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Gender and Racial Training Gaps in Oregon Apprenticeship Programs

Günseli Berik[1], Cihan Bilginsoy[1], and Larry S. Williams[2]

Abstract

This study uses microdata to measure three types of training gaps by gender and minority status in Oregon apprenticeship programs: probability of graduation, time to graduation, and the quantity of training acquired by quitters. Apprentices who started training between 1991 and 2002 are tracked through 2007. After adjusting for individual, institutional, and occupational attributes, the authors find that white women apprentices were substantially less likely to graduate than white men, but the duration of training was shorter for the few women who graduated. White women dropouts received a much lower quantity of skills than white men although they stayed in the program as long as the white men did. Minority men did not face significant disadvantages relative to white men. Apprentices in union-management jointly sponsored programs were more likely to complete requirements than those in unilateral employer programs. White women and minority men benefited disproportionately more from training in union programs. However, the time to graduation is shorter in nonunion programs, which suggests that the latter allocate resources more selectively across apprentices. Yet those who quit do not appear to have acquired a sufficient quantity of skills to be able to obtain high-skill jobs.

Keywords

apprenticeship, training, gender, race, unions

Apprenticeship is the traditional route to acquire the occupational skills required to find employment in the crafts workforce. In the United States, workers are attracted to apprenticeship programs because this route is a remunerated alternative to college,

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and it facilitates building a career with high wages and perhaps opportunities to start a business. The lack of access to training would explain in large part why nontraditional workers—women and ethnic/racial minorities—have been historically underrepresented in the trades. The barriers are present both at the point of entry into and during apprenticeship. In this study, we focus on the second stage of the process. Our objective is to evaluate the relative performances of white men, white women, and minority men in apprenticeship programs in the state of Oregon.

The newly available Oregon state apprenticeship database provides the most complete set of training quantity measures hitherto available for the United States. Between 1991 and 2007, some fifty thousand new workers joined the apprenticeship workforce in Oregon. They were distributed across 132 occupations in all major industries. Women made up 6 percent of all new registrations, and ethnic/racial minorities—men and women (henceforth minorities)—accounted for 14 percent. We use this database to define three kinds of training gaps by gender and race/ethnicity: the probability of completing training, the time to complete requirements for graduation, and the quantity of training received by terminated apprentices as measured by the number of on-the-job-credit hours accumulated at the time of exit. Jointly, these gaps provide a full picture of the relative performance of traditional and nontraditional apprentices in training. We will adjust each of these gaps for observable individual, institutional, and occupational characteristics. This exercise will show the magnitude of training gaps that are attributable to gender and minority status after accounting for workforce characteristics. Among the institutional characteristics, we will pay special attention to the role of union-management cooperation in training because the literature has shown it to be a strong predictor of the apprentice performance.

Determinants of the Quantity of Training

Registered apprenticeship in the United States combines on-the-job training (OJT) and in-class related theoretical instruction (RTI) to provide general skills in an occupation. Apprenticeship programs have predetermined hours of formal OJT (typically ranging from 2,000 to 10,000 hours) and RTI (144 to 720 hours). Upon completion, the apprentice receives certification that recognizes him or her nationwide as a journey worker in the trade. Apprenticeship programs are sponsored either jointly by unions and signatory employers, or unilaterally by employers (henceforth union and nonunion programs, respectively). The costs of administration of training are shared by employers and unions (generally through a training trust) in the union-management jointly sponsored programs and borne by employers in nonunion programs. Apprentices also bear a portion of the training costs by working for training wages, which start at a fraction of the journey-level wage and rise over the course of training. In addition, apprentices may pay for tools, tuition, and books, either out of pocket or through a scholarship loan agreement. Apprentices can quit the program without penalty.

A Conceptual Framework

At any point in time, the apprentice has to decide between continuing training and quitting. Bilginsoy (2007) suggests that an apprentice will continue acquiring skills as long as the sum of expected discounted present values of two earnings streams—apprenticeship earnings up to the completion of the program and the subsequent lifetime certified journey-level worker earnings—exceeds the expected discounted present value of lifetime income that would be generated if he or she were to quit apprenticeship at that point in time. Thus, factors that influence the expected (pecuniary and nonpecuniary) income streams of alternative career paths determine the quantity of training.

Three distinct types of exits from apprenticeship then can be identified: (1) quitting due to dissatisfaction with the training program or occupation, (2) quitting because sufficient skills are acquired and additional skills do not justify the costs of additional training, and (3) completion of apprenticeship and receiving journey worker certification.[1]

Exit type 1. Apprentices are required to obtain training jobs in order to accumulate skills and training credit. The cost of training would be higher if the pace of skill acquisition is slow due to either the labor market conditions or the quality of the training program. In combination with low apprentice wages (relative to the wage in the alternative line of work), these conditions are likely to induce early quits from the program. An apprentice may also quit early if he or she finds the occupation or the training program disagreeable for any other reason. Other factors that may induce quits include high start-up costs, including tools, transportation, clothing, initiation fees, union dues (where applicable), and RTI (which is on the worker's own time).

Exit type 2. The apprentice may quit training prior to completion once the "optimal" skill stock is accumulated. Three wages are going to be relevant to this decision: the training wage, the "outside" wage (what the apprentice can earn after dropping out), and the wage of certified journey worker. The training wage is predetermined by the program as a percentage of the journey-level wage, and it rises as the apprentice progresses in the program. The outside wage is expected to vary directly with the skill level attained during apprenticeship. The apprentice would quit training before the completion of the program if, given the journey-level wage, the gap between outside and training wages rises sufficiently in favor of the former so that the expected lifetime income in the outside career dominates the apprentice-plus-journey-worker income stream. In neoclassical terms, this kind of quit is an optimal separation. In addition, loose licensing requirements or the option of attaining a lesser license without completing the program (e.g., getting a low-voltage electrical license after quitting a general inside electrician training program) would also raise the likelihood of this type of quit. This type of exit recognizes that the optimal quantity of skills may be less than the total amount required by the program sponsor, an outcome emphasized by economists (who warn about the credentialing effect) and some nonunion apprenticeship program sponsors (who argue that high quit rates mean effective, not substandard, program performance).

Exit type 3. When the expected present value of the lifetime outside income falls short of apprenticeship-plus-journey-worker income stream, training would continue until the program is completed. The likelihood of completing apprenticeship is expected to increase with the journey-level wage relative to the outside wage. The escalating apprenticeship wage schedule over the training period also offsets, at least in part, the incentive to quit. Union workers who seek to qualify for union wages and benefits, and nonunion workers who need to signal quality in a labor market characterized by asymmetric information, are also more likely to complete training and receive certification.

These three types of exit from training suggest that expected income streams in alternative career paths are functions of an array of factors, including the worker's preexisting skills, knowledge and aptitude, job characteristics, availability and remuneration of work in and outside apprenticeship, the effectiveness of the training programs in delivering skills, expected value of acquired job skills, licensing requirements, journey worker certification premium, and the discount rate. The direction of the effects of these individual and institutional factors on alternative income streams are often theoretically ambiguous and therefore remain empirical questions.

