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Abstract

Using the NLSY79, this paper examines the pattern of on-the-job training over the career - a prominent topic in the early human capital literature, but the subject of little empirical investigation. In addition to containing a comprehensive record of formal training, employment experience, and employers, the NLSY79 has data on informal training and positions within firms for some years, allowing one to analyze the relationship of training not just to experience, but to job mobility between and within firms. Training declines slightly in the early career, but it is difficult to disentangle the influence of experience and age. Both formal and informal training decline steeply with position tenure and show relatively weak results for employer tenure and experience once position tenure is accounted for.

I. Introduction

The human capital model has been a cornerstone of labor economics since it was introduced by Becker and Mincer over fifty years ago (Becker (1962), Becker (1964), Mincer (1962)). The most immediate and perhaps most fundamental application of the model involves treating schooling and on-the-job training as investments in human capital. Viewing these investments over an individual's life cycle, one obtains the now-familiar explanation of the generally observed pattern of lifetime earnings, as described by Ben-Porath (1967): "People make most of their investments in themselves when they are young, and to a large extent by foregoing current earnings. Observed earnings are therefore relatively low at early years, and they rise as investment declines and as returns on past investments are realized. The main reason why investment is undertaken mostly by the young is that they have a larger period over which they can receive returns on their investment." Another part of the story is the cost of human capital investment. As an individual's wage increases, the opportunity cost of further investment in human capital rises. In his seminal paper, Ben-Porath develops a formal model that combines these two considerations. Heckman (1976) tests the model with census income data and finds that the point estimates, although estimated imprecisely, make economic sense.

There is a voluminous empirical literature exploring the volume and profitability of educational investments, dating from the same time period as the papers mentioned in the previous paragraph. The empirical analysis of on-the-job training was limited by a lack of data but has grown in the last few decades as new data sources have become available. While there is

now a reasonably extensive empirical literature on the returns to and incidence of training,¹ there are strikingly few papers that examine the life-cycle pattern of training in spite of its prominence in the earlier theoretical literature.

Several papers on the timing of training pre-date the availability of training data. The earlier literature relies heavily on indirect measures of training that are dependent on an assumed wage-generating mechanism. Mincer (1962) obtains an estimate of on-the-job training by comparing the average wage streams of high school and college graduates and assuming that the rate of return to on-the-job training is the same as the rate of return to schooling. Mincer (1991) obtains indirect estimates of training drawing on the wage profiles estimated by Rosen (1982) using the PSID. Similarly, Shaw (1984) uses estimates from a wage equation to infer the intensity of investment in occupational human capital.

The literature using direct measures of training is sparse. Duncan and Stafford (1980) use a small scale time use study (375 respondents) to estimate the amount of hours that workers of different ages spend in on-the-job training and to confirm the prediction of life-cycle models that working hours net of training increase over the early career. Mincer (1991) obtains a direct estimate of training from Duncan and Stafford's (1980) results and finds that his direct and indirect estimates are close.²

¹ Lillard and Tan (1986) examine how training incidence varies among men, women, whites, and blacks using training information in a CPS supplement, the National Longitudinal Surveys, and the Employer Opportunities Pilot Project. Lerman, McKernan, and Riegg (1999) examine the incidence and intensity of employer-provided training in the 1997 National Employer Survey, the 1995 Survey of Employer-Provided Training, and the 1995 National Household Education Survey. Also, see Frazis and Loewenstein (2007). More recently, see Almeida and Faria (2014) – especially Table A1 - for a listing of papers estimating the returns to a spell of training in a number of developed and developing countries.

² For a more detailed summary of the literature than that provided here, see Mincer (1997).

A few other papers have examined the time path of training within an employment spell. Using the NLSY79, Loewenstein and Spletzer (1997) find that formal training beyond the initial year of tenure (much of it first time training at an employer) is quite common. Waddoups (2012) uses the Australian Survey of Education and Training to estimate the time path of training with respect to age and tenure. The estimated tenure-training profiles are fairly flat training for men and declining for women. The estimated age-training profiles show the reverse pattern, declining for men and flat for women.

In this paper, we take a comprehensive look at training through the career using a data source with extensive measures of on-the-job training, the National Longitudinal Survey of Youth (NLSY79). The NLSY79 contains extensive information on the hours that workers spend acquiring formal training as well as more limited information on hours of informal on-the-job training. It also contains variables describing workers' careers, allowing one to construct measures of actual experience and tenure at a given employer. In addition, it has information on whether individuals have experienced a position change since the last interview, enabling one to calculate position tenure. Finally, the panel aspect of the survey allows us to correct for biases in training profiles estimated from cross-sectional data.

It is of interest to determine what happens to the relationship between experience and training once one controls for employer and position tenure. One reasonable hypothesis is that most training occurs when a worker moves to a new position – either at the same employer or at a new employer – as training is required to accomplish the tasks associated with the position.³ While this implies a more discontinuous experience/training profile for individual workers than

³ This is similar to Shaw's (1984) hypothesis that human capital investment declines as an individual spends time in an occupation and then picks up when the individual moves to a new occupation.

that of the Ben-Porath model, it need not contradict the basic implication that training declines with experience. At the beginning of their careers, individuals move around quite a bit and receive a lot of training. Over time, mobility falls, which may have the consequence that workers on average need less training. One can think of different positions as corresponding to different levels of human capital. As the career progresses and human capital investment declines, promotion or mobility to a higher position at another employer becomes less frequent. (An interesting question that we do not examine here is the extent to which training in earlier positions is valuable in a new position and the extent to which training at an initial employer is useful at a similar job at a new employer.⁴)

In the analysis to follow, we use a two-part model to examine the time pattern of training over workers' careers. While our two-part model allows for distinct incidence and duration effects, our emphasis is on overall mean training. We use the estimates from the two-part model to generate expected training profiles. We estimate separate equations for formal and informal training. Furthermore, we include controls for worker heterogeneity. A unique feature of our analysis is the inclusion of a position tenure variable.

Specifically, we are concerned with the relationship between training and experience, employer tenure, and position tenure. We are interested in the following types of questions. Does training fall over individuals' working lives, as intuition might indicate and as Mincer's

⁴While Becker originally defined specific training as a human capital investment that raises a worker's productivity only at the employer providing the training, Loewenstein and Spletzer (1999) find that employers and workers believe that little on-the-job training is truly employer-specific. Altonji and Williams (2005) find that the return to employer tenure plays only "a modest role in the determination of wages" and Neal (1995) argues that "the literature on returns to seniority focuses too narrowly on firm-specific factors. Displaced workers who find new jobs in their predisplacement industries earn substantial returns to their predisplacement tenure." A focus on industry instead of the type of job workers are in may be too narrow as well. Kambourov and Manovskii (2009) find substantial return to occupational tenure. Controlling for occupational tenure, they find that industry and employer tenure both have "relatively little importance in accounting for the wage one receives."

findings suggest? To what extent might an observed relationship between training and experience and (employer or position) tenure reflect worker heterogeneity? What happens to the relationship between training and experience and worker tenure when one controls for position tenure?

To anticipate some of our results, position tenure is the key variable affecting training. Formal and informal training both fall sharply as position tenure increases. Experience has a more ambiguous role. We have consistent evidence that training declines at a relatively slow but statistically significant pace as workers acquire experience. However, it is difficult to disentangle the separate contributions of aging and labor market experience, or the extent to which the experience effect is due to declining job mobility. We find a decline in training with employer tenure, but this appears to be due to its association with position tenure. We also find evidence that formal training declines in the period before workers leave employers.

II. Data Description

We use the NLSY79 to analyze the timing of formal and informal training through most of an individual's working life. The NLSY79 is a dataset of 12,686 individuals who were aged 14 to 21 in 1979. These individuals were interviewed annually from 1979 to 1994, and every two years since then. The response rate was over 90 percent for each year until 1996, and as of 2000 was 83 percent. We use data from the 1979 through 2012 surveys.

The formal training section of the survey begins with the question, "Since [the date of the last interview], did you attend any training program or any on-the-job training designed to help people find a job, improve job skills, or learn a new job?" Individuals who answer yes to this question are then asked a series of detailed questions about each of their different training spells. In 1988 and thereafter, individuals are asked about the duration of their various training spells in

weeks and the average number of hours each week that were spent in training. For each training spell, we have calculated the number of hours spent in training as the product of the duration in weeks and the average number of hours spent in training during a week. The key training variable used in the empirical work to follow is training occurring in the past year. In calculating this variable, we do not include training occurring more than 52 weeks prior to an individual's interview.

The training questions were changed somewhat in 1988. From 1979-1986, detailed information was obtained only on training spells that lasted longer than one month.⁵ We have used the information contained in the later surveys to impute hours spent in training for training spells in the early surveys that last less than one month. Besides conditioning on the fact that a spell lasts less than one month, our imputations also condition on an individual's age, gender, race, education, and experience.⁶

The focus of our analysis is training whose explicit cost is at least partly paid for by the employer.⁷ Information on who paid for training is available only after 1987; prior to 1987, we include only company training and spells lasting less than one month. (The post 1987 data

⁵ Training questions were not asked in 1987.

⁶ In the later surveys, individuals were explicitly asked about both the weekly duration of training and the year and month that a training spell began and ended. In the early surveys, individuals were asked about the year and month that a training spell began and ended, but were not explicitly asked about the number of weeks that a training spell lasted. We used the information in the later surveys to impute the number of weeks in the early surveys - our imputation is a quadratic in months, where months is calculated as the difference between the ending and starting month. In both the early and later surveys, individuals were not asked about the number of weeks that a training spell lasted if the training spell was ongoing at the time of the interview. We used the same quadratic in months to impute for number of weeks when training is ongoing at the time of the interview.

⁷ Presumably, some of this cost can be passed on to the worker in the form of a lower wage. Eighty-five percent of the training spells in the NLSY79 are at least partially paid for by the employer. We focus on this training because it would appear to correspond most closely to the on-the-job training concept referred to by Becker and subsequent human capital theorists.

indicate that company training was generally paid for by the employer. Prior to 1987, individuals with spells less than one month were not asked about the type of training they received; the post 1987 data indicate that short spells are generally employer-paid).

