation. As one manager in Lady Smith reports: "In smaller towns, you have to be more involved in what's going on. It's their McDonald's, and they want to see you."

Siemens of Lake Mary, Florida

Siemens is an international telecommunications and electronics company with more than 370,000 employees in 190 countries. Although apprenticeships are relatively new in Siemens' U.S. operations, worldwide more than 40% of Siemens' upper management and engineers began their careers as apprentices. The Siemens American apprenticeship programs began in 1992, as the presidents of each of Siemens' U.S. operating companies recognized their common difficulty in recruiting and retaining qualified technicians. Siemens Telecom Networks (STN), an international telecommunications company headquartered in Boca Raton, Florida, initiated the first youth apprenticeship program in the fall of 1992. STN has more than 3,000 employees involved in the design, manufacture, and marketing of digital central office switching systems, personal communications systems, and fiber-optic transmission products. The youth apprenticeship program,

Table 4. Training, Costs, and Benefits of McDonald's School-to-Work Program in Lady Smith, Wisconsin.

Program Description: High school students take a McDonald's-sponsored business course in school during their study periods, and work part-time at the local McDonald's franchises.	
Program Costs (per student):	
Cost Category	*Costs and Sensitivity Analysis*
Fixed costs	$417 to $550 distributing fixed costs only over the 12 students who have participated to date; $42 to $55 assuming fixed costs distributed over 10 cohorts of students, with cohorts of 12 students each
Training[a]	$455
Student Labor	$5,000 per year ($4.75 per hour, 20 hours per week)
Program Benefits (per student):	
Benefit Category	*Benefits and Sensitivity Analysis*
Value of Student Labor	$5,000 per year ($4.75 per hour, 20 hours per week)
Reduced Turnover among Apprentices vs. Regular Employees	$390
Benefits/Costs:	*Assumptions*
0.90	Lower bound (distribute fixed costs over current program participants only)
0.98	Upper bound (distribute fixed costs over 10 cohorts, each equal to 12 students in size)

[a]A McDonald's manager spent 420 hours working with the 12 students enrolled in the school-based business course developed by the national McDonald's corporation.

known as the Electronics Technicians Advanced Program (ETAP),[3] is based in the company's manufacturing plant in Lake Mary, Florida, and involves collaboration between STN, Siemens Business Communications, and Seminole Community College (SCC). ETAP is a registered apprenticeship program in the state of Florida.

The ETAP program is designed to train students to become electronics technicians. To be eligible for ETAP, students must satisfy certain criteria related to grades, coursework, and standardized scores on college-preparation tests. In addition to taking regular community college courses, Siemens employees provide instruction to ETAP students in fairly general topics such as electronics, safety, documentation, corporate culture and identity, career development, team building, customer service, and quality awareness. Two of the three academic terms per year are spent in on-the-job training. During these 29 weeks, students work full-time in the Lake Mary manufacturing plant or at other Siemens sites.

At the completion of the 24-month program, students receive an associate's degree in electronics engineering technology, as well as government certifications from the Florida Department of Labor, the U.S. Department of Labor, and the German Chamber of Industry and Commerce. While Siemens does not guarantee jobs to students upon graduation from ETAP, so far each of the 68 students who have entered the program has joined the company. Students are aware that by entering the program they commit to accepting a job offer if one is extended by Siemens, and to

[3]Siemens also sponsors a high school vo-tech program in Lake Mary, which serves in part as a feeder for the ETAP community college program. Details on the vo-tech component are provided in Bassi et al. (1997).

remaining with the company for at least one year. Graduating students are qualified for hire as customer/systems engineers, field service technicians, installation specialists, and manufacturing/test technicians. The starting salaries for graduates of the program range from $18,000 to $36,000 per year.

