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NEGATIVE RETURNS TO SENIORITY—
NEW EVIDENCE IN ACADEMIC MARKETS

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A data appendix with additional results, and copies of the computer programs used to generate the results presented in the paper, are available from the authors at Department of Economics, Kansas State University, Waters Hall 327, Manhattan, KS 66506-4001.

Abstract

Prior studies of faculty pay have failed to account for match quality between faculty and university, leading to a positive bias in the estimated returns to seniority. When we account for match quality with a Topel two-step estimator, the negative returns to seniority double in size. Failure to account for quantity and quality of research results in a roughly equal bias in the opposite direction. Based on a sample of economics faculty at five research universities over a 21-year sample period, and accounting for both match quality and faculty research productivity, we estimate that the penalty for twenty years of seniority is 16 percent of salary.

JEL classification: J44, J42, J31

Faculty pay structures have long been of interest to economists.[1] Consistent with findings for nonacademic markets, faculty pay has been found to rise with experience and to be positively related to measures of productivity. But, unlike other markets, there is evidence that returns to seniority are commonly negative. Among the reasons offered for this anomalous finding are monopsony power on the part of most colleges and universities and raiding models, in which high-quality faculty are bid away, resulting in a negative correlation between seniority and unmeasured faculty productivity.

Recently, Moore, Newman, and Turnbull (1998) argued that estimated returns to seniority in previous studies are biased downward because of the failure of these studies to control for quality of faculty research. Consistent with this claim, they showed that the coefficient of *seniority* became less negative once controls for research quality were included in the empirical model. Indeed, when the coefficient of *seniority* lost statistical significance, they concluded that the puzzle had been resolved: There is no need to explain negative returns to seniority because, once research productivity is accounted for, faculty pay is no longer significantly related to seniority.

Although Moore et al. demonstrated convincingly that omission of controls for research quality does impart a downward bias in estimated returns to seniority, neither they nor other authors have recognized a potential bias in the opposite direction caused by a positive correlation between seniority and unobserved quality of the job match. Beginning with the influential

[1]Early studies of academic pay include Cohn (1973), Siegfried and White (1973), Ferber and Loeb (1974), and Johnson and Stafford (1974).

studies by Abraham and Farber (1987) and Altonji and Shakotko (1987), a large empirical literature has stressed the role of quality of the match between worker and employer in shaping the length of employment relationships. Because the quality of the job match is unobserved by the researcher and because match quality is positively correlated with wages and seniority (good job matches survive), cross-sectional estimates of returns to seniority are upwardly biased. We argue that match quality is an important determinant of the length of faculty employment with a university and that failure to account for match quality undermines prior estimates of returns to seniority in academic markets.

The present study incorporates longitudinal data to examine pay of economics faculty at five public universities in the Midwest over a 21-year sample period. First, we examine the effect of sequentially adding controls for service, quantity of research (number of articles and number of research books), and quality of research (as measured by journal quality and number of articles to cite the author). In addition to providing important information about returns to faculty productivity, the analysis also indicates how controlling for faculty quality affects the estimated returns to seniority. Next, we address the extent to which failure to account for match quality biases estimated returns to seniority and adopt the two-step estimator of Topel (1991) to eliminate this bias. Although results are limited to a particular sample of large nonunion universities, which points to the need for additional research based on other samples, this study demonstrates that modeling faculty pay with detailed longitudinal data and accounting for match quality provides important insights regarding academic pay structures.

Prior Research

Virtually all studies of academic pay include variables to control for experience or, less commonly, for age. When studies also control for seniority—years at the current academic institution—estimated returns are generally negative (see Table 1). For example, Gordon, Morton, and Braden (1974), in their study of a large urban university, estimated that each year of seniority reduces pay by 0.49 percent.

Hoffman (1976) found tentative evidence of a more modest penalty for seniority at the University of Massachusetts at Amherst (UMASS). In a baseline model similar to that of Gordon et al., Hoffman obtained a coefficient of -0.002 for *seniority*. Once variables on academic rank were omitted, however, the coefficient of *seniority* was no longer statistically significant.[2] When Hallock (1995) examined the pay structure at UMASS for the year 1989, using the same baseline specification as Hoffman, he obtained a coefficient of -0.0018 for *seniority* (significant at the 5 percent level). But Hallock demonstrated that this finding was not robust. In fact, when he introduced a quadratic specification, marginal returns to seniority were estimated to be positive for the first 14 years. Hallock was careful not to generalize these findings to other universities. He pointed out that UMASS is unionized and that contracts there have led to cost-of-living raises for all faculty. To the extent unions increase returns to seniority

[2]Both Hoffman and Hallock (1995) include faculty rank in certain regressions to replicate the specification of Gordon et al. The only other study to control for rank is Barbezat (1989). Hallock argues against inclusion of rank on the grounds that rank is endogenous and finds that the addition of rank variables flattens the seniority profile.

and reduce returns to merit, one might anticipate that returns to seniority will be more positive for faculty covered by collective bargaining.

Evidence from Barbezat (1989) suggests that returns to seniority may indeed depend on bargaining status. Barbezat's sample consisted of 1977 survey data from 158 institutions of higher education in the United States. In her basic model, the coefficient of *seniority* was a highly significant -0.002. But when she allowed for a differential effect in union and nonunion institutions, coefficient estimates were -0.003 in nonunion colleges and universities and +0.002 in the union sector. The results of Hoffman (1997) are also consistent with the proposition that returns to seniority are negative only for nonunion faculty. For her first sample, consisting of faculty across the state of Illinois, the estimated coefficients of both *seniority* and $seniority^2$ were negative. In contrast, for faculty at the unionized Western Michigan University returns to seniority were significantly greater than zero.