In investigating the timing of training through individuals' careers, it is important to distinguish between training that took place on the current job and training that took place on other jobs. By comparing the beginning and ending dates of a training spell with the date that the individual started working at his current job, we are able to classify a training spell as occurring on the current job or on a previous job.⁸

Besides providing information on formal training, the NLSY79 has information on informal training in 1996, 1998, and 2000. After being asked about formal training, individuals who have worked at a given employer are asked the following question in the 1996 – 2000 interviews: “Besides the schooling and training programs we've just talked about, during the last 4 weeks while working at [employer name] did you receive any informal on-the-job training from your supervisor, your coworker(s) or both?” Individuals who indicate that they received informal on-the-job training from supervisors are then asked how many weeks and how many hours per week they spent with their supervisor receiving informal training. Similarly, individuals who received informal training from coworkers are asked about the number of weeks and the number of hours per week that they spent receiving informal training from co-workers.

Respondents are next asked whether during the last four weeks they received “any informal on-the-job training by making use of any self-study material or self-instructional packages, such as manuals, workbooks or computer-assisted teaching programs.” As with the

⁸ In cases where the individual holds more than one job simultaneously, we assume that training occurs on the individual's main job.

other types of informal training, individuals indicating that they used self-study material are asked about the number of weeks and the number of hours per week that they engaged in self-study.⁹ For the years 1996 – 2000, we use the responses to the informal training questions to construct estimates of the number of hours individuals spent receiving each of the three types of informal training during the four weeks prior to their interview. Adding up the hours individuals are engaged in the different kinds of informal training, we obtain a measure of the total number of hours of informal training during the four week period prior to an individual’s interview. We annualize by multiplying by 13 for comparability with the formal training data.

We are interested in determining how training evolves over the course of workers’ careers as they gain experience at an employer and in a given position at an employer and as they move among employers and positions. The longitudinal information in the NLSY79 allows us to determine both accumulated labor market experience and workers’ tenure at their current employer at the time of the interview. It also allows us to measure the tenure they eventually achieve at this employer before they move on to another employer, the survey ends, or they attrit from the survey.^{10,11}

⁹ Unlike the questions about informal training from a supervisor or coworker, the questions on self-study continue to the present.

¹⁰ The survey provides information on all jobs worked at during the time period between the last interview and the current view. A previous employer indicator allows one to link these jobs with jobs that were reported at the last interview, enabling one to construct a tenure profile from the time workers begin working for an employer until the time they move on. In a few cases, the tenure information is inconsistent, often as a result of ambiguities in the previous employer indicator. We delete these jobs from our analysis.

¹¹ The NLSY79 tenure variable is simply the difference between a worker’s ending and starting date at an employer. In our analysis, we use an adjusted tenure variable, obtained by subtracting out “job gaps” or periods during which an individual does not work at the employer.

In addition to providing information on a worker's tenure at an employer, the NLSY79 also provides information that allows us to determine a worker's tenure in a position from 1996 onward. Specifically, workers are asked whether they have "experienced a promotion, a demotion, or any other type of position change" since the last interview (or since they started working at an employer if the employer is new). Individuals responding that they experienced a position change are then asked when this occurred.¹² Using this information, we are able to calculate a worker's position tenure. Specifically, for a worker who experienced a position change, tenure in the new position is simply the length of time from the date of the position change to the interview date. And for workers who have not changed positions at their employer, position tenure is equal to position tenure at the time of the previous interview plus the change in employer tenure since the last interview.

III. Estimation Method

A relatively small proportion of the sample have any training during the reference period. Accordingly, we estimate the effects of our variables of interest on training using a two-part model¹³:

$$1) \Pr(T > 0) = F(X\beta)$$

$$\ln T = X\gamma + e \text{ if } T > 0$$

where T denotes hours of training, F is the standard normal distribution, X is a vector of covariates including a constant, β and γ are conformable vectors of coefficients, and e is a mean-zero residual. If e is homoscedastic, the expected value of training conditional on X is

¹² Individuals experiencing more than one position change are asked about their most recent position change.

¹³ There is an extensive literature on two-part models of this type in health economics. See Mullahy (1998) and Manning and Mullahy (1999) for a discussion and consideration of alternatives.

$$2) \quad E(T|X) = F(X\beta) \exp(X\gamma)E(\exp(e)).$$

We use the sample mean of $\exp(\hat{e})$, where $\hat{e}$ is the residual from the $\ln T$ regression, to estimate $E(\exp(e))$ (this is the “smearing” estimator of Duan 1983).¹⁴

Cross-sectional estimates of the effect of experience and tenure on training, such as those in Waddoups (2012), are potentially misleading. Workers with a greater attachment to the labor force and hence who acquire more experience will (other things equal) have a greater return to general human capital and would be expected to get more training. Similarly, workers in a good job match would be expected to both have greater ultimate job tenure and to acquire greater specific capital (Jovanovic 1979).

The longitudinal nature of the NLSY79 allows us to correct for heterogeneity of this sort. Accordingly, most of the specifications that we report include the variable years not employed at a given age as a measure of attachment to the labor force. In addition, final employer tenure and final tenure in the position are included as measures of match quality. We will refer to these collectively as “heterogeneity controls”. This approach is similar to that in Abraham and Farber (1987) and Loewenstein and Spletzer (1997). Further details of the construction of these variables are given below. Pure fixed-effect approaches are not practical in our current application given the non-linearity of the probit function (see Maddala, 1987, for example). In addition, the relatively small number of respondents with multiple training spells (especially within a given employer or position) means that fixed-effects are problematic for the second stage of the estimation.

¹⁴ We tested for the presence of heteroscedasticity by regressing estimated $\exp(e)$ on X in all of our estimated equations. In no case was the regression as a whole significant at the 10 percent level.

NLSY79 data are weighted to compensate for oversampling of particular groups and differential attrition. However, weighting does not necessarily yield correct answers to questions of interest. Consider the regression $y = \sum_g I_g(\alpha_g + \beta_g X + e)$, where I_g is a dummy for membership in group g , X is a vector of explanatory variables and e is a residual. The sampling rates are assumed to differ across groups. As pointed out in Solon, Haider, and Wooldridge (2015), if one runs the regression $y = \alpha + \beta X + e$ using weights to compensate for unequal sampling, the resulting estimate of β will not in general equal the population average of β_g . Accordingly, we run separate regressions for six demographic groups determined by sex and ethnicity (Black, Hispanic, Non-Hispanic White). We present averages weighted by the proportion of the (weighted) sample in each demographic group.

While the heterogeneity controls allow us to examine the tendency of training to increase or decrease with a given worker's experience and tenure, such estimates cannot be interpreted causally. Training may itself cause increased tenure and greater attachment to the labor force.¹⁵ We do not attempt to estimate a causal effect in this paper.

IV. Results

We present three main sets of estimates. In all three specifications we include a cubic in age. As we account for labor market experience in all our estimates, the age-training profile holding other variables constant reflects the impact of aging without obtaining labor market experience. In the specifications we present, we also include the number of years not employed at age 45 as a measure of labor-force (non)-attachment and heterogeneity control. (For formal

¹⁵ For a short review of the literature on training and turnover, see Frazis and Loewenstein (2007, ch. 5 and ch. 6.3)

training before 1987, we use years not employed at age 30 instead as a better guide to labor force attachment in the early career.)¹⁶ In these specifications, the age-training profile reflects the effect of aging without obtaining experience at the current age while keeping constant experience obtained over the career.

In our first set of estimates, we include a cubic in experience E . In this specification coefficients on the experience variables show how training evolves with years in the labor market, on top of the pure aging effect. For formal training, the training variable in this specification includes all employer-provided training in the last 52 weeks. Where the respondent has not worked the entire 52 weeks the training variable is normalized by dividing by the fraction of the previous 52 weeks worked.

In the second set of estimates, we add a cubic in tenure with the current employer T , and for ease of interpretation convert the experience variables to a cubic in experience at the beginning of employer tenure $E - T$. Unlike the experience specification which includes training at all employers in the previous year, the tenure specification restricts training to that received with the current employer. In the formal training specifications, if tenure is less than 1 year, the variable is normalized by dividing by tenure as a fraction of a year. For the informal training estimates, which are limited to training in the previous 4 weeks, training is normalized if tenure is less than 4 weeks. Here the tenure coefficients show the effect of accumulating a year of tenure at the current employer along with a year of experience, while the experience coefficients show how the level of training shifts with experience at previous employers.

¹⁶ Years not employed are imputed for observations where the respondent has dropped out of the sample before the relevant age. Specifically, we predict the proportion of weeks spent employed between the last interview and age 45 (30) from a tobit regression (with limits 0 and 1) on the vector of covariates using a sample with age 45 (30) observed.

In the third set, we add a cubic in tenure in the current position P and convert the employer tenure term to tenure at the beginning of the position $T - P$, so the tenure coefficients now reflect how training shifts with employer tenure previous to the current position. Formal training in this specification is training in the current position, normalized analogously to the tenure specification. (Similarly, informal training is normalized if position tenure is less than 4 weeks.) All our estimates also include controls for years of education and its square and indicators for individual calendar year.

We will refer to the specifications described above as the experience, tenure, and position tenure specifications, respectively. The three specifications correspond to different questions. The experience specification describes how training evolves as labor market experience accumulates over the career abstracting from employer or position mobility. The employer tenure specification shows how experience is intermediated by employer tenure. Employer tenure also picks up the effect of position tenure when position tenure is not available, as in our pre-1987 formal training data.

The position tenure specification describes both the direct effect of position tenure and, by comparison with the experience and tenure specifications, how the experience and tenure effects are intermediated by position mobility. As we noted above, if mobility falls over the life cycle, even a large degree of intermediation is consistent with the basic Mincer/Ben-Porath model of human capital accumulation.

For the tenure specification we add final tenure with the current employer and its square as heterogeneity controls. Where the job is continuing as of the last interview, we impute final tenure (and final position tenure) from a hazard regression whose explanatory variables are the other covariates aside from tenure and the calendar year dummies plus a cubic in the start date of

the job (these latter terms are highly significant). The hazard model assumes a log-normal distribution of completed tenures.¹⁷ For the position tenure specification we add final position tenure and its square, with incomplete spells handled analogously to our treatment of final tenure.

We exclude the military and poor-white supplementary samples as well as respondents who were enrolled in school since the previous interview.¹⁸ We only include observations whose current or most recent job since the last interview is in the private sector. We use a measure of actual labor market experience that includes time spent in the armed forces,¹⁹ although current active duty armed-forces members are excluded from the sample by restricting the sample to current private sector employment. We also exclude experience attained before the first 12-month gap in schooling.