Siemens spent $900,000 to develop the Lake Mary program, a figure that is measured with some precision from a Siemens grant application to the U.S. Department of Labor. These fixed costs included $311,000 to work out the logistics of the program and translate the apprenticeship curriculum from German, among other tasks, $86,500 to refurbish and equip rooms at the Siemens facility and another $250,000 for rooms at SCC, $67,000 in training supplies, and $27,000 to send a group of representatives from the Lake Mary partnership to Germany and Denmark to observe apprenticeship training programs in the fall of 1992. Because these costs are borne in part to develop a program that can be applied to other sites, allocating fixed costs is somewhat complicated. One approach is to recognize that the $311,000 spent on adapting the German curriculum for use in the United States may have value at other Siemens operations in this country, and thus allocate this portion of the fixed costs evenly across the firm's 17 American companies. A more conservative approach is to assign all fixed costs to Lake Mary.

Students are compensated for the hours they work during the on-the-job training part of the program, though they are not paid for the training-center–related hours and they do not receive benefits. As seen in Table 5, additional costs at Lake Mary thus include $8,600 over two years (discounted at 10%) for 1,160 hours of work at an hourly wage of $7.50. During the on-the-job portion of the program, students spend 2–15 hours per month with their mentors learning new tasks. We value the costs of this mentoring by choosing an intermediate estimate of 8.5 hours of mentoring per month and assume that mentors are not productive at all while they are working with students. At the average salary and benefit level of Siemens mentors, these training and supervision costs average $5,800 per student over two years. Siemens also covers the $1,000 in material costs for each student's program participation. Because ETAP is an apprenticeship training program registered by the state of Florida, the state reimburses SCC for students' tuition and laboratory fees. Students are responsible for textbooks.

The benefits from the program come from the value of student labor and the savings Siemens enjoys from reduced recruitment and training costs. Siemens managers estimate that the productivity of ETAP students during their 1,160 total hours of on-the-job training averages around 75% that of more experienced employees. More experienced full-time employees who perform similar work earn $12 per hour, and as a result the value of the students' labor is roughly equal to $10,000 over two years. Siemens has also been able to hire each of its ETAP participants to date, who tend to be more productive than other newly hired workers with two-year degrees. One Siemens manager reports that new hires from technical schools "take years to catch up with students from the ETAP program." Another manager reported: "What sometimes takes people a month to get, [ETAP graduates] get in an hour. I'm not exaggerating; I've seen it happen." While Siemens usually spends around $33,000 in salary plus benefits over six months to train new hires, ETAP graduates reach this level of proficiency in two to eight weeks. ETAP graduates on average also require around 50 fewer hours of supervision than new hires who have completed the six-month training program. Together, the reduced training supervision saves between $10,330 and $13,636 per student.

ETAP students produce other benefits to the firm that are more difficult to quantify. For example, in one department ETAP students suggested replacing a glass part that commonly needed repair with one fashioned out of plastic, which served to reduce the machine's down time. In several departments, managers reported that the pres-

Table 5. Training, Benefits, and Costs of Siemens' School-to-Work Program in Lake Mary, Florida.

Program Description: Participants rotate between coursework at Seminole Community College and employment at Siemens. Students also receive instruction from Siemens personnel in subjects such as electronics, safety, team building, and quality awareness.

Program Costs (per student):	
Cost Category	*Costs and Sensitivity Analysis*
Fixed Costs	$13,235 if all fixed costs borne by Lake Mary, distributed across 68 students who have participated to date $8,931 if costs of translating German curriculum allocated across 17 Siemens U.S. operations, and Lake Mary fixed costs distributed across 68 students who have participated to date $4,500 if fixed costs borne by Lake Mary site, distributed across 10 cohorts of 20 students each $3,037 if costs of translating German curriculum allocated across 17 Siemens U.S. operations, and Lake Mary fixed costs distributed across 10 cohorts of 20 students each
Material Costs	$1,000
Supervision/Training	$5,755 over two years at 10% disc. rate ($6,209 at 5%, $6,267 at 3%)
Student Salaries	$8,591 over two years at 10% disc. rate ($8,786 at 5%, $8,869 at 3%)
Program Benefits (per student):	
Benefit Category:	*Benefits and Sensitivity Analysis*
Student Labor	$9,965 over 2 years at 10% disc. rate[a] ($10,191 at 5%, and $10,288 at 3%)
Reduced Basic Training	$10,330 to $13,636 at 10% disc. rate[b] ($11,338–14,966 at 5%, and $11,782–15,553 at 3%)
Benefits/Costs:	*Assumptions*
0.71	Lower bound (10% disc. rate, use high estimate for fixed costs and low estimate for reduced basic training)
1.11	Intermediate (10% disc. rate, use mid-range estimates for fixed costs and reduced basic training)
1.35	Upper bound (3% disc. rate, use low estimate for fixed costs and high estimate for reduced basic training)