Individual Factors

Among the factors that determine the expected present value of training, the neoclassical theory emphasizes the preexisting levels of basic and job-specific skills (e.g., Altonji and Spletzer 1991; Lynch 1992; Lillard and Tan 1992; Barron, Black, and Loewenstein 1993; Barron, Berger, and Black 1997). Much of the empirical evidence indicates that there is a positive relationship between the preexisting skills and the quantity of training, on grounds that these either are complementary or are jointly influenced by other factors, such as aptitude. In the case of apprenticeship, it is plausible that a higher level of preexisting basic skills would improve access to training jobs and therefore positively affect the quantity of training. A good high school education would also keep apprentices on track by helping in the RTI, which has a heavy math component in some trades. However, the relationship between prior skills and the quantity of training is not necessarily direct when high levels of preexisting skills substitute for training (Altonji and Spletzer 1991). Following this line of reasoning, an interesting possibility is that a combination of high level of preexisting skills coupled with sufficient amount of training can lead to high outside wages and quits from apprenticeship prior to completion. In such a case, the preexisting skills–training profile could have an inverted-*U* shape.

Economic theory also suggests that the quantity of training would decline with age because lifetime returns to training are higher for the younger workers. However, to the extent that age serves as a proxy for life and labor market experience, prior skills, or commitment to the labor force, it is likely for the quantity of training to rise with age over a range. Therefore, the age-training profile, again, would have an inverted-*U* shape.

Institutional Factors

A program's success in delivering skills depends on institutional factors that determine its ability to match the prospective apprentices with occupations and its effectiveness in organizing RTI and providing training jobs and job rotation, paying better wages, and offering a higher overall quality of training. Institutional factors may include union involvement in managing the program, adequacy of the funding mechanism to support training, the number of participating employers, and whether the program has adequate training facilities.

In union programs, the apprenticeship committee is composed of the representatives of the employers and workers, whereas there is generally no worker representation in nonunion programs (Oregon nonunion programs constitute an exception). Previous comparisons of union and nonunion apprenticeship programs found that the retention rate in union programs is substantially higher (Bilginsoy 2003, 2007). This could be attributed to a host of factors, including mandatory participation of signatory employers, multiemployer cooperation, entrenched tradition of apprenticeship and mentoring in the unionized trades, more strict observation of jurisdictional boundaries between trades, union grievance procedures, and unions acting on behalf of the apprentice. These factors ensure stable funding of the training programs and prevent exploitation of apprentices as cheap labor. Unions are more likely to provide better job rotation because they work apprentices on both private and prevailing-wage jobs, while the nonunion contractors tend to use apprentices in prevailing-wage jobs and rely heavily on helpers otherwise. Some union-training trusts use scholarship loan agreements that require the apprentice to pay back the cost of training, unless they work a certain number of years for a participating contractor after program completion (with the loans forgiven after journey-level work begins). The higher retention rate in union programs can also be explained by the fact that union workers have higher incentives to complete the program in order to qualify for union wages and benefits, and to be dispatched as a journey worker, which requires either program completion or other formal union recognition of journey status. Finally, nonunion programs in construction may have lower retention rates due to prevailing-wage laws, which permit hiring of only registered apprentices at below prevailing wages in public construction. Contractors may be merely recruiting helpers into apprenticeship programs for prevailing-wage work, and then neglecting their training.

Women and Minorities Training in the Crafts Workforce

Many researchers have found a training gap against women (e.g., Lynch 1992; Knoke and Ishio 1998; Berik and Bilginsoy 2000, 2002, 2006). Neoclassical economic theory attributes the gender gap in training to the division of labor by gender. Women's specialization in household tasks and caring labor arguably weaken attachment to the labor force and commitment to long-term training. Since they are likely to work fewer years than men and therefore reap smaller returns to investment in training, women

are not expected to engage in training as much as men. By contrast, the poor showing that has historically been observed for minority men is attributed to the discriminatory tastes of the white union workers, with the corollary that rising competition in the labor market (the weakening of unions) would erode the factors that hinder the entry of minority men workers to the crafts workforce.

While they are often discounted by neoclassical theory in favor of subjective preferences, historical and institutional factors have played a very important role in the shortage of women and minorities in training programs. The trades workforce has been historically dominated by men of European ancestry with strong local networks. One Oregon program administrator characterized the trades workforce as the "FBI" (friends, brothers, and in-laws) (Oregon Consortium 1996, 171), which excluded outsiders from these well-paying careers. Since entry into the trades requires substantial front-loaded training, the control of the training programs, often by the trade unions, has been an effective device for exclusion of women and minorities.[2]

In recent decades, however, many unions have acted as vehicles of integration for minority workers, following the push of the Civil Rights Act of 1964 and affirmative action policies, and the pull of the need to adapt to the changing ethnic composition of the labor force.[3] The barriers that minorities faced largely have been removed (particularly in the trowel trades). Government agencies also made an historic push in the late 1970s to increase women's participation in the trades, but there has been minimal government support since the 1980s, as affirmative action programs have been reduced to equal opportunity pledges. The result has been a marginal level of integration of women that has not been sufficient to achieve a status for tradeswomen beyond being a "wedge in the door" (Berik and Bilginsoy 2006).

Nonetheless, problems persist even for those nontraditional workers who successfully navigate entry into a training program. An Oregon survey conducted in 1996, for instance, documents the refrains of nontraditional apprentices who endure shortage of meaningful work assignments and condescending or patronizing behavior on the job, which slow their progress or stop it altogether (Oregon Consortium 1996). These problems have been documented more frequently for white and minority women than for minority men, suggesting an ossified male culture of the crafts, which has created a work environment that is more hostile for women than for minority men. The 1996 Oregon survey records that sexual harassment, physical and emotional stereotyping, discrimination in job rotation, lack of sanitary facilities, and accusations of reverse discrimination are rampant. Such conditions undoubtedly make the integration of women into apprenticeship an ongoing challenge. In addition, women usually bear the burden of competing domestic responsibilities, which limit their ability to pursue training jobs. For instance, in construction (where most apprenticeships are), there are considerable search and travel costs because jobs are intrinsically temporary and workers are required to move from one site to another continuously. Women's prospects may also be limited by their background: they are less likely to have taken shop classes in high school, to be familiar with tools and technical skills, and to have received advice from industry insiders or high school counselors about career

opportunities in trades. Finally, the lack of a critical mass of women in the trades to provide mentoring and other kinds of support mechanisms may have limited the number of women participating in apprenticeship training and entering the journey-level workforce. These findings are not unique to Oregon, as they are experienced by tradeswomen across the United States (for example, Eisenberg 1998; Berik and Bilginsoy 2000, 2006; Paap 2006).

Empirical Models

Most empirical studies of training focused on its incidence, estimated by a binary choice model (Altonji and Spletzer 1991; Lillard and Tan 1992; Lynch 1992). Knoke and Ichio (1998) utilized a proportional hazard model to estimate the probability of entering a training program over a fifteen-year period. Training gap measures are then found by breaking down either the incidence or hazard estimates by gender, race, or other groups. Different from these studies, our objective is to evaluate the skill level of the worker at the time of exit from training. Berik and Bilginsoy (2000, 2006) made this assessment by estimating the completion probability using the multinomial logit method. Bilginsoy (2003, 2007) measured the quantity of training acquired in terms of the duration between the entry and exit dates conditional on the type of exit.