Table 1 shows descriptive statistics. We describe results for each variable of interest in turn. Turning to formal training first, we divide the NLSY79 sample period into two parts—1979-86 and 1988-2010--corresponding to the change in the training sequence described earlier.

We focus our attention on the $E(T|X)$ function shown in (2) and its associated slope. (For reasons of space, we only briefly discuss separate incidence and duration effects toward the end of our analysis.) We calculate $E(T|X)$ averaged across demographic groups at mean values for covariates aside from the variable of interest and graph $E(T|X)$ from the 10th to the 90th percentile of the variable of interest. Standard errors are estimated by bootstrap (200 replications) and

¹⁷ Abraham and Farber (1987), in an analogous situation, used a gamma distribution, which nests the log-normal. Estimates with the gamma are close to those using the log-normal, and the estimate of the additional parameter in the gamma distribution is small and not significant. Computation of the expected value of completed spells is simpler using the log-normal.

¹⁸ For 1979, we exclude respondents enrolled in 1978 or later.

¹⁹ Our results are robust to excluding respondents with any time in the active military.

confidence intervals generated using a normal approximation. In our figures, we show the slope of the log of expected training rather than the slope of hours of training. (Note that both will have the same sign.) We do this both for comparability across dependent variables and because given the exponential factor in (2) taking the log will result in a less non-linear function for which the confidence interval is a better approximation.

Age: Formal training: While less central to the theory of human capital than labor market experience or tenure, it is important to control for aging when analyzing training over the career. Charts 1 and 2 show the age-training profile for formal training in the experience specification for the 1979-86 and 1988-2012 periods respectively. The estimated age effect for the earlier period is small. However, age has a pronounced effect on training in the later period, with training declining markedly in the early thirties from over 20 hours per year at age 30 to less than 12 hours before age 38. Part of this may have to do with the differences in measurement between the periods, with shorter spells being picked up more frequently in the later period.

In results not shown, the age-training profiles in the tenure and position tenure specifications are not substantially different from those in the experience specification.

Age: Informal training. Chart 3 shows the profile for informal training. Informal training shows a consistent but not statistically significant decline with age, with the point estimate declining from over 110 hours per year at age 34 to 85 hours by age 40. Note that sample members are already in their mid-thirties by the time informal training questions are asked in 1996. In results not shown, the age-training profile is somewhat flatter in the position tenure specification, but this appears to be at least partly caused by differences in the sample caused by the fact that position tenure is not measured for all sample members. Restricting the sample to observations with observed position tenure results in flatter age-training profiles in all

specifications. Overall it does not appear that employer and position mobility have a strong effect on the association of age and training.

Experience: Formal training. As can be seen in Chart 4, the training profile declines with experience in the pre-1987 period, from about 12 hours per year with at one year of experience to less than 7 hours after 5 years. The slope is statistically significant for low values of experience. In Chart 5, which shows the equivalent specification for the post-1987 period, the function increases for high values but the slope is not statistically significant in the range examined. Chart 6 shows that adding tenure to the specification almost completely eliminates the decline for low values of experience shown in Chart 4 for the early period, and while the point estimate indicates that training generally declines with experience the estimated slope is not significant in the tenure specification. For the post-1987 period the experience-training profile for the tenure and position tenure specifications has a similar shape to Chart 5, and is never significant (results not shown).

Experience: Informal training. As shown in Chart 7, the experience-training profile for informal training is fairly flat in the range examined, and the slope is not significant. One should keep in mind that we only observe informal training approximately 10 years into the career. In results not shown, the tenure and position-tenure specifications show similar results.

Does training decline over the career? While the results for age and experience have both shown equivocal effects on training, one should keep in mind that so far we have been considering their effects separately. The age profile shows the effect of spending a year not employed, and the experience profile shows the incremental effect of a year of employment on top of the pure aging effect. This does not give a direct answer to the question of how training evolves as a person acquires job experience. As a convenient way of considering the combined

effect of age and experience, we ran a specification where we substituted years not employed, measured as age minus experience, for age. In this specification the years-not-employed/training profile will correspond to the effect of aging without acquiring labor market experience, and the experience-training profile will reflect the effect of aging while acquiring labor market experience.

Charts 8, 9 and 10 show experience-training profiles in this “age plus experience” specification. As can be seen, the slope of training with respect to experience is significantly negative in the lower part of the range for both periods of formal training and for informal training. For the later period of formal training and for informal training, this range extends to over 10 years of experience. The rate of decline is up to .3 log points for formal training prior to 1987 and up to about .1 log points for informal and post-1987 formal training, and is relatively precisely estimated compared to the age-training or experience-training profiles considered separately above. The rate of decline of training with respect to experience is non-trivial, although not as large as we will see for tenure and, especially, position tenure. Charts 11 and 12 show experience-training profiles using the age-plus-experience parameterization in the position tenure specification. The effect of experience declines in magnitude or changes signs, but the lower part of the range is quite imprecisely estimated. We conclude that we have consistent evidence that training declines over the early career, but are not terribly successful in disentangling the separate contributions of age and experience or in determining whether the decline in training with experience is due to declining frequency of position changes over the career.

Tenure: Formal Training. In the pre-1987 period, formal training with the current employer declines steeply in the first few years of tenure, falling from over 30 hours after 3

months to about 5 hours after 2 years, as shown in Chart 13. Post-1987, the profile in Chart 14a shows formal training with the current employer declining with tenure, from about 14 hours to 9 hours after 5 years, followed by a corresponding increase for higher values. Chart 14b shows that the initial decrease is sufficiently large and precisely estimated that the decrease is statistically significant, whereas the later increase is not. In the later period, where we have position tenure data, there is no evidence that employer tenure affects training once position tenure is taken into account, as shown in Chart 15, although we might note that the tenure estimate is quite imprecise.

Interestingly, changing the dependent variable from formal training with the current employer to formal training over the last 52 weeks reduces the magnitude of the slope of the tenure-training profile and it is no longer significant in either period. We show this in Charts 16 and 17. The estimated magnitude of the decline is still substantial in the earlier period (note the scale of Chart 16b, which matches Chart 13b), but the estimate is quite imprecise.

The difference between the measures of training in Charts 13 and 14 and Charts 16 and 17 mostly consists of training at previous employers.²⁰ The contrast between the sets of charts suggests that training may decline before a job change. To confirm this we ran a specification omitting the final tenure heterogeneity control and substituting a “years before job change” variable consisting of final tenure minus current tenure, which is entered as a cubic. For both the pre- and post-1987 periods we find that training declines at a (statistically significant) rate of .1

²⁰ Actually, this not exactly right. There are cases where there is not sufficient information to associate training with a particular employer, but the amount of training in question is quite small.

log points as the time to a job change approaches zero (Chart 18 shows the post-87 period; the pre-87 period is qualitatively similar).²¹

Tenure: Informal training. The results for informal training are similar to those for post-1987 formal training. Training decreases substantially with employer tenure, from about 150 hours after 1 year to less than 75 hours after 5 years, as shown in Chart 19. However, once one accounts for position tenure the effect disappears, as shown in Chart 20. In results not shown, we also estimated a model with “years before job change” added, as above; time to job change showed little association with informal training.

Position tenure, formal training. The position-tenure/training profile shown in Chart 21 indicates that formal training declines at a fairly rapid and statistically significant rate in the initial years of position tenure, from a rate of over 15 hours per year in the first half year to about 7 hours after 4 years. (The finding of a significant decline does not change when we use all training in the last 52 weeks as a dependent variable.)

Position tenure, informal training. Chart 22 shows informal training as a function of position tenure. As can be seen, training decreases dramatically with position tenure, from 300 hours per year near the start of the position to 75 hours after 2.5 years. Note that the scale of Chart 22b is increased to accommodate the steep decline in log hours of training.

Training incidence vs. duration: Much recent literature on the effects of training has concentrated on training incidence measures while ignoring duration of training conditional on incidence, implicitly using incidence as a proxy for quantity of training.²² However, incidence

²¹ Note that the horizontal axis in Chart 18 goes backward in time, hence a positive derivative indicates a decrease in training as we approach the job change.

²² For example, see Dearden, Reed, and Van Reenen (2008), Dostie (2013), and Leuven and Oosterbeek (2009).

and duration of training do not have the same pattern with respect to career variables, and as a consequence the time path of the total quantity of training does not correspond to the time path of incidence. Charts 23 and 24 show an example of this. As shown in Chart 14, the formal-training/tenure profile is U-shaped for the post-1987 measure of training, with only the declining portion having a statistically-significant slope. This pattern more closely resembles the pattern of hours of training conditional on incidence than the training incidence profile. Incidence of formal training increases with tenure for low values of tenure before essentially leveling off.²³ Many other cases show contrasting shapes of training profiles between incidence and duration.

V. Conclusion

In this paper we use the NLSY79 to examine the pattern of on-the-job training over the career, a prominent topic in the early human capital literature but the subject of little empirical investigation. The NLSY79 has a reasonably comprehensive record of formal training, employment experience, and employers, as well as data in some years for informal training and positions within firms. We are thus able to examine the relationship of training not just to experience, but to job mobility between and within firms.

The evidence that training declines early in the career is reasonably consistent across our measures. However, it is difficult to disentangle the effect of job experience from the effect of aging. Human capital acquisition is usually described as a function of job experience rather than pure aging, though in earlier datasets without experience measures it is not possible to distinguish the two.²⁴ Age might affect training due to maturity, where one might expect

²³ It is of interest to compare our findings to those of Loewenstein and Spletzer (1997), who examined incidence but not duration. Our finding that incidence is relatively flat or increasing for low values of tenure is compatible with their analysis, but is not the whole story.

²⁴ See Lazear (1976) for an early effort to distinguish human capital acquisition through age and experience.

training to increase with an increase in the ability to absorb the material. However, while we have attempted to correct for overall attachment to the labor market by including total work experience by a given age, non-participation in the labor force at any age may signal to employers a lack of commitment even if total experience rises to a given level at future ages. This would be expected to decrease training, as we observe for formal training in the post-1987 period.