[a]Students spend a total of 10,440 hours in on-the-job work and training at Siemens during the two-year program. Siemens managers estimate that over this period apprentices average around 75% of the productivity of full-time employees who earn $12 per hour.

[b]Program graduates who join Siemens as full-time employees require less training and supervision to reach full productivity. To date, Siemens has hired all of its STW graduates, in part because apprentices understand that participation in the program commits them to working at Siemens for at least one year.

ence of ETAP students allowed for greater specialization of labor, as more experienced employees were able to focus on the most complex tasks. ETAP graduates seem to have higher promotion rates than other new hires. Assuming that promotions are correlated in some way with employee productivity and skills, differentials in promotion rates reflect further productivity differentials.

In sum, students pay around $1,400 of the costs of on-the-job training in this program by accepting wages below their marginal products, an estimate that is not very sensitive to our choice of discount rate. Siemens pays the rest of the training costs, most or all of which the firm manages to recoup by hiring apprentices as full-time employees. In our preferred estimate, which uses a 10% discount rate and intermediate estimates for the fixed costs and benefits from retaining apprentices, the benefit/cost ratio for the program is equal to 1.11. Using what we believe are the highest justifiable figures for fixed costs and the lowest estimates for benefits leads

to a benefit/cost ratio no lower than 0.71, while the upper bound for this ratio is 1.35. The key to the program's financial viability is thus Siemens' ability to retain and profit from apprentices once they have completed the STW program.

Siemens of Wendell, North Carolina

Another youth apprenticeship program is operated by Siemens Energy and Automation, Incorporated (SEA). SEA designs and produces electrical switch gear for commercial and utility markets in Wendell, North Carolina. Wendell is a bedroom community of neighboring Raleigh, and has had very tight labor markets for the past decade, with unemployment rates as low as 2%. In 1992, SEA approached East Wake High School about establishing a training partnership between the school and the nearby Siemens plant. East Wake has a student population of approximately 1,600 students, roughly 35% of whom are members of ethnic minorities and 33% of whom are classified as academically or economically disadvantaged. Student recruitment is targeted toward the 10th grade, with emphasis placed on the program's benefits to those who will not attend college. Interested students must apply for admission to the Siemens program, must have a 2.0 GPA and at least a C average in algebra, and are required to complete an aptitude test, interest profile, and interview with the company.

Participants enroll at East Wake in two specialized courses during their junior year (Siemens I and Principles of Technology I) and two more during their senior year (Siemens II and Principles of Technology II). During the summers following their junior and senior years, students are required to work full-time at the Siemens plant for at least six weeks, although most choose to work eight to ten weeks. At the completion of the program, students have the option of going to work for Siemens as full-time employees. So far, most of the graduates have continued on to post-secondary school, though these students still have the option of working for Siemens during summers and school breaks. Forty-two students have participated in the program, with an average cohort size of 14 students each year.

