Review of Applied Economics, Vol. 2, No. 1, (2006) : 99-109

RESEARCH FUNDING, EXPERIENCE AND SENIORITY IN ACADEMIA

Paul A. Nelson and Terry Monson*

Research funding as a measure of faculty productivity has not been incorporated into previous studies of academic salary profiles. Here, we examine the effects of research funding, as well as publications, at a mid-sized, non-unionized, science and engineering-focused, American public university. Our conclusions are that research funding is more significant than publications in explaining salary differences for engineering and hard science faculty members; in contrast, only publications contribute to salary differences for faculty members in other disciplines. In addition, returns to seniority are generally nil or negative, which corroborate most other studies of this nature. Higher graduate and lower undergraduate student credit hour generation are associated with increased salaries in disciplines (in this case, engineering and the hard sciences) that have been expanding their graduate programs, but have no impact upon salaries in other disciplines.

***JEL Classifications:** J24, J41, J44*

***Keywords:** Human capital, specific human capital, professional labor markets*

INTRODUCTION

We examine the effects of experience, seniority, research productivity and teaching emphases at Michigan Technological University (MTU), an engineering and science-focused American public university with enrollment of about 6,000 students of whom two-thirds are engineering majors. There are several differences between our efforts and other studies of this nature. First, we examine a university with a different institutional focus. Second, in addition to faculty publications, we introduce funded research as a productivity variable. This variable is introduced because, over the past 25 years, MTU has focused on growth in funded research and doctoral programs. While publication in peer reviewed journals is required in all academic units for promotion to the associate professor level, there is a common perception that promotion to the full professor level in the College of Engineering generally requires at least $1,000,000 in funded research. Third, we use student credit hour generation to capture the effects of teaching emphases (though not necessarily teaching effectiveness) on salaries. Finally, we experiment with an

* Associate Professor of Economics and Engineering Management and Professor of Economics, respectively; corresponding author: Monson at School of Business and Economics, Michigan Technological University. 1400 Townsend Drive, Houghton, MI 49931 USA, telephone 906-487-3174, fax 906-487-2944, e-mail: *tmonson@mtu.edu*.

alternative specification of the experience-seniority relationship in order to avoid problems of multicollinearity found in our data set.[1]

EXPERIENCE, SENIORITY AND FACULTY INCOME PROFILES

The human capital literature on age-income profiles dates to Mincer (1974). These age-income profiles are quadratic with incomes rising at a decreasing rate as individuals invest in human capital through formal educational programs and/or informal on-the-job learning. Besides investment in general (or marketable) human capital, other explanations of the rising age-income profile include employer-employee shared returns to firm-specific investment, job matching models, job durability, and the nature of previous experience [Becker (1993), Abraham and Farber (1987), Topel (1991), Goldsmith and Veum (2002)].

Researchers studying university faculty income-experience profiles commonly separate working lifetimes into years of experience and years of seniority because of the likelihood of each having different productivity effects [e.g., Barbezat (1989), Bratsberg, Ragan, Warren (1993), Brown and Woodbury (1995), Hallock (1995), Hoffman (1997), Lindley, Fish, Jackson (1992), McNabb and Wass (1997), Monks and Robinson (2001), Moore, Newman, Turnbull (1998), and Ransom (1993)]. Positive returns to experience that increase at a decreasing rate are expected since experience should provide human capital of a general (or marketable) nature. The studies cited above observed experience-income profiles conforming to these expectations though magnitudes of the experience effects upon incomes varied somewhat. Estimates of seniority-income profiles have not been consistent, though they usually suggest that returns to seniority, if not initially negative, eventually become negative.[2,3] Our analysis is intended to shed further light on inconsistencies observed in seniority-income relationships.

RESEARCH PRODUCTIVITY AND FACULTY INCOME PROFILES

One explanation of a negative seniority effect is that senior faculty members are less research productive (Ransom, 1993, p. 229). This possibility would tend to be corroborated if the coefficients on seniority variables become insignificant, smaller, or negative when measures of faculty research productivity are incorporated in the analysis. Moore, Newman and Turnbull (1998, p. 307) suggest that "once research productivity is accounted for, faculty pay is no longer significantly related to seniority."