Position tenure has by far the strongest effect on training of the variables we examined. Both formal and informal training decline steeply with position tenure. This suggests that on-the-job training primarily occurs when necessary to learn the tasks associated with a new position. Interestingly, when one does not control for position tenure, both formal and informal training at the current employer fall sharply with tenure, but this effect disappears once position tenure is accounted for.

The finding that employer tenure is a strong enough proxy for position tenure to yield a substantial negative association with training when position tenure is not controlled for implies that changing employers is one method of generating the acquisition of human capital through training. Similarly, our finding that training declines before employer changes may also indicate the relevance of employer mobility in generating training opportunities. In the literature, job mobility and human capital accumulation have often been contrasted as contributors to wage growth (Rubinstein and Weiss, 2006). Our result that workers moving into new positions tend to receive a burst of training indicates that they may actually be complements.²⁵ The NLSY79 is

²⁵In a related vein, Veramendi (2011) develops a model where learning-by-doing is positively associated with job mobility within and between firms.

fairly unique in providing information on position tenure. Our discussion indicates the usefulness of this information in understanding human capital acquisition in the labor market.

One example of the usefulness of data relating position tenure to training is in examining the effect of firm size on training. The possibility of moving to a new position within the firm and in the process acquiring human capital is naturally greater at larger employers. Several researchers have found that on-the-job training is greater at larger employers.²⁶ One explanation put forward by Idson is that “a greater ability to allow employees to substitute intra-firm for inter-firm mobility” reduces turnover at larger employers, which makes them more willing to invest in worker training. A complementary explanation is that as workers move to new positions at a larger employer, they are continually acquiring more human capital. As a quick test of whether intra-firm mobility is a factor in explaining the firm-size effect, we ran our tenure and position-tenure models adding a variable for the log of establishment employment, restricting the sample to observations where position tenure is observed. Adding position tenure variables to the tenure specification reduces the effect of a 1 unit change in ln establishment size on ln hours training at the sample mean from .106 to .082 for formal training and from .106 to .081 for informal, providing support for this explanation.

It would be useful to examine the robustness of our findings across datasets in future work. As noted above, longitudinal datasets are required for this analysis in order to control for the correlation between tenure and training resulting from unobserved heterogeneity. While the heterogeneity controls made possible by a longitudinal dataset allow one to examine the tendency of training to increase or decrease with a given worker’s experience and tenure, the

²⁶ See, for example, Barron, Black, and Loewenstein (1987) , Idson (1996), and Frazis, Gittleman and Joyce (2000).

estimates cannot be interpreted causally. A possible avenue of future research would be to attempt to correct for reverse causality in the relationship between training and tenure. However, this would seem to require suitable instruments, and good candidates do not come readily to mind.

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Table 1
Descriptive Statistics. NLSY79 (weighted)

Variable	n	Mean	Std. Dev.	Min.	Max.
Hours of formal training past 12 mo. (Year<1987)	23,576	10.477	98.048	0	8,736
Any formal training past 12 months (Year<1987)	23,576	0.069	0.254	0	1
Ln(Formal training) (Tr.>0, Year<1987)	1,354	4.151	1.074	0.527	9.075
Hours of formal training (Year>1987)	69,219	13.772	131.346	0	8,736
Any formal training past 12 months (Year>1987)	69,219	0.123	0.328	0	1
Ln(Formal training) (Tr.>0, Year>1987)	7,675	3.406	1.544	-1.671	9.075
Hours of formal training with current employer (Year<1987)	20,669	15.777	140.763	0	4,656.203
Any formal training with current employer past 12 mo. (Year<1987)	20,669	0.068	0.251	0	1
Ln(Formal training current employer) (Tr.>0, Year<1987)	1,154	4.430	1.252	0.527	8.446
Hours of formal training with current employer (Year>1987)	65,116	14.024	141.767	0	8,736
Any formal training with current employer past 12 mo. (Year>1987)	65,116	0.115	0.319	0	1
Ln(Formal training current employer) (Tr.>0, Year>1987)	6,688	3.430	1.568	-0.945	9.075
Any formal training in current position past 12 mo.	27,769	0.102	0.302	0	1
Hours of formal training in current position Ln(Formal training current position) (Tr.>0)	27,769	11.031	99.443	0	4860.744
Informal training incidence	2,567	3.392	1.563	-0.733	8.489
Hours of informal training (annualized)	11,861	0.216	0.412	0	1
Ln(Informal training) (Tr.>0, annualized)	11,861	101.039	498.624	0	8736
Years employer tenure	2,440	4.969	1.512	1.872	9.075
Years final employer tenure	85,785	4.452	5.363	0.019	35.827
Years position tenure	83,339	10.049	10.357	0	43.654
Years final position tenure	27,769	3.088	3.267	0.003	23.577
Age	26,771	8.056	7.353	0.003	36.965
Years experience*	92,795	34.201	9.095	18	56.583
Year=1979	92,795	12.256	8.338	0.019	38.058
Year=1980	92,795	0.008	0.090	0	1
Year=1981	92,795	0.013	0.115	0	1
Year=1982	92,795	0.018	0.133	0	1
Year=1983	92,795	0.028	0.164	0	1
Year=1984	92,795	0.032	0.176	0	1
Year=1985	92,795	0.038	0.192	0	1
Year=1986	92,795	0.043	0.204	0	1
Year=1987	92,795	0.046	0.209	0	1
Year=1988	92,795	0.048	0.214	0	1
Year=1989	92,795	0.050	0.217	0	1
Year=1990	92,795	0.049	0.216	0	1
Year=1991	92,795	0.052	0.222	0	1

Year=1992	92,795	0.051	0.219	0	1
Year=1993	92,795	0.050	0.218	0	1
Year=1994	92,795	0.049	0.215	0	1
Year=1996	92,795	0.049	0.216	0	1
Year=1998	92,795	0.050	0.219	0	1
Year=2000	92,795	0.050	0.219	0	1
Year=2002	92,795	0.050	0.217	0	1
Year=2004	92,795	0.047	0.211	0	1
Year=2006	92,795	0.046	0.210	0	1
Year=2008	92,795	0.046	0.209	0	1
Year=2010	92,795	0.043	0.204	0	1
Year=2012	92,795	0.042	0.202	0	1
Years of education***	92,795	13.074	2.289	7	20
Hispanic	92,795	0.061	0.239	0	1
Black	92,795	0.122	0.329	0	1
Female	92,795	0.452	0.498	0	1
Years not employed at age 30**	92,748	5.643	2.726	1.019	14.917
Years not employed at age 45**	92,677	7.718	4.764	0.981	29.699

*Includes time in military

**Age - Years experience - 16

***Bottom-coded at 7 years

Chart 1a
Hours formal training vs. Age

Heterogeneity control, 1979-86, experience specification

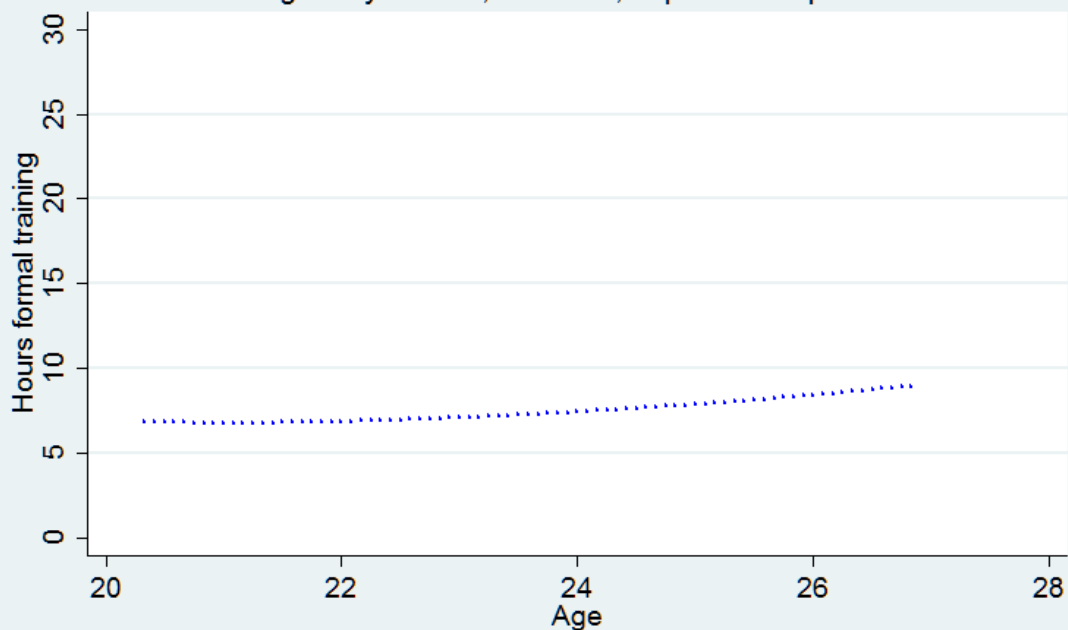
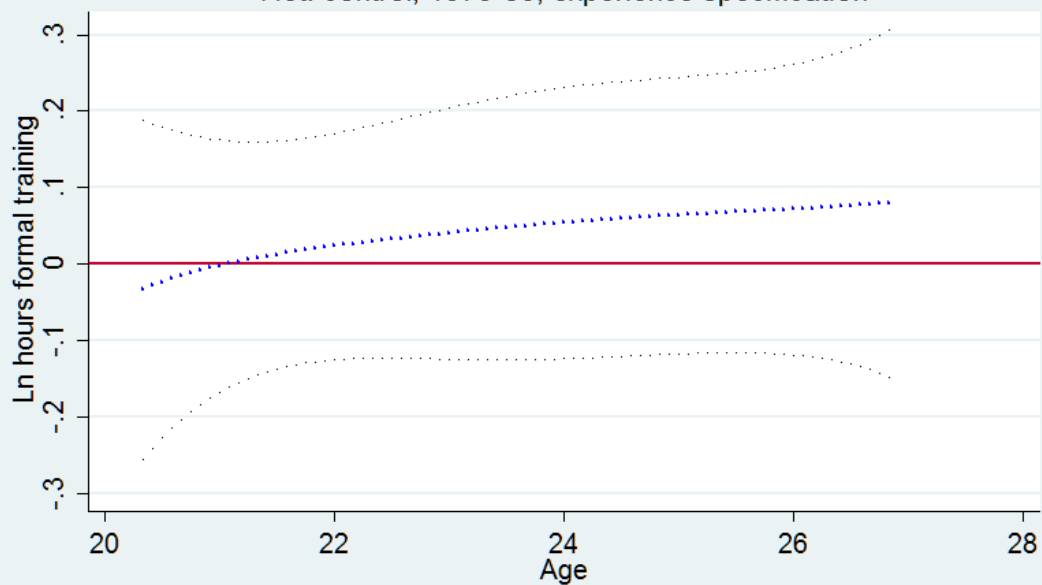