To date, Siemens has spent $434,000 to develop the program. The bulk of these costs ($330,000) was spent on renovation and equipment for two rooms at East Wake, and at least another $100,000 was devoted to staff time for program development. If we include an additional $18,000 for Wendell's share of the costs of adapting and translating the Siemens German curriculum (incurred at the Lake Mary site), these fixed costs increase to $452,000. We calculate the per-student fixed costs under a conservative method that counts only those students who have participated in the program to date, or alternatively under the assumption that the program is in operation for 10 years with 14 students per cohort. Annual operating costs of the program include $10,000 for supplies and $18,000 on staff time to administer the program and work with East Wake on the in-school coursework, which we distribute across the 28 students who participate at any point in time, and discount at an annual rate of 10% in our preferred estimates. Students also participate in a two-week unpaid training period once they start work at Siemens, which is the same training provided to temporary workers at Wendell. While participants are unpaid in this course, Siemens does pay an average of $75 per student for the instructor's salary. Finally, students in the program earn $8 per hour to start. Students typically work eight to ten weeks during the summers after their junior and senior years, for total earnings of $4,400 to $5,500 over the two years.

The bulk of the program's benefits to Siemens has come from the value of the student labor. The work students perform would have been completed by temporary workers earning $9.25 an hour. The other benefit comes from rents Siemens captures by hiring graduates of the STW program. A randomized experiment Siemens initiated with full-time workers at another site highlights the productivity gains from the STW program's training component. In the experiment, 50 production-line workers were

randomly assigned to two groups—a control group, and a treatment group that went through two of the training modules used in the apprenticeship program. Relative to the control group, the treatment group was on average 42% more productive and had a 71% lower defect rate, for savings of $9,500 per year for each full-time worker. We assume that the hourly productivity gains from the apprenticeship training will be similar to what is estimated from this experiment. In reality, the productivity gains from the apprenticeship program could be somewhat higher because the apprentices participate in more than the two training modules used in the training experiment, or they could be somewhat lower if younger people are less able to take advantage of the training program.

To date, Siemens has hired one of the 13 students who entered the apprenticeship program as a full-time employee, and four other students work full-time during summers and college breaks. Assuming that these hiring rates will hold for future cohorts, Siemens gains $1,022 (discounted at a 10% rate) for each apprentice who begins the STW program.

Our estimates thus suggest that students pay for a relatively small share of the training costs, between $700 and $900, by accepting a wage below their marginal product (assuming that apprentices are as productive as temporary workers once both groups have completed training). Even though most of the training in this program apparently occurs at East Wake High School rather than at the Siemens facility, the company has invested heavily in the infrastructure and staff at East Wake. In light of these substantial program costs, the fact that students do not pay for much of the training, and the difficulty the Wendell site has had in retaining apprentices, even our upper bound estimate suggests that program costs exceed the measurable benefits to date. As seen in Table 6, our intermediate estimate for the program's benefit/cost ratio is equal to 0.69, with a lower bound of 0.35 and an upper bound of 0.72. The variation in our estimates is determined more by our decisions about how to allocate fixed costs than by our choice of discount rate.

Conclusion

An important goal for school-to-work programs in the United States is to prompt additional investment by firms in human capital. Yet there remains considerable uncertainty about whether STW programs that develop general skills are sustainable in America given current labor market characteristics and public policies. The classic Becker model suggests that firms will be unwilling to finance training in general skills, and that students may be unable or unwilling to finance training because of wage floors or difficulty signaling skills to future employers. On the other hand, any imperfection in the labor market that allows firms to extract rents from trained workers will provide firms with incentives to provide general training (Acemoglu and Pischke 1998a,b). We find that most of the STW innovators we have studied are apparently willing to pay for general training, though it is less clear whether firms will be able to recoup the full costs of this training given current labor market institutions and public policies in the United States.

Table 7 summarizes the results of our case studies. Contrary to the prediction of the classic Becker model, we find that in all but one case the firm pays for some or all of the costs of general training. Our finding that firms pay for training is consistent with the results of two national surveys of American firms (Barron, Berger, and Black 1999), though these national surveys are somewhat limited in their ability to determine whether training is in general- or firm-specific skills. In the present paper, our detailed case studies suggest that most of these STW programs provide quite general skills through informal employer-based training, related coursework in public high schools or community colleges, and, in some cases, formal employer-based classroom training.