At Michigan State University, where faculty are not covered by collective bargaining, Brown and Woodbury (1998) found negative returns to seniority, at least for males. For 1990, the penalty at ten years of seniority was estimated to be a statistically significant 7 percent for males and an insignificant 3 to 4 percent for females, depending on specification.[3]

Barbezat and Donihue (1998, p. 244) suggest that negative returns to seniority, where they occur, are likely to be the consequence of "the tenure system, a unique institutional feature

[3]In one set of regressions, Brown and Woodbury interacted the seniority variables with a variable linked to entry-level salaries. For ease of comparison, Table 1 presents estimates of the regressions without interaction terms, but seniority profiles are very similar. Brown and Woodbury also examined pay structures for 1981 and 1986. For males estimated returns to seniority were negative and significant both years.

of academia" that reduces worker mobility and increases monopsony power. Using national survey data from 1988, they find that returns to seniority are negative for tenured faculty but positive for untenured faculty. The latter sample includes lecturers, instructors, and others not on tenure-track lines. Because such faculty have different responsibilities (e.g., they are not expected to conduct research or to serve on graduate committees), their pay structures cannot be expected to be the same as those for tenure-track faculty. For this reason, results for the untenured sample are more difficult to interpret and less relevant to the literature on pay structures of tenure-track faculty.

The most compelling evidence of negative returns to seniority, at least among nonunion faculty, comes from Ransom (1993). Ransom examined data from multiple sources, including the May/June 1988 Current Population Surveys, the 1969 Carnegie Survey of Higher Education, the 1973 American Council on Education Survey, and the 1977 Survey of the American Professoriate. Except in the 1977 data, faculty pay is inversely related to seniority, and at least for research universities this relationship is statistically significant. Ransom then explored the relationship in detail at one nonunion institution, the University of Arizona, for the years 1972, 1977, and 1982. For all three years, faculty pay declined significantly with seniority, although at a decreasing rate (the coefficient of the quadratic term was positive). Summarizing his empirical findings, Ransom (p. 228) writes:

> For a typical professor, with about 10 years of seniority, changing employers would result in an increase in pay of from around 5 percent (using estimates from the national samples) to about 10 percent (using estimates from the University of Arizona sample).

To explain the negative relationship between seniority and faculty pay, Ransom developed a model of monopsonistic discrimination in which faculty with high mobility costs have higher seniority and lower wages than other faculty.[4] Later work by Penrod (1995), based on 1990 U.S. Census data, provided support for Ransom's model. Using a Herfindahl index to measure local monopsony power, Penrod found that, for faculty in research universities, wages were modestly lower in markets with greater monopsony power, an outcome predicted by Ransom's model.

As Ransom acknowledged, a negative relationship between seniority and salary is also consistent with models of Harris and Holmstrom (1982) and Lazear (1986), in which worker quality is unknown when the worker is hired. Because only high-quality workers receive outside offers, low-quality workers tend to acquire higher levels of seniority. According to these models, faculty with high seniority receive lower pay not because of monopsonistic discrimination but rather because such faculty tend to be of lower quality. Ransom rejected these models, however, arguing that the relationship between seniority and salary remained strong even when he included variables to standardize for number of books and number of articles published.

In their study of 142 economics faculty at nine state universities, Moore, Newman, and Turnbull (1998) also found evidence that faculty pay and seniority are inversely related when the only measure of research is quantity of publications. Based on a linear specification of the seniority variable, they uncovered one of the largest penalties yet—1.5 percent per year. But the authors argued that failure to control for quality of research will bias estimates of returns to

[4]See Boal and Ransom (1997) for a more general derivation of the monopsony model.

seniority if seniority and research quality are correlated. They further observed that prior research on seniority profiles did not include variables on research quality. Actually, most studies omitted measures of quantity as well as quality, further complicating interpretation of the seniority coefficients. Of the studies cited, only three report estimates for models that include quantity of research.[5]

To examine the importance of research quality, Moore et al. included variables measuring number of level-one (top-ten) articles, level-two articles, and citations. When they reestimated the model, the coefficient of *seniority* became smaller in absolute value: -0.003 in the specification without controls for years as chair and teaching awards (significant at the 10 percent level) and -0.002 with the controls added.[6] The implied penalties are lower than those typically obtained for nonunion universities but similar to the penalties in Hoffman (1976) and Barbezat. Nonetheless, Moore et al. (p. 363) argued that the negative relationship "disappears" based on the statistical insignificance of the coefficient:

> In sum, the negative seniority-earnings relationship found here and elsewhere appears to be driven by an omitted variable bias. Faculty with greater seniority appear to be rewarded relatively less simply because, as a group, many have been relatively less productive than their colleagues with less seniority at similar stages in their careers.

[5]The literature on academic pay reveals that salaries depend on both quantity and quality of research and that quality is by far the more important factor; see Katz (1973), Hamermesh, Johnson, and Weisbrod (1982), and Ragan, Warren, and Bratsberg (1999). Oster and Hamermesh (1998) show that research productivity of economists is correlated with age, which points to bias in estimates of experience-earnings profiles when research is omitted.

[6]For a discussion of the returns to serving as department chair, see Saks (1977) and Ragan and Rehman (1996).

Although Moore et al. contributed to our understanding of the relationship between faculty pay and seniority and of the need to control for research quality, the issue involving the slope of the seniority profile is far from resolved. First, there is the matter of replication. For other, preferably larger, data sets, what are the consequences of controlling for quantity and quality of faculty research? Second, and more important, is the need to explicitly consider the role of match quality, something ignored in prior empirical analyses.