Chart 1b
dLn hours formal training/dAge

Het. control, 1979-86, experience specification



Outer lines denote 95% confidence interval

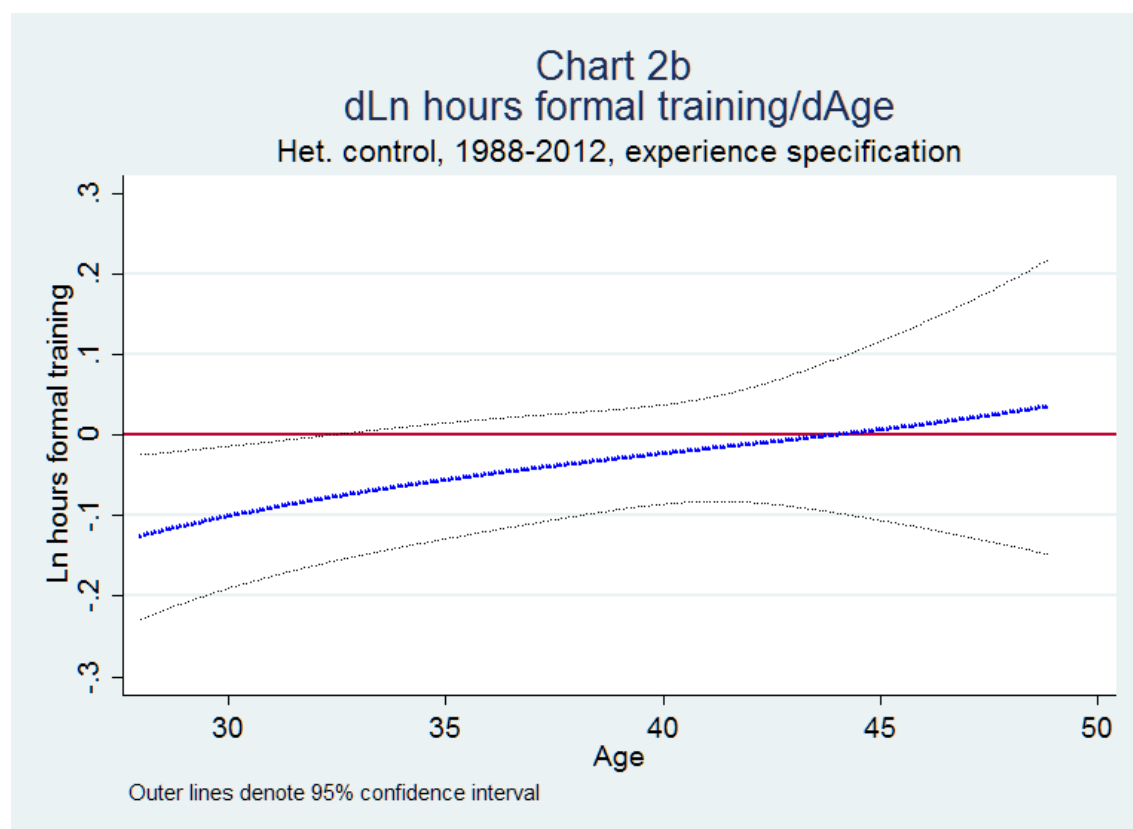
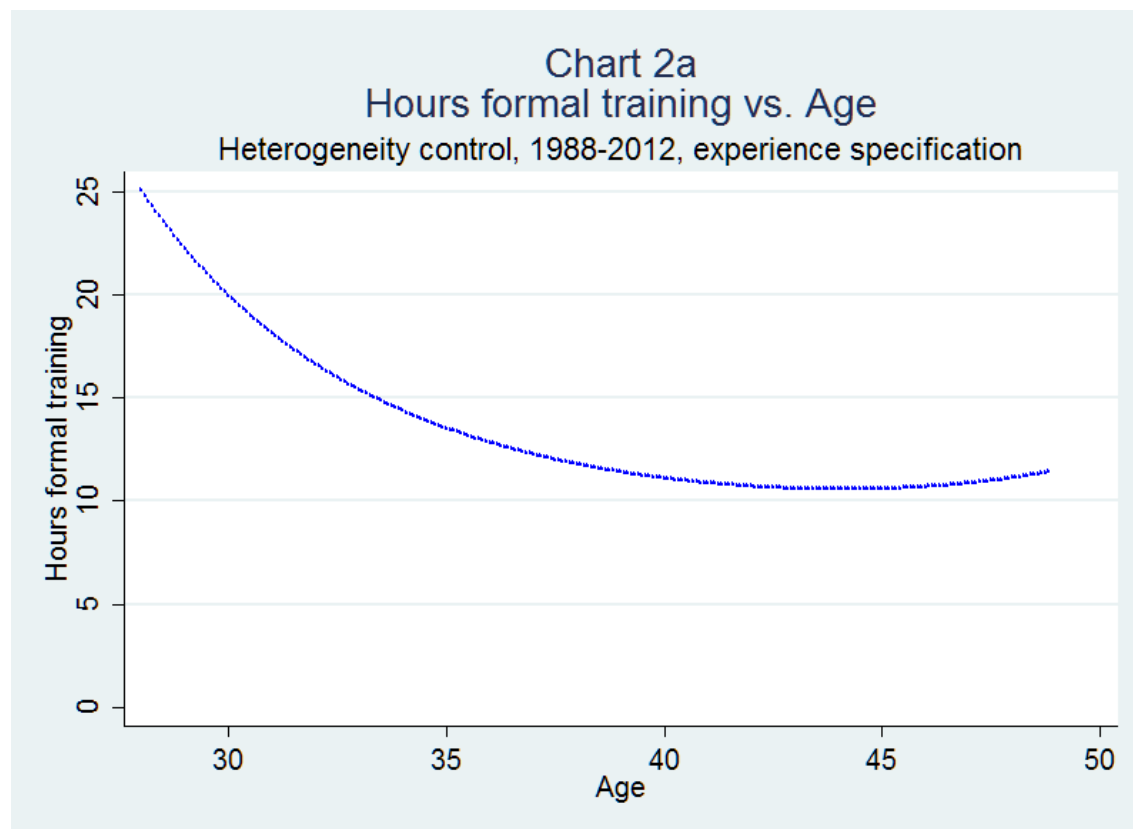


Chart 3a
Hours informal training vs. Age

Heterogeneity control, 1996-2000, experience specification

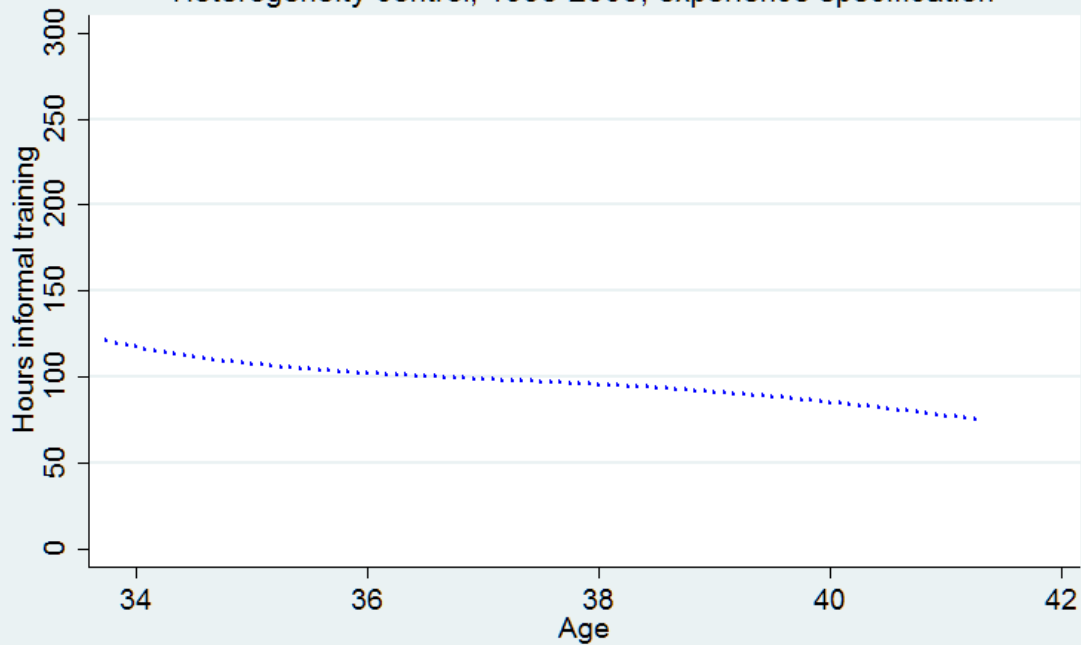
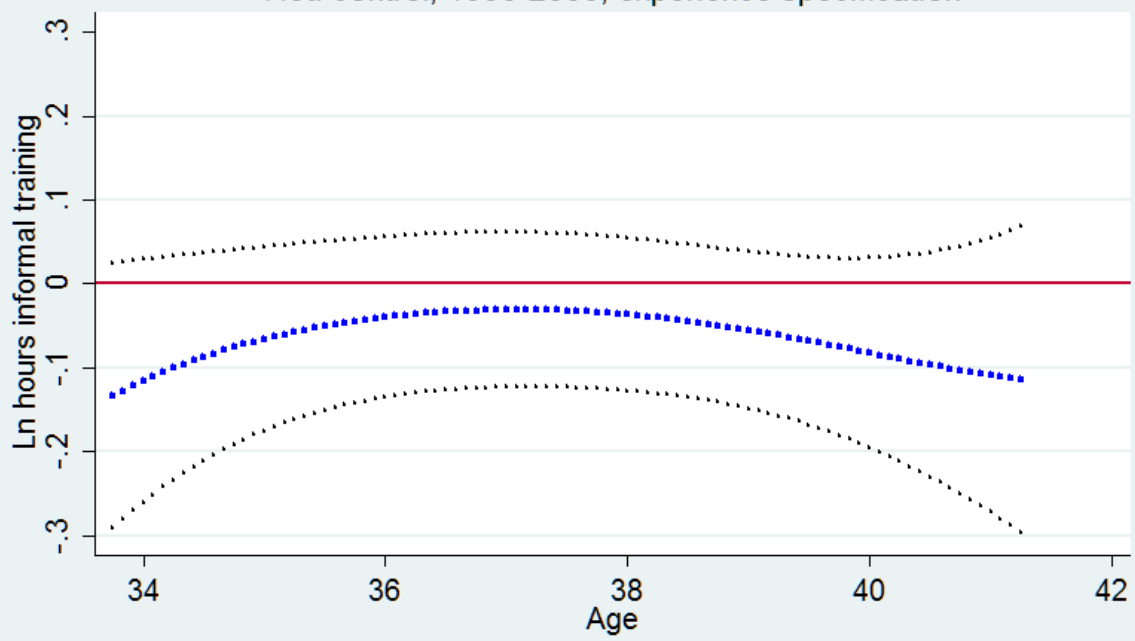