Similar to other apprenticeship databases in the United States,[4] the Oregon database reports the dates of entry into and exit from the program for each new registration, the mode of exit (e.g., completion, cancellation, transfer to another program), and a set of individual- and program-level attributes.[5] Apprentices who are still in training as of the last date of data compilation are reported as "active." The Oregon database also provides, hitherto unavailable, the OJT credit accumulated by each apprentice who quit. We use these pieces of information to construct three measures of training: the probability of completion of graduation requirements, the time to graduate, and the OJT credit hours earned by apprentices who quit. We then compare each measure across gender and minority status.[6]

We adjust training gaps for effects of individual and institutional factors on the measures of quantity of training. Individual-level determinants of training are age, years of education at the time of entry into the program, trade school attendance, and veteran status. Age and education are the standard proxies for experience and preexisting skills. Education ranges from nine to sixteen years of schooling.[7] Trade school attendance may imply a higher level of preexisting skills. Our perusal of the apprentice files revealed, however, that the trade schools are often "skills centers" that require ninth-grade reading and eighth-grade math, and hold classes in conjunction with the high schools. Thus, it is likely that the trade school provides preparatory programs in specialized training to help youth who face obstacles or demonstrate difficulties in formal education, and therefore trade school attendance is likely to indicate an early deficiency in basic skills rather than a higher level of preparation. Veteran status may capture preexisting skills in view of the likelihood that basic skills are acquired in the military. Both trade school attendance and veteran status are binary variables.

Program-level variables are the shares of women and minorities, program size, and program sponsor type, all defined at the program-occupation level.[8] Shares of women and minorities are included to account for the possible threshold effects for these groups. Size is introduced to capture economies of scale in the delivery of skills. Both program size and female and minority shares are calculated for the year in which the apprentice started training. The distinguishing feature of the Oregon apprenticeship system is that it requires all training committees to have equal numbers of employer and employee representatives, whereas in other states, this is true only in the union programs. Thus, the Oregon case permits addressing the question of whether universal worker representation in training committees closes the union-nonunion performance gap observed elsewhere in the United States. The Oregon system also has "mixed" programs, with which both union and nonunion employers can be affiliated, once they are registered as training program sponsors.[9] Program sponsorship is thus a categorical variable: union (base), nonunion, and mixed. However, only a small minority of apprentices were in mixed programs, because many programs that were reported as mixed were dominated by either union or nonunion apprentices. We recategorized these cases as either union or nonunion accordingly.

Unemployment rate captures the effect of labor demand on the quantity of training. The direction of the impact is theoretically indeterminate. A higher rate of unemployment would imply a shortage of both outside and training jobs. The lack of attractive job offers from outside, on the one hand, would reduce the probability to quit apprenticeship training and increase the quantity of training (albeit credited hours of training are likely to accumulate over a longer duration). On the other hand, the shortage of training jobs may also force the apprentice out of the program in order to pursue a different career path (such as college education). The data provide the entry and exit dates of each apprentice. We used these dates and monthly Oregon unemployment rates to calculate the average monthly unemployment rate each apprentice faced until he or she exited from the program.

In addition, we also added apprentice residence in the Portland metropolitan area, occupation, industry (construction vs. nonconstruction), and entry year dummy variables as control variables.[10]

Each empirical model is estimated separately for white men, white women, and minority men apprentices. Cell sizes for women and minority apprentices were fairly small, and we omitted minority women, for whom this problem was the most severe (0.6 percent of all apprentices). In all estimations, we clustered observations by program-occupation-year, considering that the error terms of observations within each cluster would be correlated.

The Data

The database includes all new registrations in the Oregon Apprenticeship System from January 1, 1991, to December 31, 2007. We made program requirements uniform by including only programs with an eight thousand–hour OJT requirement. These are

Table 1. Descriptive Statistics

Characteristic	All	White men	White women	Minority men
Earned on-the-job-training credit hours	6,327 (2,764)	6,432 (2,699)	5,139 (3,184)	5,699 (3,064)
Completions (%)	70.0	71.6	51.7	60.0
Age	29.3 (8.1)	29.3 (8.2)	31.3 (7.1)	29.0 (7.4)
Education	12.6 (1.3)	12.6 (1.3)	13.0 (1.5)	12.6 (1.4)
Attended trade school (%)	14.1	13.6	18.3	17.8
Veteran (%)	15.9	16.7	5.3	12.5
Program size	160.4 (146.3)	157.2 (145.1)	199.2 (157.1)	179.4 (149.8)
Portland (%)	38.2	36.5	54.4	50.2
Construction (%)	82.8	82.0	94.7	86.0
Union program (%)	42.2	41.3	56.9	44.9
Nonunion program (%)	46.5	46.7	38.9	47.3
Mixed program (%)	11.4	12.0	4.1	7.9
Unemployment (%)	6.0 (0.7)	6.0 (0.7)	5.9 (0.7)	6.0 (0.7)
Carpenter (%)	15.9	15.0	23.6	23.0
Communication technician (%)	8.4	8.0	13.1	10.3
Electrician (%)	39.3	39.2	47.8	35.4
Maintenance electrician (%)	8.8	9.2	3.6	6.8
Maintenance mechanic (%)	5.5	5.9	1.1	4.0
Millwright (%)	2.4	2.5	1.4	2.1
Pipefitter (%)	6.0	6.0	6.7	5.8
Plumber (%)	13.7	14.3	2.8	12.7
n	8,829	7,847	360	622

Source: Oregon Apprenticeship System Database.
Note: Standard deviations in parentheses.

by far the most popular programs, accounting for 57 percent of the total 49,468 new registrations. We narrowed observations by selecting apprentices who registered in the eight largest occupations (82 percent of the subtotal) before January 1, 2003 (in order to allow a time period long enough to complete apprenticeship requirements), and who did not receive OJT credit for prior experience at the time of entry (in order to make their performances comparable).[11] We excluded apprentices who dropped out or transferred to other programs for observable "exogenous" reasons (e.g., medical condition, death, program termination). Finally, we excluded those who quit within thirty days of indenture or with zero hours of credit on grounds that they effectively did not start the program. After removing observations with missing or erroneous values, we have a total of 8,829 observations.