The results shown in Table 7 also highlight the substantial variation in benefit/cost ratios across these STW programs. One

Table 6. Training, Benefits, and Costs to Siemens' School-to-Work Program in Wendell, North Carolina.

Program Description: Students from East Wake High School enroll in two specialized courses per year during their junior and senior years (Siemens I and II, and Principles of Technology I and II). Students work full-time during the summers at the Wendell Siemens plant, and after high school graduation have the option of joining the company as full-time employees.

Program Costs (per student):	
Cost Category	*Costs and Sensitivity Analysis*
Fixed Costs	$11,548 if Wendell site shares costs of adapting Siemens' German curriculum with Lake Mary site, and fixed costs are distributed across 42 students who have participated in Wendell to date $11,119 if Wendell does not share curriculum-adaptation costs with Lake Mary, and fixed costs are distributed across 42 students who have participated in Wendell to date $3,464 if Wendell site shares costs adapting German curriculum with Lake Mary site, and fixed costs are distributed across 10 cohorts with average of 14 students per cohort $3,336 if Wendell does not share curriculum-adaptation costs with Lake Mary, and fixed costs are distributed across 10 cohorts with average of 14 students per cohort
Program Supplies	$619 over two years at 10% disc. rate ($649 at 5%, $684 at 3%)
Training/Admin.	$1,115 over two years at 10% disc. rate ($1,195 at 5%, $1,230 at 3%)
Instructor Salary	$75
Student Salaries	$4,443 over two years at 320 hrs./yr. and 10% disc. rate ($4,760 at 5%, $4,898 at 3%) $5,554 over two years at 400 hrs./yr. and 10% disc. rate ($5,950 at 5%, $6,123 at 3%)
Program Benefits (per student):	
Benefits	*Benefits and Sensitivity Analysis*
Student Labor	$5,137 over two years at 320 hrs./yr. and 10% disc. rate ($5,504 at 5%, $5,664 at 3%) $6,422 over two years at 400 hrs./yr. and 10% disc. rate ($6,880 at 5%, $7,079 at 3%)
Increased Productivity from Retaining App's.	$1,022 if firm hires 8% apprentices as full-time and 30% as part-time employees, using 10% disc. rate ($1,175 at 5% discount rate, $1,245 at 3% rate)
Benefits/Costs:	*Assumptions*
0.35	Lower bound (10% disc. rate, 320 hrs./wk per year, high end of fixed cost range)
0.69	Intermediate (10% disc. rate, 400 hrs./wk per year, middle of fixed cost range)
0.72	Upper bound (3% disc. rate, 400 hrs./wk per year, low end of fixed cost range)

obvious explanation for this variation is that firms with relatively high benefit/cost ratios may be the ones that provide little training. While this explanation receives some support from the observation that the program with the least amount of formal training (Autodesk) has the highest benefit/cost ratios, this hypothesis does not seem to fit the overall pattern of results particularly well. For example, the Crown Auto World and Siemens–Lake Mary programs appear to have formal training programs that are at least as intensive and structured as those at the other sites, yet Crown and Siemens–Lake Mary have among the highest benefit/cost ratios. More plausible explanations for the variation in benefit/cost ratios across firms stem from dif-

Table 7. Summary of Training and Firm/Student Investments in School-to-Work Programs.