Chart 3b
 $d\ln \text{ hours informal training} / d\text{Age}$

Het. control, 1996-2000, experience specification



Outer lines denote 95% confidence interval

Chart 4a
Hours formal training vs. Years experience
Heterogeneity control, 1979-86, age specification

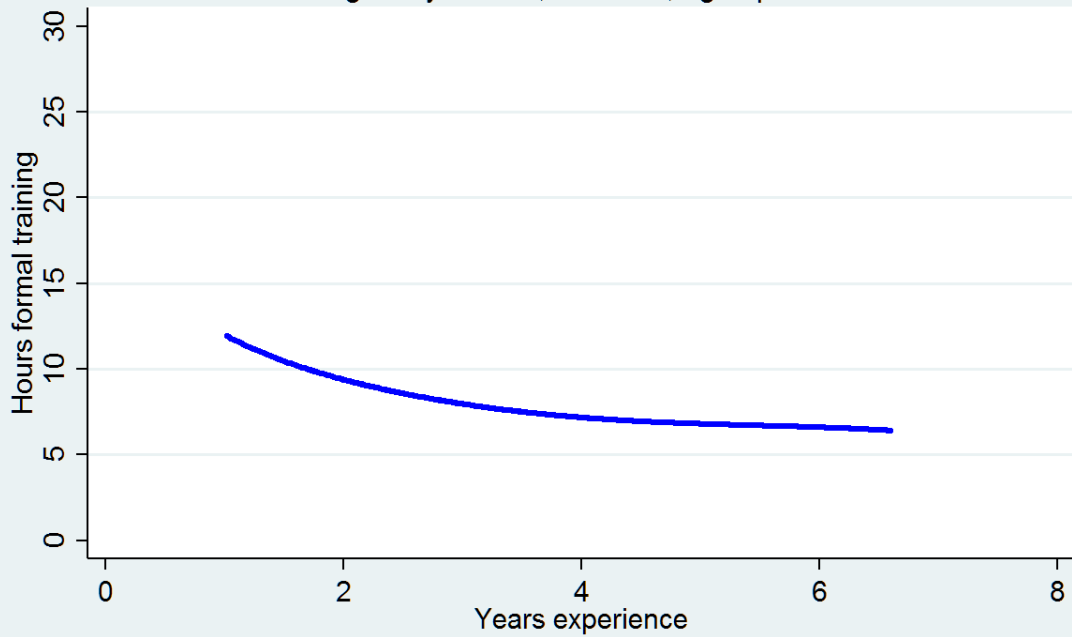


Chart 4b
dLn hours formal training/dYears experience
Het. control, 1979-86, experience specification

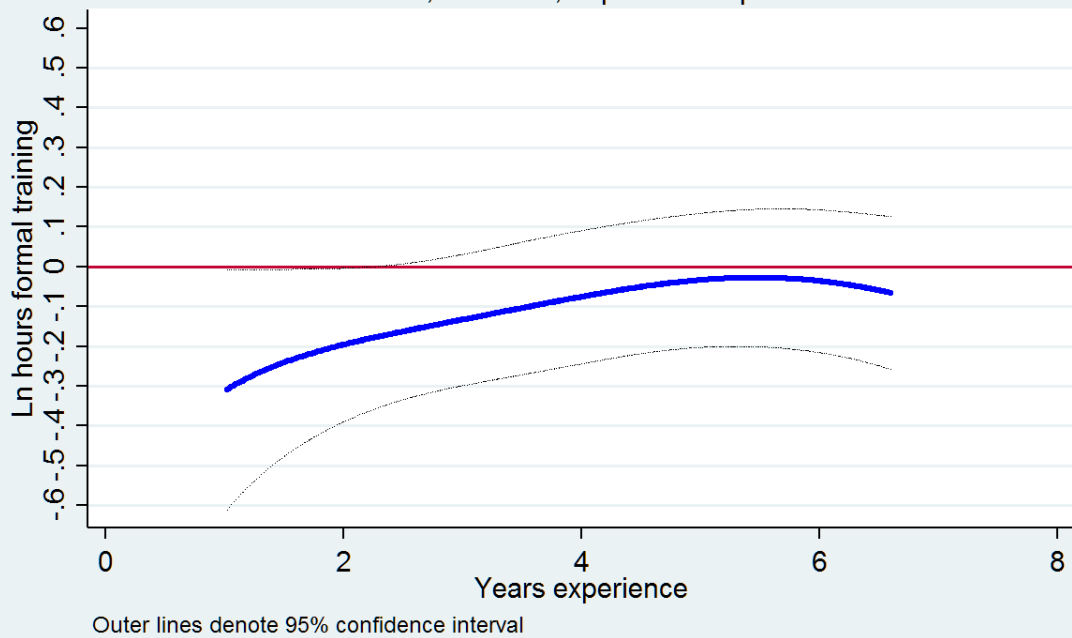


Chart 5a
Hours formal training vs. Years experience
Heterogeneity control, 1988-2012, experience specification

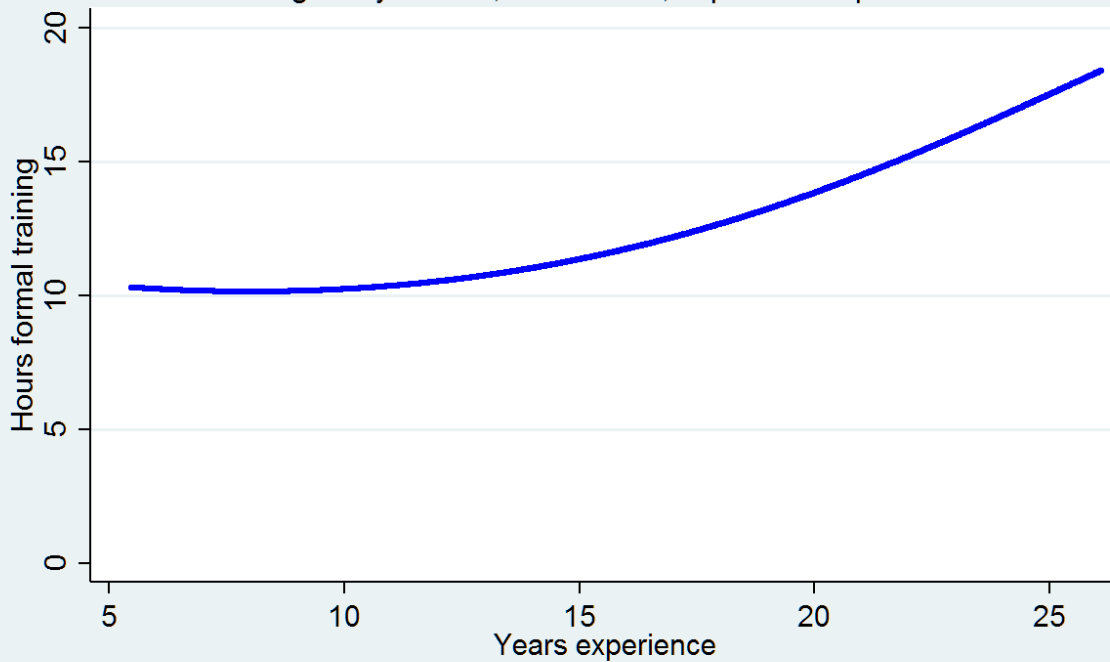
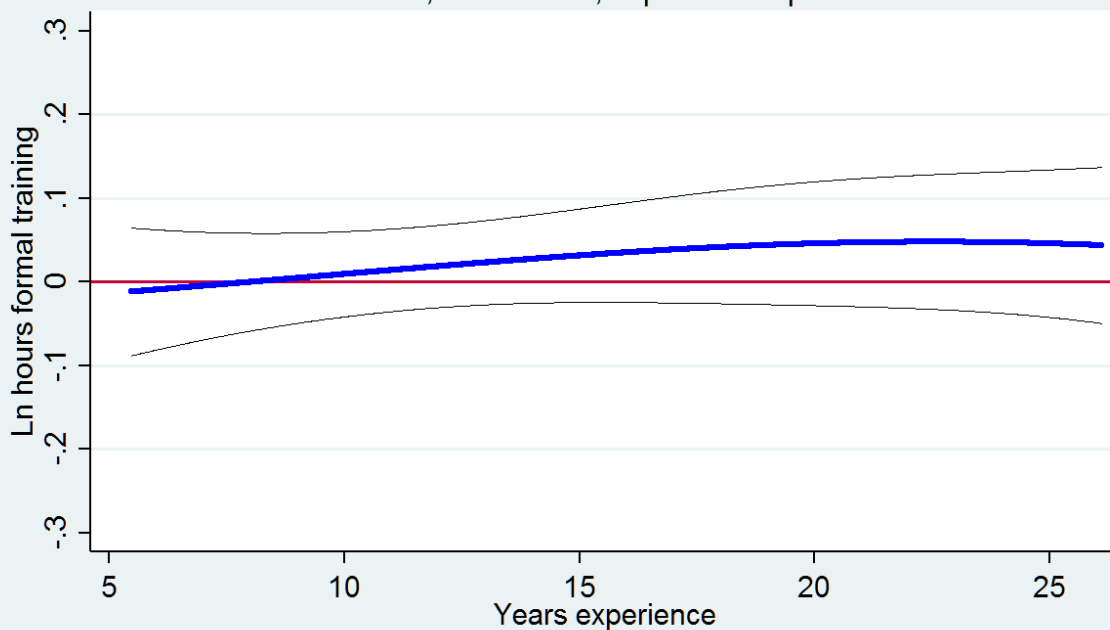