Table 1 presents descriptive statistics of the selected sample. Nontraditional apprentices constituted 11 percent of all apprentices. Minority representation (7 percent) was smaller than their share in apprenticeship nationwide. The latter is attributable both to the smaller share of the minorities in the Oregon labor force (13 percent) and to the concentration of minorities, as in the rest of the United States, in trades that have less than an eight thousand–hour OJT requirement. Women were on average older and

Table 2. Completion Probabilities and Gaps

	Union	Nonunion	Across-sponsor gap[b]
Raw completion probabilities and gaps			
White men	73.2%	68.8%	−6.1%
White women	56.6	44.3	−21.7
Minority men	62.0	56.5	−9.0
Within-sponsor gaps[a]			
Gender gap	−22.7%	−35.6%	
Minority gap	−15.3	−17.9	
Adjusted completion probabilities and gaps			
White men	78.0% [74.2, 81.3]	62.1% [56.6, 67.3]	−20.3%
White women	67.0 [40.5, 85.9]	43.4 [22.0, 67.6]	−35.3
Minority men	84.6 [76.4, 90.3]	60.0 [47.9, 70.4]	−29.4
Within-sponsor gaps[a]			
Gender gap	−14.0%	−30.1%	
Minority gap	8.5	−3.9	

Note: Adjusted completion probabilities are based on logit estimations of the likelihood to complete apprenticeship program and graduate (see Table 3). The 95 percent confidence intervals are reported in brackets.

The hypothetical apprentice used in the calculation of adjusted probabilities is a nonveteran union apprentice registered in a program outside the Portland metropolitan area and works in the construction industry; continuous variables are set at the mean values for white male apprentices; values of occupation and entry-year dummies are set to the shares of incoming white male apprentices.

[a]Within-sponsor gap_i = Prob(Completion$_i$)/Prob(Completion$_{\text{white male}}$) − 1, where i = white women, minority men.

[b]Across-sponsor gap_i =Prob(Completion$_{i,\text{nonunion}}$)/Prob(Completion$_{i,\text{union}}$) − 1, where i = white men, white women, minority men.

more educated than white and minority men. Nontraditional workers were more likely to have attended trade school, be located in the Portland area, and be registered in programs that are on average larger in size and are in the construction industry.[12] Electricians and carpenters jointly accounted for 55 percent of all apprentices. These two were also the largest trades for women and minorities.

Most of the apprentices were enrolled in nonunion programs (47 percent) followed closely by the union programs (42 percent). The organized sector accounted merely for 23 percent of the Oregon workforce in industries represented in the apprenticeship population and, therefore, relative to its size, trained disproportionately larger number of apprentices. White women and minority men were overrepresented in the union programs, which is consistent with the national patterns (Berik and Bilginsoy 2002).

Completion Probability Gaps

All apprentices in the sample exited training either through completion or cancellation. The upper panel of Table 2 reports unadjusted completion probabilities and gaps. We define the gender completion gap as the percentage deviation of white women's completion probability from that of the white men's. The minority men completion probability gap is defined similarly relative to white men. These gaps are reported for

both types of sponsors under the "within-sponsor gaps" title. Since the literature found that program sponsor type is an important predictor of the completion rate, we also report "across-sponsor gaps" for each demographic group, defined as the percentage deviation of nonunion completion rate from the union value.

White men had the higher raw completion probabilities, 73 percent in union and 69 percent in nonunion programs. Both white women and minority men were less likely to complete training than white men, and their deficits were wider in the nonunion programs. Gender gaps were –23 percent in union and –36 percent in nonunion programs. Minority gaps were smaller than gender gaps. Across-sponsor gaps indicate that apprentices in union programs had on average higher completion probabilities regardless of their gender or race. The largest difference is observed in the case of women. Nonunion women's completion probability was 22 percent lower than that of women in union programs.

The raw apprenticeship completion probability gaps may at least in part be attributable to differences in distributions of individual, institutional, and occupational characteristics across white men, white women, and minority men apprentice workforces. In order to adjust for these factors, we estimated logit regressions of completion probability on workforce characteristics and predicted the probabilities of completion for hypothetical apprentices who are identical except for their gender or minority status. The lower panel of Table 2 reports these predicted probabilities and the 95 percent confidence intervals. The hypothetical apprentice is defined as one who did not attend trade school, is not a veteran, resides outside the Portland metropolitan area, and is registered in a construction industry program; his or her values for continuous variables are set at the means for white men to determine the completion probabilities for white women and minority men had they displayed white men's characteristics. By the same token, values of occupation and starting-year variables are set using white men's distribution by these variables.

Adjusted completion probabilities reported in lower panel of Table 2 show that raw within-sponsor gaps are indeed partially attributable to workforce characteristics. Adjusted gender gaps within union and nonunion programs were smaller than raw gaps by 9 and 6 percentage points, respectively. Minority gaps change far more dramatically, turning in favor of minorities in the union and rising to –4 percent in nonunion programs. The narrowing of completion probability gaps suggests that the lower raw likelihood to graduate of white women and minority men may be due in part to labor market discrimination and greater access of white men to better training conditions and more attractive occupations.

Logit estimates of marginal effects reported in Table 3 underscore the importance of union sponsorship for completion probability. White male nonunion program apprentices were less likely to graduate by 16 percent ($p < .001$). The corresponding figures were 24 percent for white women ($p < .001$) and 25 percent for minority men ($p < .001$). These marginal effects translate to adjusted across-sponsor gaps in the lower panel of Table 2 that are much wider than the raw gaps. Nonunion program completion rates were lower for the hypothetical apprentice by 35 percent in the case

Table 3. Marginal Effects on the Probability of Completion: Logit Estimates

Variable	White men	White women	Minority men
Age	0.124 (3.97)***	0.318 (1.28)	−0.026 (0.26)
Age-squared	−0.015 (3.81)***	−0.044 (1.47)	0.002 (0.16)
Education	0.148 (2.90)**	0.287 (0.86)	0.233 (2.47)*
Education-squared	−0.005 (2.49)*	−0.009 (0.76)	−0.009 (2.36)*
Trade schooled	−0.015 (1.17)	−0.038 (0.42)	−0.089 (2.31)*
Veteran	−0.005 (0.39)	0.146 (1.46)	−0.045 (1.15)
Nonunion program	−0.158 (8.07)***	−0.236 (3.55)***	−0.249 (5.85)***
Mixed program	−0.073 (1.31)	−0.243 (0.34)	−0.252 (1.35)
Female share in program	0.019 (2.36)*	−0.008 (0.20)	0.005 (0.37)
Minority share in program	−0.011 (1.58)	0.045 (0.91)	−0.004 (0.72)
Program size	−0.001 (0.99)	−0.007 (4.04)***	−0.000 (0.15)
Portland resident	0.028 (1.64)	0.001 (0.03)	−0.026 (0.72)
Unemployment rate	0.128 (4.68)***	0.195 (2.06)*	0.154 (3.80)***
Nonconstruction	0.116 (2.65)**	−0.090 (0.27)	0.022 (0.19)
n	7,847	360	622

Note: Dependent variable: Prob(apprentice completed eight thousand hours of on-the-job training and graduated).
z values in parentheses.
Observations are clustered by program-occupation.
Occupation and entry-year dummies are included in all regressions but not reported.
Marginal effects are calculated for eight-year change in age, one-year change in education, 4 percentage point change in female and minority shares, 1 percentage point change in unemployment rate, and ten apprentices in the case of program size.
Marginal effects are calculated for the hypothetical apprentice as described in notes to Table 2.
*$p < .05$. **$p < .01$. ***$p < .001$ (two-tailed tests).

of white women, 29 percent for minority men, and 20 percent for white men, which were higher than raw gaps by 13 to 20 percentage points.[13]

Table 3 also shows that the probability of completion increased at a decreasing rate with age for white men ($p < .001$).[14] Unemployment rate was also a strong predictor of the completion probability for all groups ($p < .001$). Higher unemployment rates raised the likelihood of completion, which suggests that apprentices who eventually graduated were more likely to keep at training as outside job opportunities declined. Completion of requirements in the face of higher unemployment, however, might have come at the cost of longer duration of training, which we examine in the next section.