Many researchers use published research output to capture research productivity. Results of experimentation with this variable have been mixed. Hallock's (1995, p. 656) results did not change when he added a publication variable while Ransom (1993, p. 229) found that the addition of a publication variable increased the penalty for seniority. Moore *et. al.* (1998) found that the addition of publication variables eliminated negative returns to seniority and all returns to experience. Monks and Robinson (2001) found positive returns to seniority and experience when they added productivity variables to their analysis though productivity variables tended to flatten income-seniority profiles for tenured faculty.

We believe that published research output may not fully capture research productivity in engineering and hard science disciplines. For many research-intensive universities, it is possible that research funding is as important, if not more important, than publication. As far as we are aware, no prior research has used funded research as a measure of research productivity. While this omission may be due to difficulties of obtaining data, it may also be due to assumptions that funded research is not an important determinant of faculty salary differences or that funded research is highly correlated with publication[4]. Here, we include funded research as a productivity variable and our results will test assumptions of its value and its relationship with published research.

ALTERNATIVE MEASURES OF SENIORITY AND EXPERIENCE

Most researchers define seniority as the number of years of longevity at one's current institution and total experience as years from receipt of one's last degree. We use this practice, but add an alternative definition of experience ('other' experience), namely years from receipt of the last degree to the year of joining the faculty at one's current institution. This approach is intended to help cope with multicollinearity problems found in data on total experience and seniority in our sample (see later discussion).[5]

Estimated coefficients using the total experience and seniority specification have different interpretations than those using the other experience and seniority specification. In the former case, the coefficient on total experience estimates the effects of 'general' human capital investment while the coefficient on seniority estimates institution-specific effects such as better job matching, the exercise of monopsony power, and the sharing (or not) of returns to 'specific' human capital investment. The sum of the total experience and seniority coefficients then estimates the 'total' effect of a year of at the institution. With the latter specification, the seniority coefficient estimates both general productivity effects and institution-specific seniority effects while the other experience coefficient estimates general productivity effects of prior experience. Assuming equal general productivity effects of experience at the institution and elsewhere, then the difference between the seniority and the 'other' experience coefficients estimates the effect of institution-specific experience (i.e., seniority).[6]

METHODOLOGY

Our sample included 289 tenure-track or tenured faculty members employed in MTU's baccalaureate degree-granting departments during the 2000-2001 academic year. All possessed earned doctorates and had no major administrative functions (e.g., deans, department heads).

We used ordinary least squares regression techniques. The dependent variable was the natural log of faculty members' 2001-2002 academic year salaries. With the exception of the funded research variable, our Independent variables were similar to those used elsewhere. They include:

- GENDER is a binary variable (=1 if female) used to test for gender discrimination.
- D_i is a vector of binary variables that identify the i^{th} MTU department. Coefficients on these variables isolate differing market conditions among academic disciplines.
- TOTEXP and TOTEXPSQ are total experience and its square, which are defined as 2001 minus the year that sample members obtained their terminal degree (and its square).[7] With Mincer-like income profiles, the expectation is that their estimated coefficients

should be positive and negative, respectively, i.e., experience adds to income at a decreasing rate.

- SEN and SENSQ are seniority and its square, which are defined as 20010 minus the year that sample members joined the MTU faculty (and its square). If seniority is important, their estimated coefficients should be similar to those for total experience (and its square).
- OTHEXP and OTHEXPSQ are experience elsewhere and its square, which are defined as total experience minus seniority (and its square). These variables measure the effects of academic experience prior to joining the MTU faculty. If important, their coefficients should have signs similar to total experience and seniority (and their squares).
- PUBS is the sum of each sample member's single and co-authored scholarly articles and papers in published proceedings during the previous five years.[8]
- $FUND is research funding is the sum (expressed in $1000s) of each sample member's external research funding acquired as a principal investigator and as a co-investigator during the previous six years.[9]
- UGRADCHS is the sum of each sample member's undergraduate credit hour generation during the previous five years. It measures teaching emphasis and not necessarily teaching effectiveness.
- GRADCHS is the sum of each sample member's graduate credit hour generation during the previous five years. Again, this measure does not necessarily capture teaching effectiveness.