Chart 5b
 $d\ln \text{ hours formal training} / d\text{Years experience}$
Het. control, 1988-2012, experience specification



Outer lines denote 95% confidence interval

Chart 6a
Hours formal training vs. Years experience at job start
Heterogeneity control, 1979-86, tenure specification

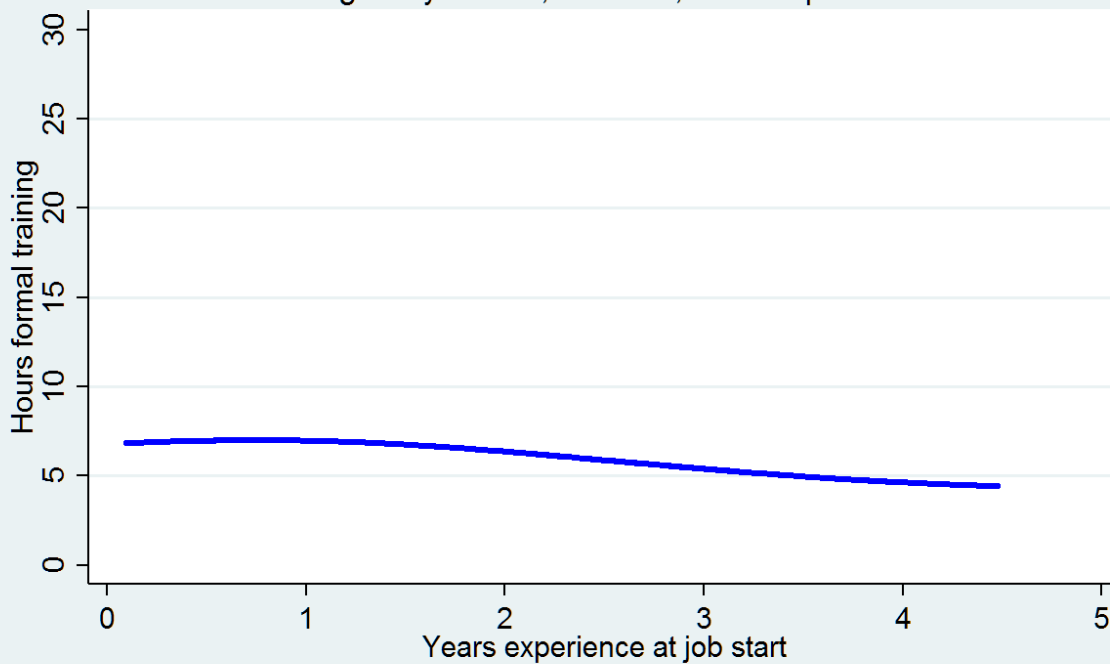
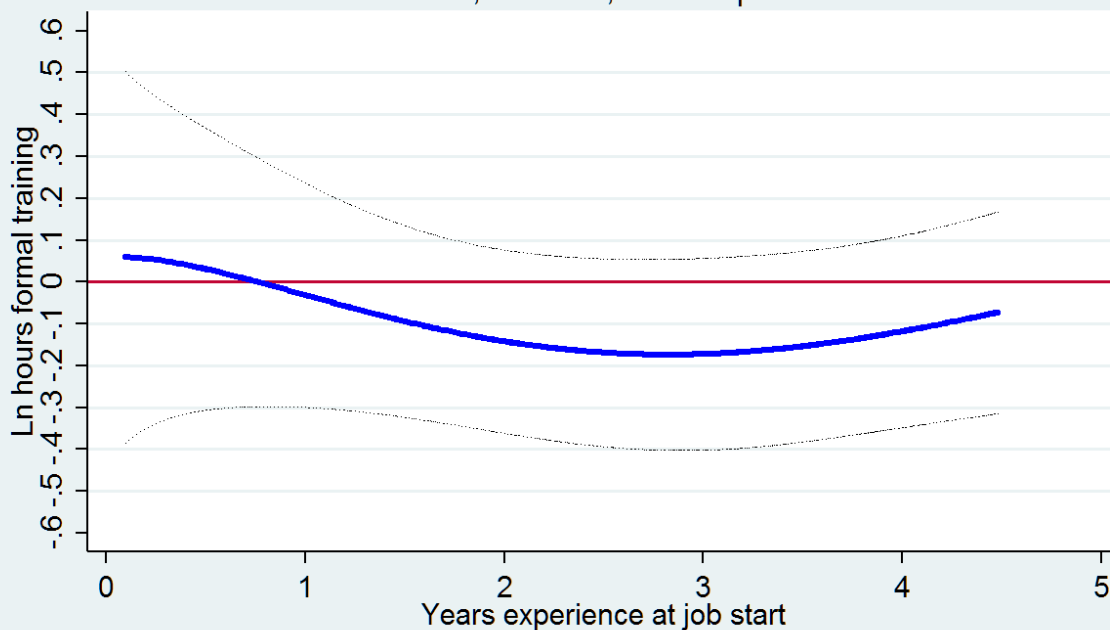


Chart 6b
 $d\ln \text{ hours formal training} / d\text{Years experience at job start}$
Het. control, 1979-86, tenure specification



Outer lines denote 95% confidence interval

Chart 7a
Hours informal training vs. Years experience
Heterogeneity control, 1996-2000, experience specification

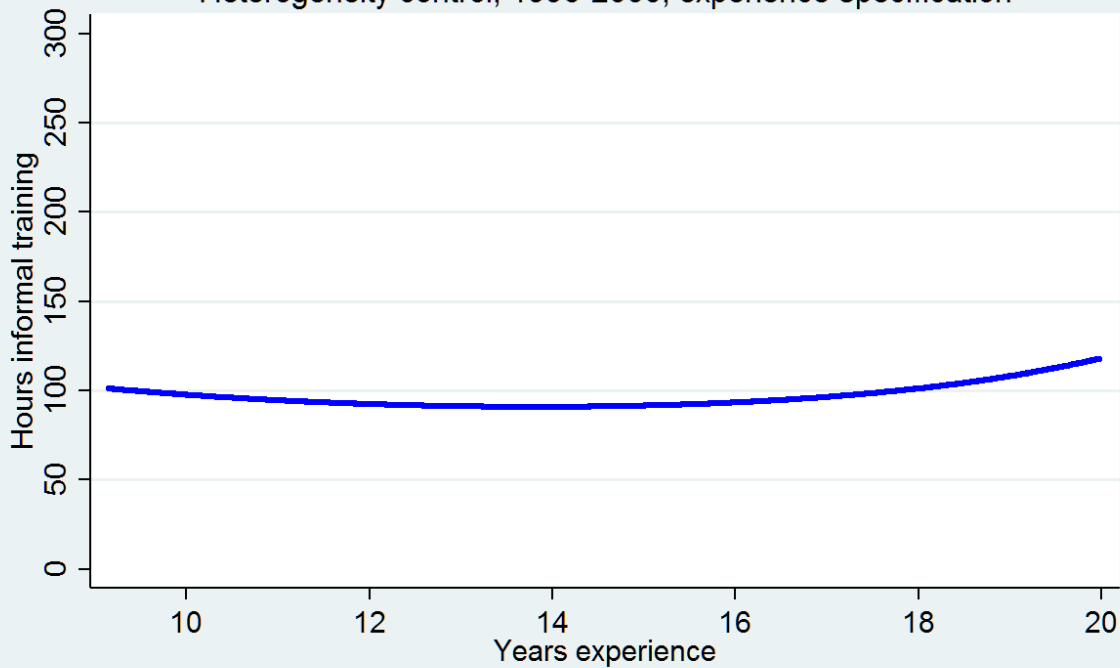
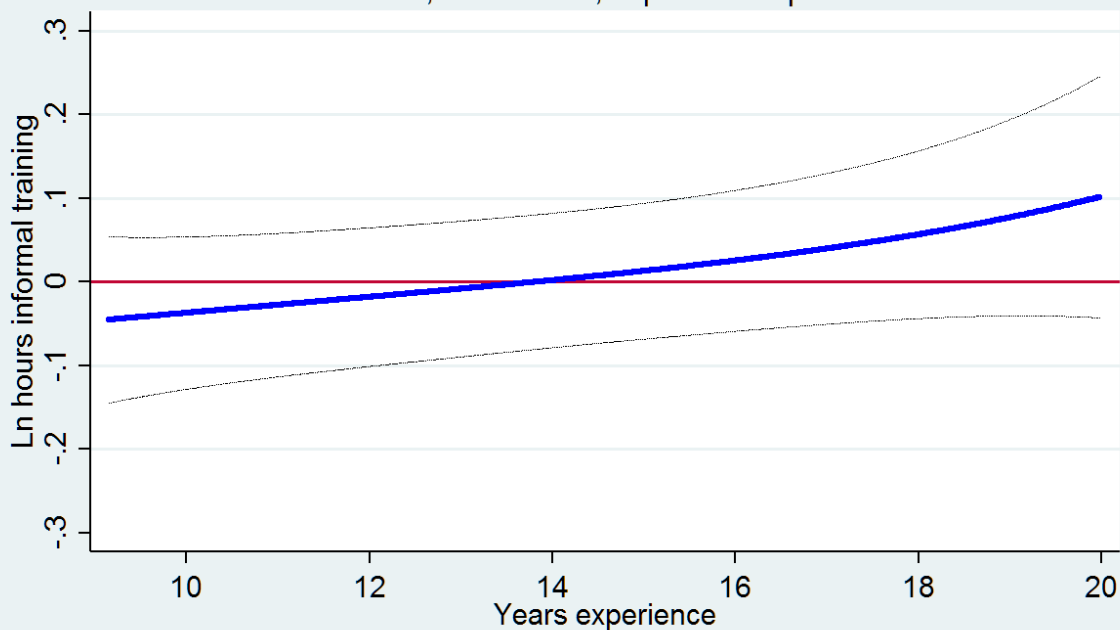


Chart 7b
dLn hours informal training/dYears experience
Het. control, 1996-2000, experience specification