Training Duration Gaps

The pace of training is the second dimension of training gaps that we consider: the time it takes to receive a given quantity of training. If certain groups of apprentices are given priority in job allocation, others will take a longer period of time to complete an equivalent number of training hours and therefore face higher costs. Competing

Table 4. Durations of Completed Apprenticeships

	Union	Nonunion	Across-sponsor gap[b]
Raw durations of completion and gaps (days)			
White men	1,721	1,575	−8.5%
White women	1,772	1,679	−5.3
Minority men	1,733	1,603	−7.5
Within-sponsor gaps[a]			
Gender gap	3.0%	6.6%	
Minority gap	0.7%	1.8	
Adjusted durations of completion and gaps (days)			
White men	1,752 [1,705, 1,800]	1,561 [1,525, 1,597]	−10.9%
White women	1,660 [1,586, 1,737]	1,586 [1,519, 1,656]	−4.5
Minority men	1,775 [1,707, 1,846]	1,592 [1,541, 1,646]	−10.3
Within-sponsor gaps[a]			
Gender gap	−5.2%	1.6%	
Minority gap	1.3	2.0	

Note: Adjusted durations of completion are based on ordinary least squares estimations of the time to graduate (see Table 5). The 95 percent confidence intervals are reported in brackets.
The hypothetical apprentice used in the calculation of adjusted durations is described in the notes to Table 2.
[a]Within-sponsor gap_i = ($Duration_i$ – $Duration_{white\ men}$)/$Duration_{white\ men}$, where i = white women, minority men.
[b]Across-sponsor gap_i = ($Duration_{i,\ nonunion}$ – $Duration_{i,\ union}$)/$Duration_{i,\ union}$, where i = white men, white women, minority men.

demands on time can also slow down skill formation and extend the duration of training. In order to test whether there are any differences in the duration of training by gender or minority status, we selected the completed apprenticeships and measured the time to graduate. The expected duration of completion of an eight thousand–hour program for a full-time employed apprentice is four years. There were a number of observations with completion durations of less than four years. One reason for a shorter period of completion is receiving credit for prior experience, but we left out these apprentices from the sample at the outset.[15] It is also possible, however, for the more motivated apprentices to collect credit hours at a faster pace at the discretion of supervisors. In recognition of this possibility, we considered only apprentices who graduated in three years or more. We believe that observations with shorter completion durations are likely to be recording errors.

Table 4 reports observed average durations of completion and gaps. Duration is defined as the number of days that elapsed between the graduating apprentice's dates of entry into and exit from the program. Similar to the completion probability gaps, we defined duration gaps as percentage differences from white men (for within-sponsor gaps) and from union (for across-sponsor gaps). The raw figures of the upper panel of Table 4 indicate that white men, on average, completed training the fastest. White women took the longest time to complete training, 3 percent (51 days) more in union and 7 percent (104 days) more in nonunion programs in comparison with white men. Minority men were only slightly behind white men in completion duration. Overall,

Table 5. Determinants of Duration to Completion of Training: Ordinary Least Squares Estimates

Variable	White men	White women	Minority men
ln(age)	0.010 (1.07)	−0.029 (0.77)	0.085 (1.85)
ln(education)	−0.039 (1.88)	−0.057 (0.90)	−0.156 (1.96)
Trade schooled	−0.001 (0.18)	0.012 (0.55)	−0.015 (0.71)
Veteran	−0.012 (2.55)*	−0.017 (0.29)	−0.020 (0.98)
Nonunion program	−0.116 (7.07)***	−0.046 (2.04)	−0.109 (5.29)***
Mixed program	−0.022 (0.87)		−0.005 (0.08)
Female share in program	−0.002 (1.22)	0.008 (2.02)	−0.004 (1.71)
Minority share in program	0.001 (0.50)	−0.011 (2.20)*	0.000 (0.49)
ln(program size)	0.002 (0.31)	−0.000 (0.01)	−0.008 (0.78)
Portland resident	−0.002 (0.20)	0.023 (1.53)	0.026 (1.72)
Unemployment rate	0.081 (2.64)**	0.180 (2.39)*	−0.111 (1.35)
Nonconstruction	−0.147 (3.48)***	0.200 (5.78)***	−0.130 (1.81)
Constant	7.299 (364.13)***	7.196 (126.44)***	7.377 (235.45)***
n	4,935	177	342
R^2	0.27	0.37	0.29

Note: Dependent variable: ln(days to complete the requirements and graduate).
Mixed-program dummy in the white women equation is dropped due to collinearity.
t values in parentheses.
Observations are clustered by program-occupation.
Occupation and entry-year dummies are included in all regressions but not reported.
Units of measurement of variables are reported in notes to Table 3.
*$p < .05$. **$p < .01$. ***$p < .001$ (two-tailed tests).

the raw gender and minority gaps are not substantial, except perhaps the gender gap in nonunion programs.

Larger gaps are observed in across-program comparisons. Nonunion apprentices completed training at a faster pace in all categories. Training duration of white men in nonunion programs was 8.5 percent (or 146 days) shorter than those in union programs. For nonunion white women and minorities, the duration gaps were smaller.

Table 5 reports ordinary least squares (OLS) estimates of completion durations for each group of apprentices. The dependent variable is the natural log of the duration of training. Age, education, and program size are also in natural logs so that the associated coefficients are elasticities. The lower panel of Table 4 reports predicted duration values for the hypothetical apprentice.

According to Table 5, independent variables explain about a third of the variation in the duration. In line with the raw statistics, hypothetical nonunion program apprentices completed training faster. Adjusted durations in nonunion programs were again shorter than those in union programs by 11 percent for white men ($p < .001$) and 10 percent for minority men ($p < .001$); for white women, adjusted duration in union programs was shorter by 5 percent, but this estimate was statistically marginally significant ($p < .06$). Thus, while nonunion programs had lower retention rates than union

programs, their apprentices completed at a much quicker pace. This finding is consistent with the hazard analysis estimates of Bilginsoy (2007), who found that the probability of completion is lower in nonunion programs but the expected completion time is shorter. Jointly, these results suggest that union programs spread training resources more widely and allocate jobs among a larger number of apprentices so that the higher number of graduates comes at the cost of longer average duration of completion. Nonunion programs, on the other hand, appear to allocate resources more selectively among the apprentices, graduating fewer but in a shorter period of time.