Institutions of higher learning differ in terms of research expectations,[7] emphasis on teaching, service responsibilities, collegiality, ideology, faculty support, and other amenities and disamenities. In turn, faculty differ in such dimensions as research skills, teaching potential, work ethic, and personality. Typically, faculty skills develop over long intervals. At the time of the initial hire, the potential of faculty is often unknown to both the faculty member and the institution. Over time, information is acquired by both parties. When the fit between faculty and institution turns out to be poor, one or both parties have an incentive to terminate the relationship.[8] Good matches are more likely to survive. Stated differently, high seniority is likely to be associated with a good fit. If match quality and wages are positively related, as the literature suggests, estimated returns to seniority will be biased upward unless the effect of match quality is taken into account.

[7]Ehrenberg, Pieper, and Willis (1998) show that tenure probabilities vary by university and that institutions with low tenure rates pay a compensating differential.

[8]An example of matching in academic labor markets can be found in Singell, Lillydahl, and Singell (1996). In their study of time allocations of university faculty, Singell et al. uncover a strong match between institutional incentive structures and faculty attributes.

Empirical Analysis

In this section we explore the importance of accounting for research quantity, research quality, and match quality when estimating returns to seniority in academia. Empirical results are based on a panel data set covering tenure-track economics faculty (including chairpersons) at five Midwestern universities with doctoral programs in economics. The universities are Iowa State University, Kansas State University, University of Kansas, University of Missouri, and University of Nebraska-Lincoln. These universities are commonly viewed as mid-level. Of the 240 institutions ranked by Scott and Mitias (1996), based on pages published in 36 economics journals, the five universities in the sample were ranked between 65 and 124. According to Tschirhart (1989), the universities were rated between 42 and 102 in terms of articles per faculty member. In Tremblay et al. (1990), four of the five universities were ranked between 51 and 92 (in pages published) out of the 119 universities sampled.[9]

The data set includes 1,897 observations of 176 faculty members at the five universities over the sample period 1975 through 1995 (see appendix for sample statistics). Unlike the panel data from household surveys, we observe wages only as long as a faculty member stays at one of these five universities. Although this may be viewed as a limitation of the data, the longitudinal nature of the data set provides an important advantage: With these data, it is possible to examine the match-quality issues raised by Abraham and Farber, Altonji and Shakotko, and others and not

[9]Only Iowa State University is listed among the top fifty economics programs in 2001 by *U.S. News & World Report*. As a point of comparison, Moore et al. report that the nine unnamed universities in their sample place approximately 30 to 75 in the Scott and Mitias ranking.

previously addressed in studies of academic pay.

Underlying the empirical analyses is the regression model

$$(1) \qquad \ln w_{ijt} = \alpha_1 T_{it} + \alpha_2 T_{it}^2 + \beta_1 X_{it} + \beta_2 X_{it}^2 + \gamma Z_{it} + \mu_i + \eta_{ij} + \varepsilon_{ijt},$$

where w_{ijt} denotes the annual salary of faculty member *i* employed at university *j* in year *t*,[10] *T* measures years of seniority with the university, *X* is years of experience, and *Z* denotes a vector of control variables. The regression error contains three separate components: μ, an individual-specific term that captures "unmeasured productivity"; η, a component that is specific to the match between worker and employer; and ε, a term representing white noise.

Regressions are based on four specifications of *Z*. All specifications include an indicator variable for gender[11] and complete sets of indicators for university and year of observation,[12] and

[10]Salary data were collected on site from official university records, which minimizes measurement errors and response biases common in studies that rely on survey data. Nominal salaries are deflated by the Consumer Price Index-all urban consumers, base period: 1982-84 = 100.

[11]The coefficient of *Female* is negative in all specifications of the model but is significant at the 10 percent level only once, in the stripped-down version of the model estimated with the two-step method (Table 4, column i). When controls are added for administrative service and research output, the coefficient becomes smaller in absolute value. Even so, we are unable to say anything strong about the effect of gender on pay because only 17 of the faculty in the sample are women, and they account for only 95 observations (5.0 percent). What is clear is that the females in the sample completed their Ph.D.s more recently and have lower seniority (a mean of 4.36 years compared to 14.04 for males).

we sequentially augment the specification with three sets of variables reflecting cumulative contributions to service, teaching, and research as of year *t*. These variables include an indicator variable for department chairpersons, years as chair, number of completed Ph.D. dissertations for which the faculty member was the major professor, number of articles published in journals listed in *EconLit*,[13] number of research books listed in *EconLit*, and number of *AER*-equivalent pages published in level-I and level-II journals adjusted for number of authors.[14] As a further dimension of quality, we include one measure of citations: the number of articles listed in the

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[12]To save space, we omit coefficients of university and year indicator variables from tables. Coefficient estimates show that salaries are significantly higher at Iowa State University than at the other four universities. The coefficients of the year variables indicate a negative trend in real salaries from 1975 until 1983, a positive trend from 1984 until 1989, and a slightly negative trend thereafter.

[13]Actually, data on publishing records are first available from *EconLit* in 1969. For prior years, data were obtained from American Economic Association, *Index of Economic Articles*, and Institute for Scientific Information, *Web of Science*. Excluded from the articles variable are book chapters, papers in conference proceedings, book reviews, and articles in journals not covered by *EconLit*.

[14]We follow Moore et al. and include the following ten journals in the level-I category: *American Economic Review*, *Econometrica*, *Economic Journal*, *Economica*, *International Economic Review*, *Journal of Economic Theory*, *Journal of Political Economy*, *Quarterly Journal of Economics*, *Review of Economic Studies*, and *Review of Economics and Statistics*. The level-II category consists of non-level-I journals included in the list of top 36 journals contained in Scott and Mitias (1996). Pages are converted to *AER*-equivalent using the transformations of Scott and Mitias and are deflated by the number of authors, consistent with Sauer's (1988, p. 863) recommendation, but robustness checks indicate that estimated returns to seniority are not sensitive to treatment of co-authors.