We ran regressions on the entire sample (n=289), then separate regressions on the sample of faculty members in engineering and 'hard' science (consisting of biological sciences, chemistry, forestry, and physics) disciplines (n=184) and on the sample of faculty members (n=105) in 'other' disciplines (business, computer science, economics, humanities, mathematics, and social sciences) since examination of research productivity variables by each group suggested that reward structures differed between for the two samples (Chow-tests confirmed this hypothesis).[10]

Table 1 provides means of the research productivity explanatory variables for the entire sample, for the entire engineering sample, for the combined engineering-hard science sample, and for individual non-engineering department sample. Averages for sample members in engineering and the hard sciences are comparable, but quite different from the sample of 'other' faculty. The sample of engineering and hard science faculty members had higher average publications and research funding and taught roughly twice as many graduate students, but about one-third fewer undergraduates than the sample from 'other' disciplines.

RESULTS

Our analysis proceeded in two steps. In the first step, we estimated regression equations without productivity variables using the two experience-seniority specifications discussed above. Table 2 reproduces estimated coefficients on the experience-seniority variables (the upper entry is the estimated coefficient; the lower entry is the standard error).

Table 1
Mean Values of Explanatory Variables by Academic Unit

	n	*PUBS*	*$FUNDS*	*GCHRS*	*UGRCHRS*
All Engineering	124	13.8	769.4	205.5	1669.3
All Non-Engineering	165	10.3	348.5	152.5	2004.1
'Hard' Sciences	60	11.2	867.8	209.9	1485.4
Biological Sciences	12	10.5	1294.1	183.3	2023.3
Chemistry	14	6.6	247.4	258.3	2174.6
Forestry	17	16.2	1681.75	272.1	877.5
Physics	17	10.3	263.9	126.8	1145.9
Engineering and 'Hard' Sciences	184	13.0	801.5	206.9	1566.8
Other Non-Engineering	105	9.8	51.8	119.5	2300.6
Business	17	9.0	5.2	14.3	1616.1
Computer Science	11	8.6	105.5	186.1	1265.4
Economics	7	9.0	124.7	51.3	4685.9
Humanities	28	12.7	38.0	154.9	1566.0
Mathematics	27	7.4	46.3	148.9	2697.2
Social Sciences	15	10.7	66.8	104.7	3379.7

Table 2
Estimated Regression Equations without Productivity Variables

	All Disciplines		*Engineering/Hard Sciences*		*Other Disciplines*	
TOTEXP	**.015277**		**.015689**		**.019831**	
	.001679		**.003989**		**.007839**	
TOTEXPSQ	-.0000002		.0000004		-	
	.0000070		.0000076		.0002321	
					.0002288	
SEN	.004718	**019985**	.006986	**.022705**	-.00128	**.015691**
	.003300	**.002778**	.003989	**.003476**	.007706	**.004798**
SENSQ	**-.000341**	**-.000341**	**-.000375**	-	-.000155	**-.000315**
	.000081	**.0000811**	**.000098**	**.000375**	.000220	**.000152**
				.000098		
OTHEXP		**.015618**		**016139**		.013722
		.003751		**.004695**		.008477
OTHEXPSQ		-.000018		-		-.000083
		.000173		.000021		.000614
				.000204		
R2	.603	.603	.514	.514	.576	.572

Bold print indicates significant at the 99% confidence level.

Binary Academic Field Variables:[11] We have not reproduced coefficients on the academic field binary variables since most followed expected patterns, given common perceptions of academic market conditions. For the engineering-hard science disciplines, we hypothesized that Materials Engineering would have a positive coefficient since, during the past 20 years, MTU has sought to create a national reputation in this field. To do so, it has aggressively hired outstanding young faculty members and recruited established faculty members from other institutions. We had no *a priori* inclination about market conditions among the other engineering/

hard science disciplines. In fact, other than Materials Engineering, salaries in the various engineering disciplines appeared to be similar. Materials Engineering was the only engineering discipline with consistently (positive) significant coefficients. However, coefficients on the four hard science disciplines were all negative and significant, meaning that hard science faculty salaries were significantly below those in engineering disciplines.

For the 'other' disciplines, we anticipated that most coefficients would be negative in the regression on the entire sample and most would be positive in the regression on the 'other' disciplines since the average faculty salary ($52,953) in the Humanities Discipline (the control group) was the lowest at Michigan Tech. As expected, coefficients on all 'other' discipline binary variables were negative and significant with the exception of computer science and business in the regression on the entire sample while all coefficients on department binary variables, except for social sciences, were positive and significant in the regressions on the 'other' sample. The largest premiums over Humanities salaries went to business administration (about 35%) and computer science (about 25%) faculty members.