The gender duration gaps were affected far more than the minority gaps by the confounding factors. In nonunion programs, the gap shrank to less than 2 percent; in union programs, the hypothetical woman apprentice's predicted completion time was *shorter* than that of either the white or minority man's. One important contributor to this outcome is the industry variable. The duration gap was in favor of white women only in the construction industry. As reported in Table 5, in the nonconstruction industry, white women's average completion duration was longer by 20 percent ($p < .001$), while white men's duration was shorter by 15 percent ($p < .001$). Another variable of interest is the unemployment rate. Unemployment rate had a negative impact on both white men's ($p < .01$) and white women's ($p < .05$) durations, but the magnitude of the impact was much stronger on women. Duration to graduation for white women who faced an average 1 percent higher unemployment rate during their apprenticeship was longer by 18 percent, while the figure was 8 percent for white men. The procyclical gender duration gap indicates that men were in a relatively more favorable position in accessing apprentice jobs when these jobs were harder to find. In contrast, the impact on the duration for minority men was not statistically significantly different from zero. Given the inverse impact on white men's duration, the race duration gap moved in favor of minorities when unemployment increased.

Training Quantity Gaps of Cancelled Apprenticeships

The Oregon data set is the first data source to provide information on the actual number of OJT credit hours the apprentice has accumulated during training, and permits direct measurement of the quantity of training received by apprentices who dropped out of the programs. This piece of information can be of critical importance in evaluating program effectiveness. In the open-shop sector of the construction industry, for instance, nonunion program sponsors often attribute their lower retention rates to what they consider to be the needlessly long apprenticeship training requirements, instruction in skills that are of little use to individual employers or employees, and the ability of their apprentices to find well-paying outside jobs before the completion of apprenticeship. If these claims are correct, then the higher completion rate in union programs is a suboptimal outcome of perverse incentives created by institutional factors: union workers are compelled to complete apprenticeship requirements fully in order to receive journey-level certification and qualify for union wage and benefits, whereas nonunion program apprentices, unburdened by the union membership requirements,

Table 6. Completed On-the-Job Training (OJT) Hours by Apprentices Who Dropped Out

	Union	Nonunion	Across-sponsor gaps[b]
Raw OJT credit hours and gaps			
White men	2,470 (645)	2,359 (653)	−1.4%
White women	2,198 (703)	1,809 (700)	−4.9
Minority men	2,344 (664)	2,085 (636)	−3.2
Within-sponsor gaps[a]			
Gender gap	−3.4%	−6.9%	
Minority gap	−1.6	−3.4	
Adjusted OJT credit hours and gaps			
White men	2,429 (547) [2,257, 2,608]	2,238 (516) [2,034, 2,454]	−2.4%
White women	1,377 (526) [1,038, 1,799]	1,142 (536) [886, 1,458]	−2.9
Minority men	2,341 (530) [1,662, 3,185]	2,121 (526) [1,589, 2,754]	−2.8
Within-sponsor gaps[a]			
Gender gap	−13.2%	−13.7%	
Minority gap	−1.1	−1.5	

Note: Numbers in parentheses are the actual (in the upper panel) and predicted (in the lower panel) durations (in days) between the entry and the exit dates.
Adjusted OJT credit hours are based on flogit estimates of the fraction of completion requirements credited prior to cancellation (see Table 7). The 95 percent confidence intervals are reported in brackets. The hypothetical apprentice used in the calculation of adjusted OJT credit hours is described in the notes to Table 2.
[a]Within-sponsor $\text{gap}_i = (\text{Hours}_i - \text{Hours}_{\text{white men}})/8{,}000$, where i = white women, minority men.
[b]Across-sponsor $\text{gap}_i = (\text{Hours}_{i,\text{nonunion}} - \text{Hours}_{i,\text{union}})/8{,}000$, where i = white men, white women, minority men.

can quit at the optimal hours of training prior to program completion.[16] If these claims are true, then completion rate is a flawed measure of program effectiveness.

Ideally, this hypothesis should be tested by comparing postapprenticeship labor market outcomes of the dropouts and the graduates. In the absence of these data, we looked into the quantity of training received by dropouts for indirect evidence. First, if quits are optimal, then the training quantity of dropouts should be "sufficiently" high so that they can get well-paying high-skill jobs. The second type of potential evidence is more circumstantial. If higher average training hours in union programs are attributable to incentives created by union membership requirements, then the nonunion program apprentices who dropped out should have received more training than union dropouts.

The upper panel of Table 6 reports the raw OJT credit hours and gaps of the subsample of apprentices who dropped out. We define within-sponsor gender (or minority) gap as the difference between the numbers of hours of OJT credit received by white women (or minority men) and white men divided by eight thousand hours. Across-sponsor gap for each group is defined as the difference between the nonunion

and union hours divided by eight thousand hours. Overall, these figures show that the average hours of training acquired by the apprentices who dropped out were modest, regardless of the sponsor type. At best, white men in union programs earned 2,470 hours of training, or 31 percent of the eight thousand–hour completion requirement. Since the first one thousand hours of training is the probationary period during which apprentices perform more menial tasks, it is unlikely that apprentices who dropped out can find outside jobs beyond the semiskilled level.

Across programs, nonunion apprentices received less training, although the difference is small. It was the widest for nonunion white women apprentices, who received 5 percent (389 hours) less training than their counterparts in union programs. Within each type of program, gender and minority gaps were in favor of white men, but again, they were relatively small. The largest was the gender gap observed in nonunion programs at –7 percent. However, these quantity gaps convey only a partial picture. As a memo item, we reported in parentheses the average number of days that elapsed between the entry and exit dates of the dropouts. These figures underscore that women received less training in spite of the fact that they remained in apprenticeship on average for a longer period of time than men. Thus, the quantity gender gap does not reflect an earlier quit by women on average, but rather the disadvantages they face in accessing training jobs, which may be due to sponsors' preferential treatment of men, competing claims on women apprentices' time, and/or women being less financially able to travel to remote parts of the state for work.

Next, we adjust the quantity of training by predicting OJT credit hours by gender and minority status for apprentices who are otherwise identical in observed traits. Since the training quantity variable is bounded (between zero and eight thousand hours, noninclusive), OLS estimation is not appropriate. Therefore, we first expressed the quantity of OJT at the time of exit as a fraction of the completion requirement by dividing it by eight thousand. We then applied Papke and Wooldridge's (1996) flogit method to estimate the fraction of OJT hours completed. The estimated marginal effects on the quantity of training for the hypothetical apprentice are reported in Table 7. The coefficient of the nonunion variable, for instance, indicates that the fraction of OJT credit hours earned (out of eight thousand hours) by the hypothetical white man apprentice in a nonunion program who dropped out of training was on average lower than his union counterpart by 2.4 percentage points. These magnitudes are easier to interpret once converted to number of hours of OJT training. The lower panel of Table 6 reports the adjusted predicted hours of training for hypothetical apprentices based on the flogit estimates. After adjustments, the terminated nonunion white man apprentice, on average, received 191 fewer hours of training than the white man apprentice in the union program. Controlling for observed attributes, canceled union apprentices in all groups received more training than their nonunion counterparts, although the differences were small in magnitude. There were no significant differences between the raw and adjusted across-sponsor gaps, although the latter were more uniform across the three groups. Low average hours of training received by the dropouts and the persistent, albeit small, negative impact of nonunion programs on the training quantity