Social Science Citation Index that cite the author's publications.[15]

Accounting for Quantity and Quality of Research

We focus initially on the importance of including controls for service and research record using traditional methods of estimation. That is, our baseline regressions ignore the match-quality component (η) of the error term and model the individual component (μ) as a random effect;[16] results appear in Table 2.

In the most basic specification (column i), seniority has a significantly negative effect on pay roughly comparable to that found at Michigan State University and the University of Arizona. The cumulative penalty to seniority is estimated to be 7.3 percent after ten years with the university and 12.5 percent after twenty years (Table 3, col. i). When controls are added for service as department chair and as major professor, the negative effect of seniority intensifies (Tables 2-3, col. ii). Because administrative service and contributions to the doctoral program are highly rewarded (and correlated with seniority), in the absence of such service the penalty to seniority is even more severe.

The models of Harris and Holmstrom and Lazear predict that faculty with high seniority will have weaker research records than other faculty, holding experience and other factors

[15]On average, each *SSCI* article that cites an author in the sample cites 1.22 of his or her publications. (As of early 2001, faculty in the sample had on average been cited in 66.72 *SSCI* articles. The average number of publications cited was 81.42.) Note that citations will be missed when an author's name is not spelled accurately.

[16]Note that treating μ as a fixed effect would preclude identification of coefficients of both seniority and experience because years of seniority, years of experience, and the individual fixed effect are perfectly collinear in the data.

constant. In that event, the effect of seniority should lessen once controls are included for quantity of publications. As shown in Table 3, column iii, the penalty to seniority falls by roughly one-third (relative to the estimates in column ii) but remains significant when we account for quantity of research.

The final specification (Table 2, column iv) includes variables for quality as well as quantity of publications. As expected, quality is rewarded. Net of returns to being cited, a ten-page article is estimated to increase pay by 1.04 percent if in an unranked journal, by 2.15 percent if in a tier-two journal, and by 2.79 percent if published in a tier-one journal. For tier-one and tier-two articles, our estimates are of a similar order of magnitude as those of Moore et al., but for unranked articles our estimates are higher.

Interestingly, the estimated value of a research book is comparable to that of a long tier-one article. Returns of this magnitude exceed those commonly estimated in the literature (e.g., Tuckman and Leahy 1975, Barbezat 1989), though they are comparable to the estimates of Freeman (1977). It is important to emphasize, however, that the book variable in the present study is restricted to research books listed in *EconLit*. With few exceptions, other studies have combined research books and textbooks. Because textbook authors are compensated primarily through royalties and because textbooks are less likely to contain original research, one might expect that research books would have a greater effect on pay than would textbooks. Indeed, this was a conclusion of Ragan and Rehman (1994), who found that only research books increase pay significantly.

The returns to publishing increase when an author's research is cited. Evaluated at the

sample mean, the marginal return to another citation is a 0.11 percent increase in pay. This estimate is greater that that of Moore et al. but falls in the ranges reported by Diamond (1986) for economics faculty at UC Berkeley and by Hamermesh (1989) for the six large public schools he examined. Because citations are one measure of research quality, the finding that citations are rewarded provides further evidence that quality matters.

As in Moore et al., controlling for quality further reduces the effect of seniority.[17] The penalty for ten years with the university falls to 6.2 percent, compared to the 10 percent estimate of specification ii (see table 3). But, importantly, the negative returns to seniority remain statistically significant even after variables are included for quantity and quality of research. At least for our sample, the inverse relationship between pay and seniority cannot be fully explained by differential research productivity of faculty.[18] Finally, we note that the difference in findings between Moore et al. and the present study, regarding statistical significance of seniority, cannot be explained by choice of estimation technique. The coefficient of *seniority* remains statistically significant when we re-estimate the equation using ordinary least squares.[19]

[17]The estimated returns to experience are also lower when the equation controls for quantity and quality of research. Estimated returns to ten years of experience are 21.3 percent in specification iv versus 37.3 percent in specification ii.

[18]When equations were estimated separately by university, the coefficient of *seniority* was negative for each of the five universities.

[19]For example, when we construct a sample based on stacked cross-sections from 1975, 1985, and 1995 (as suggested by one referee), the coefficient of *seniority* is -.0074 (*s.e.* = .0022; N = 261).

Topel's Two-step Estimator

We next adopt the two-step estimation procedure of Topel (1991) to address the importance of accounting for the quality of the match between faculty and the university. The basic premise of the match quality literature is that the job-specific component of the regression error is positively correlated with seniority, rendering estimates of returns to seniority based on traditional methods biased.

In Topel's two-step procedure, the first step yields consistent estimates of the sum of the coefficients of the linear seniority and experience terms, $\alpha_1 + \beta_1$, as well as the coefficients of the quadratic terms, α_2 and β_2, based on a first-difference regression that nets out the individual and match-quality components of the error term:

$$\Delta \ln w_{ijt} = (\alpha_1 + \beta_1) + \alpha_2 \Delta T_{it}^2 + \beta_2 \Delta X_{it}^2 + \gamma \Delta Z_{it} + \Delta \varepsilon_{ijt} . \quad (2)$$

In the second step, predicted on-the-job wage growth (based on parameter estimates from the first step) is subtracted from log salary to form the dependent variable of a second regression model. In that model an estimate of β_1 is obtained as the coefficient of the initial experience level of the faculty member when joining the university:

$$y_{ijt} = \beta_1 X_{0ij} + \gamma Z_{it} + \mu_i + \eta_{ij} + v_{ijt} , \quad (3)$$

where $y = \ln w - (\alpha_1 + \beta_1)T - \alpha_2 T^2 - \beta_2 X^2$ (carets over greek symbols omitted), and X_0

denotes initial experience.[20] The resulting estimate of the coefficient of seniority, computed as the difference between the first-step estimate of $(\alpha_1 + \beta_1)$ and the second-step estimate of β_1, is therefore by construction unaffected by any direct correlation between job-match quality and seniority.