Gender: Likewise, we have not reproduced coefficients on the gender binary variable since it was never statistically significant. The lack of a consistent pattern in its estimated coefficients (negative in some cases and positive.

Experience and Seniority Effects With No Productivity Variables: Table 2 gives seniority and experience coefficients when productivity variables are excluded. When the TOTEXP-SEN specification is used, the total experience coefficient is significant in all regressions (though experience squared is not), while the seniority coefficients are not (though seniority squared coefficients are significant with the expected sign for the entire sample and for the engineering-hard science sample). A similar pattern more or less emerges when the SEN-OTHEXP specification is used. There are significant coefficients (with expected signs) on seniority and seniority squared in all samples, while the other experience coefficient is significant in the entire sample and the engineering-hard science sample.

Without productivity variables, experience generates positive returns for the entire sample, regardless of discipline. With the alternative specification, the coefficients on other experience have magnitudes similar to those for total experience in the other specification and the differences between coefficients on seniority and other experience are positive, though small (one percent or less), suggesting modest returns to MTU seniority.

Experience and Seniority Effects With Productivity Variables: In the second step, we added productivity variables to determine the extent by which productivity differences accentuated or diminished the experience-seniority effects observed above. Table 3 provides estimated coefficients for the three groups of the entire sample.

When productivity variables were introduced, the magnitudes of coefficients on total experience, seniority and other experience fell in most categories of regressions. In general, there were better fits (more significant coefficients) using the seniority-other experience specification. Recall that the difference between the coefficients on seniority and other experience estimates the effects of MTU-specific seniority. These differences became negative for the entire sample, suggesting very low returns to seniority across all disciplines at MTU.

Table 3
Estimated Regression Equations with Productivity Variables

	All Disciplines		*Engs/Scientists*		*Other Disciplines*	
TOTEXP	**.01414**		**.01419**		**.015657**	
	.00136		**.00148**		**.007956**	
TOTEXPSQ	.000001		**.0000012**		-.0001291	
	.000006		**.0000056**		.0002294	
SEN	.000295	**.01448**	.002457	**.016728**	-.001220	**.01261**
	.002966	**.00261**	.003323	**.003007**	.008281	**.005724**
SENSQ	-.000015	**-.00015**	-.000173	**-.000173**	-.0001081	-.000185
	.00007	**.000072**	.000079	**.000079**	.0002305	.0001756
OTHEXP		**.015185**		**.014244**		.014644
		.00301		**.003483**		.00848
OTHEXPSQ		-.00005		-.0000001		-.000237
		.000139		.0001519		.000608
PUBS	**.002506**	**.002497**	**.001722**	**.0017147**	**.004107**	**.004301**
	.0007235	**.00073**	**.000821**	**.0008217**	**.001682**	**.001660**
$FUNDS	**.06214**	**.06230**	**.06105**	.06105	-.01326	-.00927
(per $1 million)	**.000007**	**.00071**	**.00710**	**.00711**	.08764	.08752
GRCHRS/1000	**.01173**	**.011653**	**.13894**	.13894	.08396	.08897
	.00428	**.004282**	**.04962**	**.04982**	.09046	.09063
UGCHRS/1000	**-.001456**	**-.00145**	**-.02261**	**-.02264**	-.00293	-.00325
	.000582	**.000582**	**.00799**	**.00802**	.00884	.00890
Adjusted R^2	.744	.744	.736	.736	.590	.589

Bold print indicates significant at the 99% or higher confidence level.

There were better fits for the engineering-hard science sample than for the sample from other disciplines. Using the seniority-other experience specification, the difference between seniority and other experience fell to about 0.25% for all engineers and hard scientists. For other disciplines, introduction of productivity variables reduced coefficients on experience and seniority to -0.20%.

Given these results, we conclude that seniority *per se* has very modest positive impact and most likely a negative impact upon MTU faculty salaries. This finding is broadly consistent with many studies of this nature.[12]

Research Productivity: Research funding was the major research productivity component in the engineering/hard science sample's reward structure. The trade-off is about three to four publications per one hundred thousand dollars of funded research for the entire sample of engineers and hard scientists. On the other hand, research funding did not contribute significantly to salary differences in other disciplines. Only published research mattered with each publication having roughly a 150% larger salary impact than a publication for the engineering/hard science sample [compare the coefficients on publications for other faculty (.041 or .043) to those for engineers/ hard scientists (.017)].