Program	*Training*	*How Is Training Financed?*	*Benefit/Cost Ratio*
Autodesk (5 departments)	Informal on-the-job learning	Students pay for training by accepting training wages	From 1.15 to 2.75 (median 2.28)
BellSouth	Worked with local school districts to provide skills training in schools, and formal on-the-job training	Firm paid for at least some of the training costs.	Program canceled in part because firm unable to recruit apprentices and recoup training costs
Crown Auto World	Coursework at local junior college, on-the-job training by shop foreman and mentor/technicians, and on-the-job learning. Program results in Associate's degree.	Firm pays for training, which it recoups by hiring former apprentices	1.81 (no lower than 0.88, no higher than 2.28)
Eastman-Kodak	On-the-job training from supervisors and other employees, including assistance on a final project. Program results in Kodak skill certifications for high school grads.	Students pay for a share of training costs by accepting training wages. Firms also pay for general training, part of which is recouped by savings in training costs from hiring former apprentices.	0.87 to 0.94 (excludes program development costs)
McDonald's of Lady Smith, Wisconsin	During school hours, students take self-administered business course developed by McDonald's. Students also work part-time at local franchises.	The program's modest training costs are paid for by the firm.	0.90 to 0.98
Siemens (Lake Mary, Florida)	Students rotate between community college and work at Siemens. While at work, they receive formal and informal training. Program results in Associate's degree and BAT and German skills certification.	Students pay for a share of training costs by accepting training wages. Firm finances rest of general training, most of which is recouped from savings in training costs when apprentices are hired as full-time employees.	1.11 (no lower than 0.71, no higher than 1.35)
Siemens (Wendell, North Carolina)	While in school, students at East Wake High School take electronics courses developed by Siemens. Students also work part-time and receive some informal training.	Students pay for a share of training costs by accepting training wages. The firm finances the rest, only a share of which it recoups from rents associated with hiring former apprentices.	0.69 (no lower than 0.35, no higher than 0.75)

ferences in the ability of students to pay for training (for example, because of unusually high productivity, such as that observed at Autodesk), and differences in the ability of firms to extract rents from trained workers.

Only one firm (Autodesk) fits the classic pattern suggested by the Becker model, where students pay the full costs of their (informal) training by accepting wages below their marginal products. Minimum wages have long been viewed as a possible impediment to such training arrangements in the United States. Yet despite the minimum wage, students are able to finance their training at Autodesk by accepting training wages because they have unusually high marginal values in the firm's high-technology setting.

The two other firms that are able to recoup training costs (Crown Auto World and Siemens of Lake Mary, Florida) do so by extracting rents from trained workers, as predicted by the imperfect-labor-market model of Acemoglu and Pischke (1998a,b,c). In the case of Crown Auto World, the firm apparently has some monopsony power in the labor market for auto technicians in Tulsa. The managers we interviewed are concerned that luring technicians away from rival auto shops requires above-market wages, which in turn may require pay increases to Crown's current stock of technicians. Perhaps as a result of the monopsony power held by Tulsa repair shops, Crown has been very successful in retaining technicians in the past, and we expect the firm to have similar success with the graduates of its STW program.

The Florida Siemens site is also able to recoup its training costs by retaining graduates of the company's apprentice program. These trained workers accept wages that are similar to those of other starting employees, yet they are more productive and require less training. The reasons for the relatively high retention rates at Siemens' Lake Mary site are less clear. One possibility is that the pledges students make at the beginning of the program to stay on with Siemens for at least one year increase the psychic costs of leaving the company.

While several of the other firms we studied also extract some rents from trained workers, the long-term benefits of these programs to the sponsoring firms are not clear. The Kodak and McDonald's programs have measurable benefits that are fairly close to costs under most assumptions, though the Kodak benefit/cost ratio is probably overestimated somewhat, given the absence of data on the program's fixed costs. And in the cases of the Siemens Wendell site and BellSouth, the available evidence points to net costs of these programs from the firms' perspectives. Generalizing from these results is complicated by the fact that our data come from a small convenience sample of firms. On the other hand, if firms choose to participate in STW on the basis of expected returns, the experiences of these trailblazers may reflect the best-case scenarios for STW in the United States, given our labor markets and public policies.