Table 4 presents estimates of the wage equation based on Topel's two-step procedure. Compared with results of Table 2, coefficient estimates are less sensitive to specification of the control vector *Z*, but the overall pattern of estimates parallels that of the earlier table. In particular, the estimated returns to seniority drop when the model controls for administrative service and rise once controls are included for quantity and quality of research. Of greater relevance, the estimated returns to seniority become more negative in the two-step procedure. In fact, the estimated penalty to seniority is roughly twice as large when based on Topel's methodology. For example, the penalty to ten years of seniority, estimated to be 6.2 percent when not accounting for match quality (Table 3, col. iv), is 11.7 percent according to the two-step estimator (Table 5, col. iv).

Predicted seniority-wage profiles of the two estimators (based on the most inclusive specification of the vector *Z*) are plotted in Figure 1. The figure neatly summarizes the main conclusions of the paper: There are substantial negative returns to seniority in our sample of economics faculty, and the estimated penalty to seniority becomes larger when the empirical

[20]Note that coefficients of time-variant factors in *Z* are overidentified in the two-step procedure. In tables we report estimates of such coefficients based on equation 3. Consistent with the approach of the prior section, we model the

strategy accounts for bias induced by the correlation between match quality and seniority.[21]

Is Match Quality More Important in Academic Markets?

The large disparity in estimates of seniority profiles depicted in Figure 1 shows that match quality is an important feature of academic pay structures. Even though the returns to seniority are negative, the evidence indicates that faculty with high seniority have better matches on average. But how does the implied role of match quality in academia compare with that in other labor markets? To provide perspective, we compare our results based on faculty data with other studies that also have applied Topel's two-step methodology, but using longitudinal data sets of very different populations.

Topel (1991) examines the relationship between seniority and wage growth for a sample of white males age 18 to 60 drawn from the 1968-83 interview waves of the PSID. In Topel's

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individual error component as a random effect in the second-step regression. In addition, we adjust standard errors for sampling error in first-step estimates using the method of Murphy and Topel (1985).

[21]One feature of academic labor markets that could give importance to match quality is the tenure process. If the tenure decision serves primarily to eliminate poor job matches, one would anticipate that failure to account for match quality would be less of a problem when the regression sample is restricted to senior faculty only. In fact, such sample restrictions are not uncommon in studies of academic pay structures (e.g., Hamermesh, 1989; Moore et al., 1998). When we re-estimated the model excluding assistant professors from the sample, results indicated a modest compression of profiles across estimators. But as in the full sample, predicted returns to seniority were negative and statistically significant. Furthermore, the pattern of the seniority penalty across estimators paralleled that of the full sample, indicating that the correlation between match quality and seniority is strong even in subsamples that exclude junior faculty.

sample, OLS (which does not consider match quality) overstates wage growth by 5.3 percentage points after five years and by 5.6 percentage points after ten years. Williams (1991) also focuses on males age 18 to 60, but draws his sample from the Seattle and Denver Income Maintenance Experiments, which were conducted between 1970 and 1974. Although the workers in Williams' sample have very short job spells, the predicted wage growth with five years of seniority is 5.6 percentage points higher when based on OLS rather than the two-step procedure. Finally, Bratsberg and Terrell (1998) study wage growth of black and white male youths using samples drawn from the 1979-91 waves of the NLSY. According to their estimates, OLS overstates wage growth after five years of seniority by 4.7 percentage points for white youths and by 2.3 percentage points for black youths. In comparison, when match quality is not accounted for in the present study, cumulative wage growth of faculty is overstated by 3.5 percentage points after five years of seniority and by 5.5 percentage points after ten years (Tables 3 and 5, col. iv). The implication is that match quality is important in academic labor markets but perhaps no more important than in other labor markets.

Biases in the Two-step Procedure

Job Shopping. Although Topel's methodology breaks the correlation between seniority and unobserved match quality, estimates from the two-step procedure remain biased if job shopping is an important feature of academic labor markets. For example, job search or matching models such as Burdett (1978) and Jovanovic (1979) suggest that match quality improves with time in the labor market. The improvement in match quality with experience

induces a correlation between initial experience and the error term of the second-step regression as faculty who join a university late in their career are more likely to enter into a high-quality job match than are junior faculty.

Topel (p. 153) shows that such correlation between initial experience (X_0) and the match-quality component of the error term (η) generates a bias in the coefficient estimate of the linear seniority term given by:

$$E\hat{\alpha}_1 - \alpha_1 = -b - \delta_{X_0 T}(a+b), \tag{4}$$

where *a* and *b* refer to the coefficients of *seniority* and *experience* if η were regressed on *T* and *X*, and $\delta_{X_0 T}$ is the coefficient from a regression of *seniority* on *initial experience*. The coefficient *a* is the bias (induced by match quality) in the OLS estimate of α_1, and *b* measures the average return to job shopping in the sample.[22] Topel also shows that a consistent estimate of the sum *a* + *b* can be obtained by adding *seniority* to the second-step regression.

Based on the most complete specification of the model, the estimate of *a* + *b* is .0032 (standard error = .0012) and the coefficient $\delta_{X_0 T}$ is -.3928. Prior research shows that $a \geq 0$, that

[22]Seventeen percent of the faculty in the sample (30 out of 176) joined the university with at least six years of prior experience. This finding is consistent with Hallock's observation that only 12 percent of tenured faculty at UMASS were outside hires.

is, OLS estimates overstate returns to seniority.[23] If $a = 0$, the return to systematic job shopping is approximately one-third of one percent per year of labor market experience, and the bias of the coefficient of *seniority* reported in Table 4, column iv, is -.0020, or 12 percent of its reported value. If $a > 0$, any downward bias of the *seniority* coefficient is smaller. Consider the penalty to ten years of seniority, estimated to be 11.7 percent in Table 5. In the event of an upper-bound bias of $\hat{\alpha}_1$, the penalty falls to 10.0 percent. Similarly, the penalty to twenty years of seniority is reduced from 15.7 percent to 12.4 percent. But even these lower estimates of the seniority discount exceed the estimates contained in Table 3. In summary, although a positive correlation between initial experience and match quality induces an upward bias in estimates of the penalty to seniority, the indication is that such bias is small relative to the downward bias from failure to account for match quality in the empirical model.