The importance of funded research in the reward structures for engineering and the hard sciences should be considered by other researchers investigating faculty salary structures at research-intensive universities. For our sample, excluding research funding in regressions on the engineering/hard science sample resulted in a significant drop in explanatory power – R^2s fell from the 73.6% reported in Table 3 to 61.8%.[13] Further, research funding was only weakly associated with publication in our engineering-hard science sample (partial correlation coefficient of 0.21).[14] The assumption that publications are the sole measure of research productivity is likely to lead to biases in the estimation of experience and seniority effects when samples contain significant numbers of faculty in these disciplines.

Teaching Emphases: Coefficients on UGCHRS and GRCHRS suggest that higher graduate credit hour generation and lower undergraduate credit generation were associated with higher salaries for engineering and hard science faculty members but neither had any effect on 'other' faculty salaries. These results are not surprising since MTU is a primarily undergraduate institution that is trying to expand its graduate programs in engineering and hard science disciplines.[15] Engineering and hard science faculty members who are primarily involved in undergraduate instruction may be penalized at the expense of those who involved in increasing graduate enrollment. Another interpretation is that teaching graduate courses may be a reward for research-active engineering and hard science faculty members.[16] Partial correlation coefficients of 0.337 between graduate credit hour generation and research funding and 0.352 between publications and graduate credit hour generation suggest that this latter interpretation may be valid for this sample. However, for 'other' faculty, graduate credit hour generation is not related to publications (a partial correlation coefficient of -.007) though it has a week positive relationship with research funding (a partial correlation coefficient of 0.238).

CONCLUSIONS

Our analysis of faculty salaries at Michigan Technological University found that experience produced higher salaries via accumulation of 'general' human capital rather than institution-specific human capital *per se*. Further, the impact of experience was generally smaller than observed in many other studies Our seniority estimates are somewhat higher (or less negative) than in other studies, ranging roughly from -0.20% to +0.25% per year of seniority.

Probably the most important lesson to be drawn from this study is that other analyses should consider research funding as a predictor of salary differences when their samples contain significant numbers of engineering and hard science faculty members. Previous analyses of research-intensive universities that exclude funded research as an explanatory variable may understate research productivity effects and may impart an upward bias to estimates of experience and seniority effects for these samples. On the other hand, analyses of specific non-engineering and non-hard science disciplines, such as Bratsberg *et. al.* (2003) and Lindley *et. al.* (1992) can correctly focus upon publications as the only measure of research productivity.

NOTES

1. We thank an anonymous referee for pointing out this problem.
2. Table 1 of Bratsberg, Ragan, Warren (2003) presents an excellent summary of previous studies.
3. For example, Barbezat (1989), Brown and Woodbury (1995), Hoffman (1997), and Ransom (1993) found negative coefficients on seniority and positive coefficients on seniority squared. Ransom (1993, p. 229) concluded that "durable employment relationships at universities are associated with low salaries!" which he finds "astonishing in the face of the current economic theories of the seniority-

pay relationship." In contrast, others [e.g., Hallock (1995), McNabb and Wass (1997), Monks and Robinson (2001), Moore et. al. (1998)] observed seniority-income profiles with positive coefficients on seniority and negative coefficients on seniority squared in analyses for various universities. In each case, returns to seniority eventually become negative, in some cases rather quickly [e.g., Hallock's estimates (1995) yield positive returns to seniority during the first 15 years of tenure; thereafter, further seniority caused estimated incomes to fall.