Table 7. Marginal Effects on Training Quantity of Apprentices Who Dropped Out: Flogit Estimates

Variable	White men	White women	Minority men
Age	0.005 (0.12)	0.108 (1.37)	0.132 (1.02)
Age-squared	0.001 (0.22)	−0.012 (1.19)	−0.020 (1.31)
Education	0.052 (1.75)	0.019 (0.31)	0.125 (1.36)
Education-squared	−0.002 (1.79)	−0.001 (0.29)	−0.005 (1.25)
Trade schooled	0.001 (0.03)	−0.050 (2.06)*	−0.039 (0.99)
Veteran	−0.014 (1.19)	0.075 (0.89)	−0.028 (0.91)
Nonunion program	−0.024 (1.92)	−0.029 (1.20)	−0.027 (0.56)
Mixed program	−0.018 (0.65)	−0.129 (3.95)***	0.328 (2.03)*
Female share in program	0.001 (0.15)	0.036 (4.05)***	0.009 (0.55)
Minority share in program	−0.005 (1.00)	−0.050 (2.98)**	0.008 (0.66)
Program size	0.001 (2.53)*	0.001 (1.37)	0.000 (0.05)
Portland resident	−0.003 (0.39)	0.050 (1.58)	−0.062 (3.00)**
Unemployment	0.087 (3.05)**	0.046 (0.95)	0.196 (4.16)***
Nonconstruction	0.135 (2.75)**	0.700 (22.23)***	−0.017 (0.13)
n	2,222	173	248

Note: Dependent variable: (OJT credit hours of cancelled apprentices)/8,000 hours.
t values in parentheses.
Observations are clustered by program-occupation.
Occupation and entry-year dummies are included in all regressions but not reported.
Marginal effects are calculated for the hypothetical apprentice described in notes to Table 2.
Units of measurement of variables are reported in notes to Table 3.
*$p < .05$. **$p < .01$. ***$p < .001$ (two-tailed tests).

indicate that quits from apprenticeship were the outcome neither of the ability to acquire sufficient training prior to completion in the nonunion programs nor of achieving the optimal training in the nonunion programs.

Within-sponsor gender gaps were much wider after adjustments, dipping to –13 percent in union and –14 percent in nonunion programs, as seen in Table 6, but the discrepancy is due primarily to the industry variable. Table 7 shows that in comparison with their peers in construction, white women dropouts in nonconstruction industry received 70 percent more training ($p < .001$). We do not observe as stark a difference for men. As in the case of the raw figures, however, reported gender training quantity gaps severely understate the challenge women face in apprenticeship training in both union and nonunion programs, given that they remain a longer amount of time as apprentices. We use the duration model specification of the previous section to predict durations of cancelled apprenticeships and reported these in parentheses in the lower panel of Table 6. These show that women dropouts accumulated fewer hours of OJT credit in spite of the fact that they remained in apprenticeship programs about as long as men, underscoring once again the differential access to training jobs by gender. In union programs, for instance, on average, men received 4.4 hours of credit per day, while women received 2.6. The corresponding hours in nonunion programs were 4.3 and 2.1, respectively.

The impact of unemployment in Table 7 also indicates that women's and men's experiences were quite different. Minority men apprentices, and to a lesser extent, white men, received more training when they faced higher unemployment during their training ($p < .01$ and $p < .001$, respectively). For white women, the effect is not statistically different from zero. This implies that men were more likely to hold on to training when overall job opportunities diminished. Conversely, men's OJT credit hours declined as the economy improved, indicating their ability to pursue nonapprenticeship jobs. Women's quantity of training was not as responsive to unemployment. Unlike men, they were not able to increase their training hours in the context of higher unemployment, although on average they remained in apprenticeship as long as the men did. Conversely, economic expansion did not provide as many outside job opportunities to women as it did to men.

Conclusion

This article used the Oregon apprenticeship data for the 1991-to-2007 period to compare the training experiences of three groups of apprentices: white men, white women, and minority men. Historically, both white women and minority men have been excluded from the craft apprenticeship programs. Women's participation in apprenticeship programs in Oregon, as in the rest of the United States, remains woefully low. While participation of minority men in apprenticeship is in line with their representation in the Oregon workforce, in the subset of occupations considered in this study—commonly recognized as the more skilled trades—their representation lags behind. We used three metrics to measure gender and minority training gaps: completion probability, duration of completed apprenticeships, and the completed OJT hours for cancelled apprenticeships. Since observed differences may be attributable to individual characteristics and occupational and institutional features, we also used regression analysis to adjust for these factors and reported the predicted values of the gaps for apprentices who had the reference white men's attributes. Among institutional factors, we focused on program sponsorship type in light of the literature that has shown it to be a major predictor of apprentice performance.

We observe the largest adjusted gender gap in the probability of completion. White women were less likely to graduate than white men by 14 percent in union and 30 percent in nonunion programs. The experiences of white and minority men were more similar. In union programs, minority men were more likely to graduate than white men, while in nonunion programs, the reverse was true, but the gaps were nonetheless narrower than gender gaps. In terms of time to graduate, differences were relatively small. White men and minority men completed training within a month of each other. In union programs, white women completed earlier than white men on average by as much as three months. Lastly, we compared the quantity of training received by the apprentices who dropped out. Again, the experiences of white and minority men were similar, with minorities receiving around 88 to 107 hours of fewer OJT training than white men, which is less than 2 percent of the total training requirement. In the case of

women, however, the difference was large. Total training received by white women dropouts was lower than white men's (in construction) by 1,052 hours of OJT, or 13 percent of the total required training. The average quantity of training received by the cancelled apprentices overall was relatively small and did not support the contention that the dropouts could have acquired sufficient skills to be employed in jobs that require more than semiskilled workers.

In addition to program sponsorship, unemployment rate and industry turned out to be of economic and statistical significance. A higher rate of unemployment raised both the likelihood of completion and the quantity of training received by the dropouts (although the latter is not statistically significant for white women). The impact on the training hours was the largest for the minority men who dropped out, which was almost twice as much as that of the white men. For white men and especially white women graduates, higher unemployment also raised the duration of training. Thus, there is strong evidence that apprentices tend to stick with training as job opportunities become scarce, at times at the cost of longer time spent as trainees.

Industry results are somewhat paradoxical. White women apprentices were statistically equally likely to complete training in construction and nonconstruction industries, but they graduated in a shorter period of time in the former. Among those who dropped out, however, women in nonconstruction industries received a much higher quantity of training. Thus, the experience of white women in construction industry is dichotomous: they either graduated in a relatively short period of time or dropped out with few, if any, acquired skills. In the construction industry, employer-employee relationship is much looser than in the manufacturing sector, and workers are in constant flux between contractors and jobs. In the manufacturing sector, apprentices probably have more steady work. In Oregon, most of the manufacturing programs seem to have a more stable contract between the employer and the apprentice, as employers (particularly when there is a collective bargaining agreement) frequently recruit current line employees to be apprentices in their maintenance departments. Working conditions are also likely to be more adverse for women in construction since the constant search for a new job as the previous one is completed and arranging transportation to changing job sites may be especially burdensome for those who are also more likely to bear greater responsibilities at home. Our empirical findings suggest that women apprentices in construction either dropped out quickly under these circumstances or, when they were able to overcome these difficulties, completed training efficiently. In the manufacturing sector, they stayed in training for a longer time period and acquired more skills, even if in the end they quit prior to the completion of all requirements. This is in sharp contrast to the white men in nonconstruction industries, who completed training in a shorter time than those in construction and who were also more likely to graduate. Experiences of minority men apprentices in and outside construction industry, on the other hand, were barely distinguishable.