Unmeasured Productivity. Another source of bias in studies of faculty pay is the potential correlation between seniority and unmeasured productivity. Topel (p. 163) asserts that such correlation is positive in survey data because more able workers change jobs less often. In our data a positive correlation could also arise if personal characteristics (maturity, interpersonal skills, etc.) are associated with seniority, perhaps the result of tenure denials and pre-tenure dismissals of faculty with unfavorable characteristics. On the other hand, the raiding models

[23]Virtually every empirical study that deals with match quality finds that OLS overstates returns to seniority; see Abraham and Farber (1987), Altonji and Shakotko (1987), Marshall and Zarkin (1987), Topel (1991), Williams (1991), Altonji and Williams (1998), Bratsberg and Terrell (1998), Light and McGarry (1998), and Parent (1999). Even though Topel argues that *a* may be negative in survey data under certain conditions, the evidence to date (including Topel's) overwhelmingly indicates that in U.S. data *a* is nonnegative.

outlined earlier point to negative correlation if raiding is based in part on characteristics unobserved by the researcher. Negative correlation could also occur if universities favor internal candidates, e.g., by applying lower promotion standards for current faculty than for outside hires. Accordingly, the resulting bias in the coefficient of *seniority* is unsigned.

The two-step procedure avoids the direct correlation between seniority and unmeasured productivity, but estimates may be biased if initial experience (X_0) and unmeasured productivity (μ) are correlated in the second-step regression (equation 3). Initial experience might be correlated with unmeasured productivity for either of two reasons. One possibility is that departments require higher unmeasured productivity of external hires than of internal candidates. It is not unreasonable that departments set higher standards in terms of measured productivity (publication record),[24] and perhaps those higher standards also apply to unmeasured characteristics. Such a policy would create a positive correlation between unmeasured productivity and initial experience. In turn, this would bias positively the estimate of β_1 and cause a negative bias in $\hat{\alpha}_1$. The other possibility is that unmeasured productivity is lower for external hires. Indeed, tenure denials elsewhere might be expected to create a negative correlation between initial experience and unmeasured productivity in our sample. In that event, the bias in $\hat{\alpha}_1$ would be positive, and our estimates would provide a lower bound of the penalty to seniority.

[24]The data reveal that outside hires indeed have favorable observed characteristics. For example, when the sample is restricted to those with more than six years of experience, the mean number of *EconLit* articles is 10.8 for outside hires and 6.7 for other faculty. (The sample *t*-statistic for the null hypothesis of equality of means is 8.41.)

We investigate the bias stemming from correlation between initial experience and unmeasured productivity in two ways. First, we recognize that gentler treatment of internal candidates would not have any force in a sample of external hires and therefore examine the subsample of the 30 outside hires in the data (293 observations). When we re-estimated the model for this restricted sample, the estimated penalty for seniority is at least as great as for the full sample. For example, the most extensive specification of the model predicts seniority penalties of 9.0 percent after five years and 15.8 percent after ten years.

Second, we follow Topel's recommendation and use *total* experience as an instrumental variable for *initial* experience in the second-step regression. Total experience is a valid instrument in a sample such of ours only if attrition of high and low productivity faculty (e.g., through raiding, tenure denials, etc.) on balance offset one another in terms of unmeasured productivity. When we use this instrument, the coefficient of *seniority* in Table 4, column iv, falls to -.0242 (standard error = .0102) and again estimated seniority penalties exceed those reported in Table 5. In summary, we find no signs of a positive correlation between unmeasured productivity and initial experience and conclude that, if anything, the estimates of Table 5 understate the penalty to seniority.

Conclusions

Prior research has documented a negative relationship between seniority and faculty pay, but recent studies have questioned the robustness of this finding. Based on a 21-year panel of data from five Ph.D.-granting departments of economics, we provide evidence that the penalty to

seniority is real and substantial. Controlling for quantity and quality of research reduces the estimated penalty, consistent with the proposition that the low wages of senior faculty result in part from low research productivity. But returns to seniority are significantly negative in all specifications of the empirical model.

The penalty to seniority is actually greater than previously estimated. Because match quality and wages are positively related, and better matches are more likely to survive, estimates of returns to seniority based on traditional methods are biased positively. When match quality is accounted for with a Topel two-step estimator, the estimated penalty to seniority roughly doubles. Based on the most complete specification of the model, the cumulative returns to seniority are -11.7 percent of salary after ten years with the university and -15.7 percent after twenty years.

We also find that faculty are rewarded for administrative service, contributions to the graduate program, research books, quantity and quality of journal publications, and citations to their research. Therefore, faculty may be able to overwhelm the adverse consequences of seniority through high productivity, though such faculty could expect even higher pay elsewhere.

In summary, faculty pay falls significantly with seniority. The penalty to seniority is overstated in models that fail to account for quantity and quality of research and understated when match quality is ignored. At least for the present sample of non-union universities, research productivity and match quality are both correlated with seniority, and the cross-sectional biases associated with these correlations are approximately offsetting.

Finally, it is appropriate to acknowledge some caveats about the generalizability of our findings. First, because the sample is restricted to a particular level of institution, it is not clear whether or not empirical results will be comparable for more elite universities or, for that matter, for institutions that emphasize teaching over research. Second, the sample is restricted to nonunion universities located in nonurban labor markets. Prior research suggests that returns to seniority are higher in unionized settings. Finally, monopsony power is likely to be weaker in urban markets, which may also lead to higher returns to seniority, i.e., a lower penalty. For these reasons, additional research is in order—research that acknowledges the importance of matching but that is based on a different sample of academic institutions.