4. It may also reflect economists' perceptions of research productivity. In the social sciences, publications are the usual measure of productivity. That perception may not apply to engineering and hard sciences.
5. Multicollinearity issues may arise if data include many sample members with little or no prior experience. That was the case for our sample (the partial correlation coefficient between seniority and total experience was.0.852 even though 62 percent of the faculty had prior experience at another institution).
6. See the appendix for a derivation of this result.
7. For faculty members who had not yet completed their PhDs when they joined the MTU faculty, total experience was defined as 2000 minus the year of joining the MTU faculty. Experience at other institutions prior to receipt of the PhD was discounted for these faculty members, which means that total experience equaled seniority.
8. Total scholarly output over sample members' working lifetimes is a better measure of the impact of research productivity. Unfortunately, these data were not available. Hence, we are implicitly assuming that the previous five years' scholarly output describes patterns over sample members' lifetimes. We follow the practice of others [e.g., Hoffman (1976, 1997)] who simply count numbers of publications since we are not aware of any simple method to account for quality differences in scholarly outlets among the academic disciplines represented in the sample. In general, regressions using the combined scholarly output variable (PUBS) provided better results, i.e., more significant coefficients, than regressions using the separately categorized variables (e.g., journal articles and proceedings).
9. We also did not have information on total research funding over sample members' working lifetimes, which would better this aspect of research productivity. In separate regressions, we also found that pro-rating of co-investigator funding had no measurable impact upon results.
10. We also repeated this analysis for samples that included only faculty members with prior experience (124 were engineers and hard scientists and 56 in 'other' disciplines).
11. The Mechanical Engineering Department was the control group for regressions on the entire sample and on the sample of engineering and hard science faculty members since it had the largest number (38) of faculty members in these samples. The Humanities Department was used as the control group in the regressions on 'other' disciplines it had the largest number of faculty members (28) in that sample.
12. Our results may understate the 'true' penalties for seniority. Bratsberg, Ragan and Warren (2003, p. 320) argue that analyses similar to that used in this paper impart an upward bias to estimates of returns to seniority. Using a Topel-like two-step estimator, they estimate penalties to seniority of 11.7 percent of salary after ten years and 15.7 percent of salary after 20 years.
13. This omission also increased the magnitude of coefficients on the experience and seniority variables by roughly one-third.
14. For other disciplines, the partial correlation coefficient was negative (-.066)
15. The specialized nature of Michigan Tech and its emphasis upon expanding graduate education in engineering and hard sciences make it unlikely that our results can be generalized to other universities.

16. A reviewer has suggested that graduate teaching and research productivity may have a more general transferable impact on salaries than undergraduate teaching and research productivity.

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APPENDIX
DERIVATION OF INSTITUTION- SPECIFIC EXPERIENCE

This appendix describes the alternative approach used in this paper to identify institution-specific or "specific" experience from prior experience and total experience measures. Let equation (1) give the general form of the regression equation with the total experience-seniority specification (TOTEXP-SEN). Recall that these measures give a faculty member's total years of experience since receipt of his/her PhD and his/her total years of experience at the current institution. Let equation (2) give the general form of the regression equation with the other experience-seniority specification (OTHEREXP-SEN). Recall that OTHEXP measures a faculty member's total years of experience elsewhere. Both equations ignore squared experience and seniority terms and other explanatory variables such as departmental dummies and proxies for research and teaching productivity ($j_1 Z_i$ where Z is a vector of these variables and j_1 is a vector of their coefficients).

$$\ln y = \alpha_1 + \beta_1 \text{ SEN} + \gamma_1 \text{ TOTALEXP} + \varepsilon \qquad (1)$$

$$\ln y = \alpha_2 + \beta_2 \text{ SEN} + \gamma_2 \text{ OTHEREXP} + \varepsilon \qquad (2)$$

Now, substitute SEN plus OTHEREXP for TOTALEXP in Equation (1) to obtain (1)'.

$$\ln y = \alpha_1 + \beta_1 \text{ SEN} + \gamma_1 (\text{OTHEREXP} + \text{SEN}) \text{ or } \alpha_1 + (\beta_1 + \gamma_1) \text{ SEN} + \gamma_1 \text{ OTHEREXP} \qquad (1)'$$

Comparison of equations (1)' and (2) suggests that γ_1 should equal γ_2 and $\beta_1 + \gamma_1$ should equal β_2. The coefficient on SEN (β_1) in equation (1) captures the effects of another year of MTU seniority with total experience held constant. The coefficients on TOTALEXP and SEN must be added ($\beta_1 + \gamma_1$) to capture the 'total' effect of another year of seniority since one year of seniority adds to both TOTALEXP and SEN simultaneously. In equation (2), β_2 (the coefficient on SEN) captures this 'total' effect and $\beta_2 - \gamma_2$ identifies the effects of a year of seniority with total experience held constant.