The effect of training sponsorship is one of the most prominent findings. Across the board, probabilities of completion were higher in union programs. The Oregon practice of including worker representatives in the nonunion apprenticeship training

committees did not improve the performance of nonunion programs. Similar to the experience of other states, nonunion programs lagged behind union programs in graduating apprentices. Union programs were especially beneficial for nontraditional workers. White women and minority men were more likely to complete by 35 percent and 29 percent, respectively, compared to their nonunion counterparts. Differential completion rates demonstrate that white women and minority men benefited disproportionately more from training in union programs. In contrast, time to complete was shorter in nonunion programs, around 10 percent for both white men and minority men, and by 5 percent for white women (although the latter is marginally statistically significant). Thus, nonunion programs graduated relatively fewer apprentices but on average at a faster pace. Nonunion programs appear to allocate resources more selectively, so that the few who graduate did so in a shorter span of time. Union programs were only slightly ahead of nonunion ones in terms of the quantity of skills imparted to terminated apprentices, but overall, the quantity of training acquired by these workers is low, and the evidence does not support the hypothesis that quits in the nonunion sector is an indicator of the acquisition of sufficient skills that would secure well-paying jobs.

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Notes

1. There is also the possibility that the program terminates the training agreement because the apprentice fails to meet the program requirements (e.g., due to absenteeism). This is formally the same as a type 1 quit.
2. See, for instance, Marshall and Briggs (1967) on the exclusion of blacks. The exclusionary behavior of unions has, in turn, shaped the "choices" of minority and women workers not to seek entry to these programs.
3. Several studies have shown that in the 1990s and early 2000s, women and minority workers were better represented in the union apprenticeship programs than in the nonunion programs, suggesting a shift in union practices (Berik and Bilginsoy 2000, 2002, 2006).
4. These are the Apprenticeship Information Management System and Registered Apprenticeship Information System of the U.S. Department of Labor, and the California Apprenticeship Agency Database.
5. Each registration does not necessarily refer to a unique apprentice because the same worker can register in different programs at different times. We are interested in the outcome of each registration and therefore use it as the unit of observation. Thus, in the following empirical work, *apprentice* refers to a registration, not an individual apprentice.
6. While these measures jointly provide a more complete account of the performance of apprentices than past studies, three shortcomings still remain. First, apprenticeship requirements include both on-the-job training (OJT) and related theoretical instruction (RTI). Lacking RTI data, we are forced to ignore

in-class instruction and therefore fail to capture this dimension of apprenticeship training. Second, our measurement of training assumes that the training hours are homogenous, that is, an hour of training yields the same amount of skills at any point during apprenticeship. Strictly speaking, this is not accurate. The first phase of training, corresponding to around one thousand hours in an eight thousand–hour program, for instance, is usually the probationary period during which the apprentices are assigned more menial tasks and probably acquire fewer skills than in any other period of equal length. This source of nonhomogeneity is time specific and requires care in interpretation of results for workers who quit early. It is also conceivable that the training sponsor may schedule provisioning of skills strategically, for example, saving the most valuable ones until the end of the training in order to raise retention. Such a scheme is not very likely in practice (at least in construction, where most of the apprentices are) because the sequencing of the skill acquisition is often dictated by the availability of the training jobs. Thus, our assumption of the uniformity of training hours is admittedly an approximation but not entirely unreasonable. Third, given the lack of quality measures, we will assume that the quality of training, that is, the amount of skills delivered in each hour of training in each occupation, does not vary across programs and sponsors.

7. We topcoded schooling at sixteen years for the twenty-six apprentices who reported longer years of schooling because our review of registration forms indicated that these figures were not reliable due to the questionnaire format. We counted a general equivalency diploma as twelve years of schooling.
8. We specify the training supplier as "program-occupation" because in some instances, a single program provided training in several different occupations, and each of these occupations could have different standards of curriculum and wage progression.
9. See Oregon Consortium (1996) and Byrd and Weinstein (2005) on the Oregon apprenticeship system.
10. We did not include licensing regulation as a separate control because it is highly correlated with occupational categories that pick up the effect of licensing.
11. The occupations included are carpenters, communications technicians, electricians, maintenance electricians, maintenance mechanics, millwrights, pipefitters, and plumbers. There were no graduating white women apprentices in the next two largest occupations, drywall applicators and HVAC technicians.
12. Most nonconstruction apprentices were in the manufacturing sector.
13. Union effect estimates would be biased if unobserved attributes of the apprentices are correlated with the union status. However, the direction of this bias is not obvious. Anecdotally, union programs have the reputation of being better organized and more committed to training (Oregon Consortium 1996). They also provide better wages and benefits. On the down side, union dues may make union training unaffordable for a beginning apprentice, especially when there is a shortage of training jobs. If, on balance, workers with higher unobserved capabilities and motivation choose union programs, then the reported estimate of the union effect would be biased upward (and biased downward if they choose nonunion programs). One may discern relative selectivity of union and nonunion programs by combining information on applications and admissions. Information on the Oregon apprenticeship applications is available only for the 1991-to-1995 period and is limited in terms of the reported attributes of applicants. These data do not indicate a sharp difference between the rejection rates of union and nonunion programs (66 percent vs. 59 percent). Women and minority workers were more likely to be rejected by 14 percentage points each. Lacking information on individual attributes of the applicants (e.g., basic skills, education levels), it is difficult to assess relative competitiveness of union and nonunion programs from these figures. As an alternative, we identified the 1,788 apprentices with

duplicate applications to both union and nonunion programs and examined the chances of an applicant, who is initially rejected by a union program, entering a nonunion program, and vice versa. Six percent of these apprentices were rejected by union programs but were eventually admitted to a nonunion program; and 5 percent were rejected by nonunion programs but were eventually admitted into a union program. Moreover, 25 percent were rejected by both union and nonunion programs. These findings do not suggest that one type of program takes the cream of the crop first and leaves the lesser qualified apprentices to others, and hence selection bias in our study is probably not a serious problem.

14. Age is in quadratic specification because while it may serve as a proxy for experience initially, with advancement of age and shortening of the remaining work life, the marginal cost of continuing apprenticeship may eventually exceed the lifetime returns to additional training. Education is also in quadratic form in view of the possible substitutability between training and higher levels of education.
15. Some programs may grant credit for prior experience at a time other than entry, for example, at the end of the probationary period. Since we had observations only on credit received at the time of entry, we were able to exclude only these apprentices.
16. Under conditions of asymmetric information, nonunion workers may also have the incentive to get certification to signal worker quality.

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Bios

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