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Appendix Table A-1

Sample Descriptive Statistics

Variable	Mean	Standard Deviation	Minimum	Maximum
ln(Salary)	10.533	.241	9.924	11.287
Seniority	13.553	9.716	0	42
Experience	15.645	9.872	0	42
Female	.050	.218	0	1
Chair	.047	.213	0	1
Years Chair	.611	2.406	0	20
Ph.D. Advisees	2.878	4.817	0	30
Journal Articles	6.278	7.328	0	67
Books	.037	.227	0	3
Pages, Level I	8.817	15.803	0	83.956
Pages, Level II	10.713	18.308	0	109.481
Citations	28.159	47.754	0	532

Appendix Table A-2

Sample Correlation Coefficients (Seniority, Experience, and Research Variables)

	Seniority	Experi-ence	Journal Articles	Books	Pages, Level I	Pages, Level II
Experience	.926					
Journal Articles	.282	.361				
Books	.081	.122	.363			
Pages, Level I	.097	.216	.496	.085		
Pages, Level II	.104	.166	.574	.176	.283	
Citations	.312	.372	.726	.409	.516	.363

Note: Sample size is 1,897.

Table 1. Faculty Seniority/Pay Profiles—A Summary of Prior Research

Study		Coefficient (standard error), Seniority Variables		Institution(s)	Research Variables?	Remarks
Gordon, Morton, Braden (1974)		-.0049 *T* (.0009)		not revealed	no	large urban university
Hoffman (1976)		-.002 *T* (.0008)		UMASS	no	unreported coefficient of seniority not significant when rank is deleted
Hallock (1995)	(i)	-.0018 *T* (.0008)		UMASS	no	specification similar to Hoffman's
	(ii)	.0123 *T* (.0026)	- .000447 T^2 (.000069)			expanded specification
Barbezat (1989)	(i)	-.002 *T* (.0006)		national survey	quantity	does not allow returns to seniority to vary by union status
	(ii)	-.003 *T* (.0007)	+ .005 *T* *Union (.002)			allows differential returns for union faculty
Hoffman (1997)	(i)	-.0170 *T* (.0132)	- .00039 T^2 (.00040)	throughout Illinois	no	sample of 22 public and private institutions in the state
	(ii)	.0278 *T* (.0034)	- .00052 T^2 (.00010)	Western Michigan Univeristy	no	unionized institution
Brown, Woodbury (1998)	(i)	-.00812 *T* (.00219)	+ .000063 T^2 (.000073)	Michigan State	no	males, 1990
	(ii)	-.00424 *T* (.00448)	+ .000160 T^2 (.000147)			females, 1990
Barbezat, Donihue (1998)	(i)	-.0107 *T* (.0038)	+ .0002 T^2 (.0001)	national survey	quantity	tenured faculty
	(ii)	.0254 *T* (.0102)	- .0007 T^2 (.0005)			untenured faculty
Ransom (1993)	(i)	-.0037 *T* (.0009)	+ .000054 T^2 (.000026)	national survey	no	relationship persists when controls added for research quantity (coefficients unreported)
	(ii)	-.0111 *T* (.0022)	+ .0001 T^2 (.00006)	U. of Arizona	no	nonunion university, 1982
Moore, Newman, Turnbull (1998)	(i)	-.015 *T* (.003)		unspecified state universities	quantity	data for 142 economics faculty
	(ii)	-.003 *T* (.002)			quantity + quality	no controls for years chair, teaching awards
	(iii)	-.002 *T* (.003)			quantity + quality	with controls for these variables

Notes: *T* = Years at the current academic institution. Gordon et al. and Hoffman (1976) control for age, as does Hallock (i). In all other cases, a quadratic specification of experience is used in place of age. All studies control for department or discipline and for gender (either by adding a dichotomous variable or, where indicated, estimating regressions separately for males and females). The only study not to include a variable for doctoral degree is Moore at al., but it restricts the sample to tenured faculty. Only Gordon et al., Hoffman (1976), Barbezat, and Hallock (i) control for rank. Ransom (i) refers to 1973 data for research universities.

Table 2. Faculty Earnings Profiles—Random Effects Estimates

	(i)	(ii)	(iii)	(iv)
Seniority	-.0086***	-.0107***	-.0092***	-.0079***
	(.0030)	(.0027)	(.0023)	(.0023)
Seniority^2/100	.0097*	.0012	.0124**	.0157***
	(.0059)	(.0056)	(.0050)	(.0050)
Experience	.0380***	.0372***	.0273***	.0237***
	(.0031)	(.0028)	(.0024)	(.0024)
Experience^2/100	-.0592***	-.0552***	-.0449***	-.0435***
	(.0059)	(.0055)	(.0049)	(.0050)
Female	-.0292	-.0246	-.0044	-.0014
	(.0340)	(.0296)	(.0250)	(.0242)
Chair		.0779***	.0778***	.0740***
		(.0103)	(.0092)	(.0090)
Years Chair		.0119***	.0131***	.0130***
		(.0020)	(.0018)	(.0017)
Ph.D. Advisees		.0136***	.0056***	.0044***
		(.0013)	(.0012)	(.0012)
Journal Articles			.0146***	.0104***
			(.0007)	(.0009)
Books			.0295***	.0457***
			(.0106)	(.0113)
Pages, Level-I Journals/10				.0171***
				(.0036)
Pages, Level-II Journals/10				.0109***
				(.0026)
Citations/10				.0127***
				(.0018)
Citations^2/1000				-.0028***
				(.0004)

Notes: Dependent variable is the natural logarithm of annual salary. Sample consists of 1,897 observations of 176 faculty. Standard errors are reported in parentheses. Regressions also include indicator variables for university and year of observation.