Our findings thus suggest that American labor markets are imperfect enough to motivate firms to participate in STW and finance some general training. On the other hand, it remains unclear whether labor markets are imperfect enough to guarantee that firms will be able to recoup their investments in general training, since in only a few cases can firms' hiring of former apprentices yield rents sufficient to fully offset the program costs. It is possible that we have underestimated the long-term benefit/cost ratios of these programs, since we have employed conservative assumptions throughout, and each program is relatively new and small in scale and may have higher benefit/cost ratios as it matures. Despite this uncertainty, if our conjecture is correct that these programs represent the best-case scenarios for STW under current conditions, then these findings seem to raise questions about whether firms can sustain STW programs absent some change in labor markets or public policies. Moreover, to the extent that STW programs are financially viable because firms extract rents from trained workers, the level of training through such programs will be suboptimal (Acemoglu and Pischke 1998b).

Whether STW programs are desirable from a societal perspective is an issue beyond the scope of this paper. The benefits and costs of these programs to society will differ from those that we have estimated from the firm's perspective. For example, our focus on each firm's benefit/cost calculus leads us to ignore resources that local school systems have devoted to these programs and increases in student productivity that are not captured by the sponsoring firms. Yet our case studies suggest that even if these programs produce net benefits to society, there is no guarantee that under the current U.S. policy regime firms will be able to finance STW programs over the long run.

REFERENCES

Acemoglu, Daron, and Jorn-Steffen Pischke. 1998a. "Why Do Firms Train? Theory and Evidence." *Quarterly Journal of Economics,* Vol. 113, No. 1, pp. 79–119.

____. 1998b. "The Structure of Wages and Investment in General Training." NBER Working Paper 6357.

____. 1998c. "Beyond Becker: Training in Imperfect Labor Markets." NBER Working Paper 6740.

Barron, John M., Mark C. Berger, and Dan A. Black. 1999. "Do Workers Pay for On-the-Job Training?" *Journal of Human Resources,* Vol. 34, No. 2, pp. 235–52.

Bassi, Laurie J., Theresa Feeley, John Hillmeyer, and Jens Ludwig. 1997. "Learning and Earning: An Employer's Look at School-to-Work Investments." Alexandria, Va.: American Society for Training and Development.

Becker, Gary. 1964. *Human Capital.* New York: Columbia University Press.

Blank, Rebecca M. 1997. *It Takes a Nation.* New York: Russell Sage.

Burtless, Gary. 1994. "Comment [on Heckman, Roselius and Smith]." In Lewis C. Solmon and Alec R. Levenson, eds., *Labor Markets, Employment Policy, and Job Creation.* Boulder, Col.: Westview, pp. 123–38.

Harhoff, Dietmar, and Thomas J. Kane. 1997. "Is the German Apprenticeship System a Panacea for the U.S. Labor Market?" *Journal of Population Economics,* Vol. 10, No. 2, pp. 171–96.

Heckman, James, Lance Lochner, Jeffrey Smith, and Christopher Taber. 1997. "The Effects of Government Policy on Human Capital Investment and Wage Inequality." *Chicago Policy Review,* Vol. 1, No. 2, pp. 1–40.

Heckman, James J., Rebecca L. Roselius, and Jeffrey A. Smith. 1994. "U.S. Education and Training Policy: A Re-evaluation of the Underlying Assumptions Behind the 'New Consensus.'" In Lewis C. Solmon and Alec R. Levenson, eds., *Labor Markets, Employment Policy, and Job Creation.* Boulder, Col.: Westview, pp. 83–122.

Lerman, Robert, and Hilary Pouncy. 1990. "The Compelling Case for Youth Apprenticeships." *The Public Interest,* No. 101 (Fall), pp. 62–77.

Lynch, Lisa M. 1994. "Introduction." In Lisa M. Lynch, ed., *Training and the Private Sector: International Comparisons.* Chicago: University of Chicago Press, pp. 1–24.

Soskice, David. 1994. "Reconciling Markets and Institutions: The German Apprenticeship System." In Lisa M. Lynch, ed., *Training and the Private Sector: International Comparisons.* Chicago: University of Chicago Press, pp. 25–60.

Topel, Robert H. 1997. "Factor Proportions and Relative Wages: The Supply-Side Determinants of Wage Inequality." *Journal of Economic Perspectives,* Vol. 11, No. 2, pp. 55–74.