*Statistically significant at the .10 level; **at the .05 level; ***at the .01 level.

Table 3. Estimated Penalty to Seniority by Years of Seniority, Random Effects Estimates (as percent of pay)

Years of Seniority	Specification (i)	(ii)	(iii)	(iv)
5	4.0	5.2	4.2	3.5
10	7.3	10.0	7.6	6.2
15	10.1	14.6	10.4	8.0
20	12.5	18.9	12.6	9.1
Controls:				
Chair, Ph.D.s	No	Yes	Yes	Yes
Research Quantity	No	No	Yes	Yes
Research Quality	No	No	No	Yes

Note: Based on parameter estimates of Table 2.

Table 4. Faculty Earnings Profiles—Topel's Two-step Method

	(i)	(ii)	(iii)	(iv)
Seniority	-.0182***	-.0198***	-.0179***	-.0164***
	(.0051)	(.0048)	(.0048)	(.0049)
Seniority^2/100	.0294**	.0264*	.0354**	.0389***
	(.0146)	(.0144)	(.0143)	(.0147)
Experience	.0368***	.0377***	.0309***	.0287***
	(.0052)	(.0049)	(.0049)	(.0050)
Experience^2/100	-.0580***	-.0565***	-.0598***	-.0633***
	(.0144)	(.0142)	(.0140)	(.0145)
Female	-.0728*	-.0464	-.0270	-.0217
	(.0382)	(.0307)	(.0279)	(.0273)
Chair		.0917***	.0823***	.0764***
		(.0116)	(.0106)	(.0105)
Years Chair		.0118***	.0141***	.0139***
		(.0028)	(.0026)	(.0026)
Ph.D. Advisees		.0121***	.0052***	.0042***
		(.0017)	(.0016)	(.0016)
Journal Articles			.0161***	.0107***
			(.0008)	(.0011)
Books			.0269**	.0419***
			(.0132)	(.0140)
Pages, Level-I Journals/10				.0205***
				(.0045)
Pages, Level-II Journals/10				.0099***
				(.0037)
Citations/10				.0147***
				(.0026)
Citations^2/1000				-.0029***
				(.0006)

Notes: Parameter estimates are based on the two-step estimator of Topel (1991), augmented with an individual random effect in the second step. Sample sizes are 1,718 in the first step and 1,897 in the second step. Standard errors are reported in parentheses and are adjusted for sampling error in first-step estimates using the method of Murphy and Topel (1985). Regressions also include indicator variables for university and year of observation.

*Statistically significant at the .10 level; **at the .05 level; ***at the .01 level.

Table 5. Estimated Penalty to Seniority by Years of Seniority, Two-step Estimates (as percent of pay)

Years of Seniority	Specification (i)	(ii)	(iii)	(iv)
5	8.0	8.8	7.7	7.0
10	14.1	15.7	13.4	11.7
15	18.7	21.1	17.2	14.6
20	21.8	25.2	19.4	15.7
Controls:				
Chair, Ph.D.s	No	Yes	Yes	Yes
Research Quantity	No	No	Yes	Yes
Research Quality	No	No	No	Yes

Note: Based on parameter estimates of Table 4.

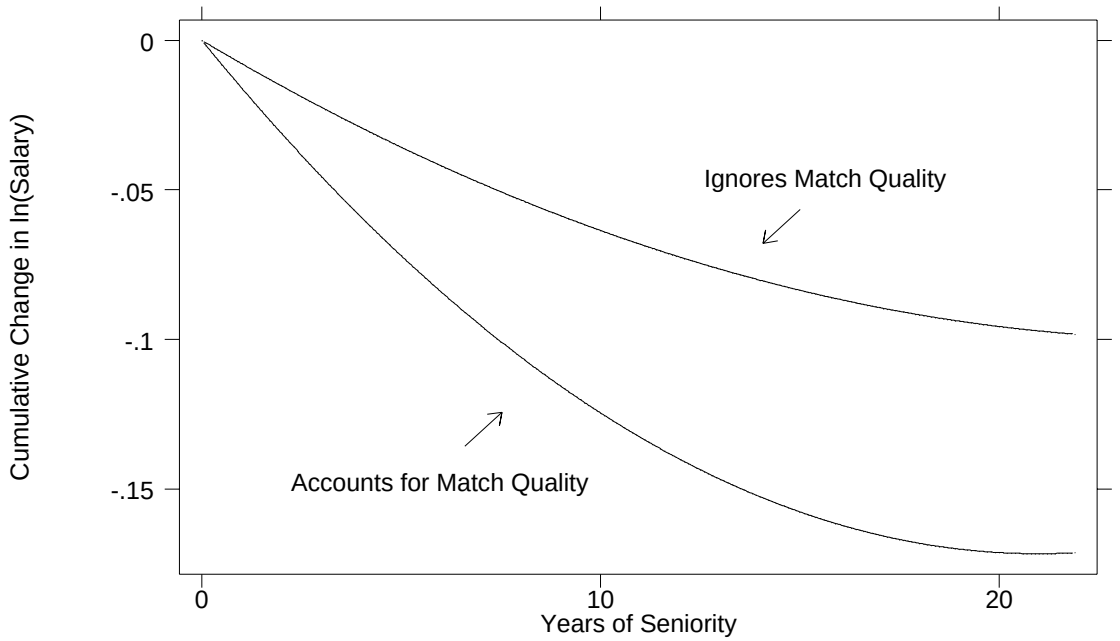

Figure 1: Predicted Wage Paths

Note: Based on parameter estimates of Table 2, column iv (Ignores Match Quality) and Table 4, column iv (Accounts for Match Quality).