Outer lines denote 95% confidence interval

Chart 8a
Hours formal training vs. Years experience
Heterogeneity control, 1979-86, age + experience specification

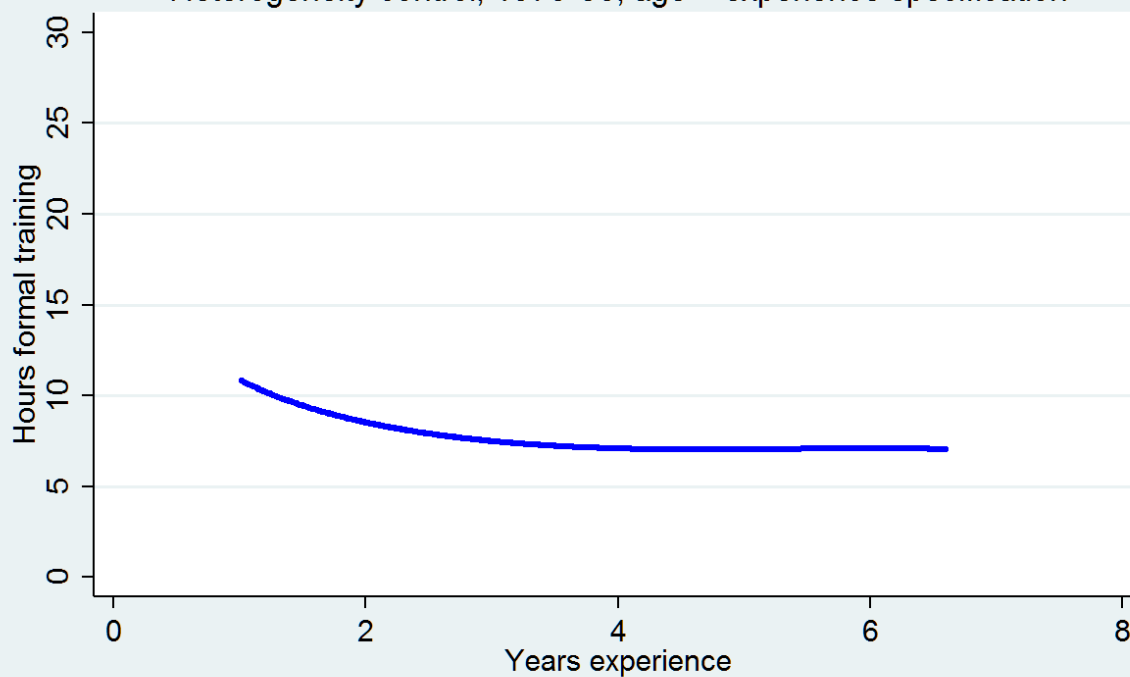
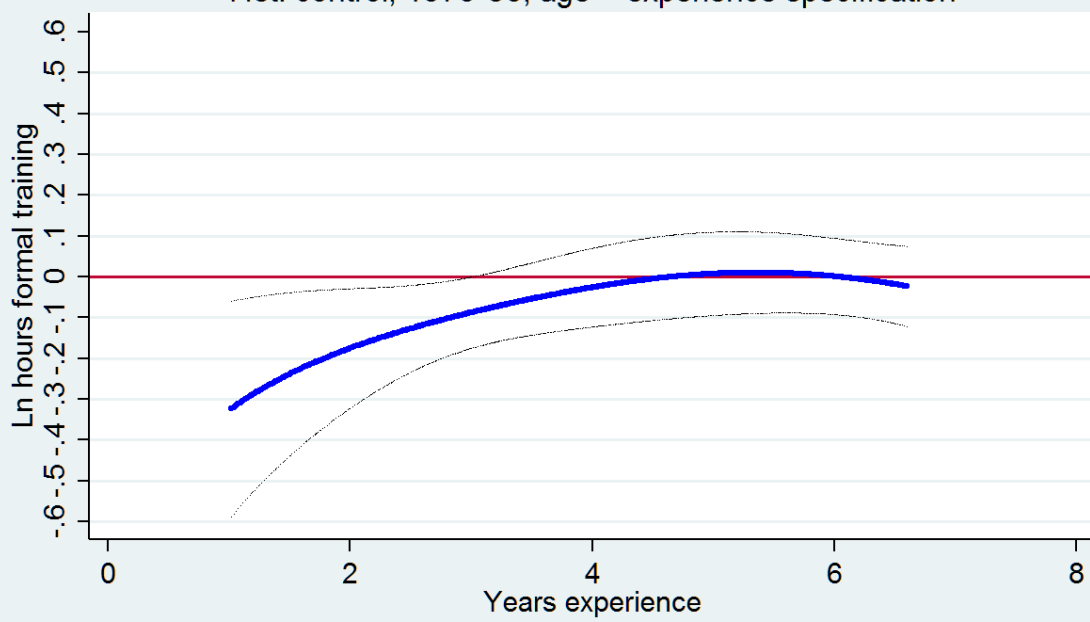


Chart 8b
dLn hours formal training/dYears experience
Het. control, 1979-86, age + experience specification



Outer lines denote 95% confidence interval

Chart 9a
Hours formal training vs. Years experience
Heterogeneity control, 1988-2012, age + experience specification

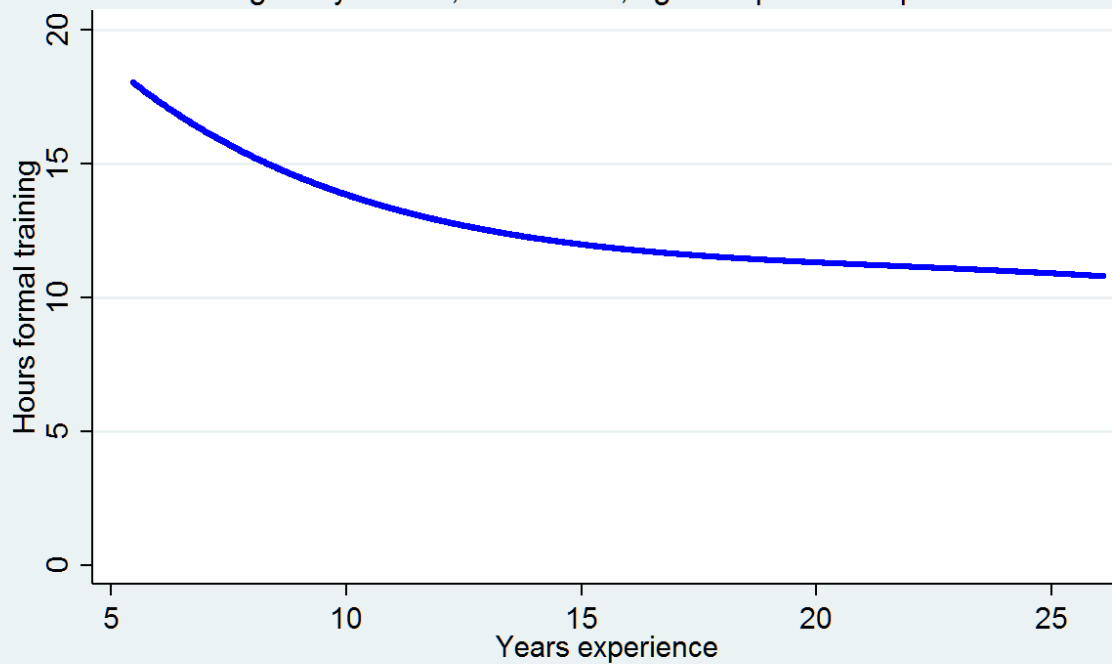


Chart 9b
dLn hours formal training/dYears experience
Het. control, 1988-2012, age + experience specification

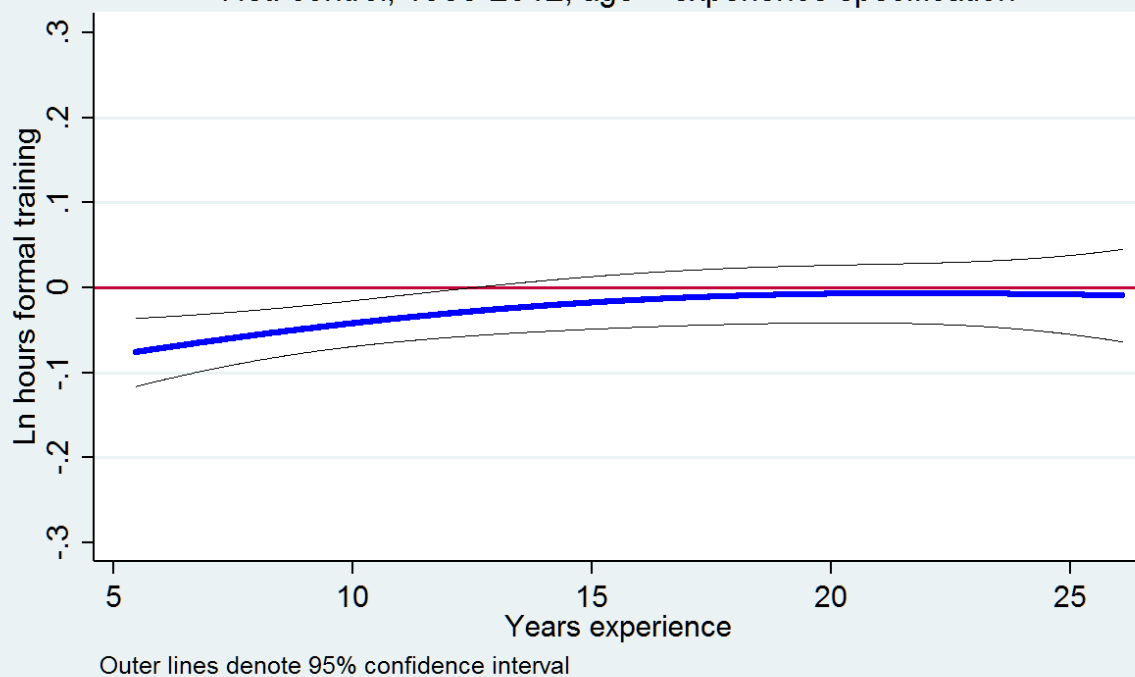


Chart 10a
Hours informal training vs. Years experience
Heterogeneity control, 1996-2000, age + experience specification

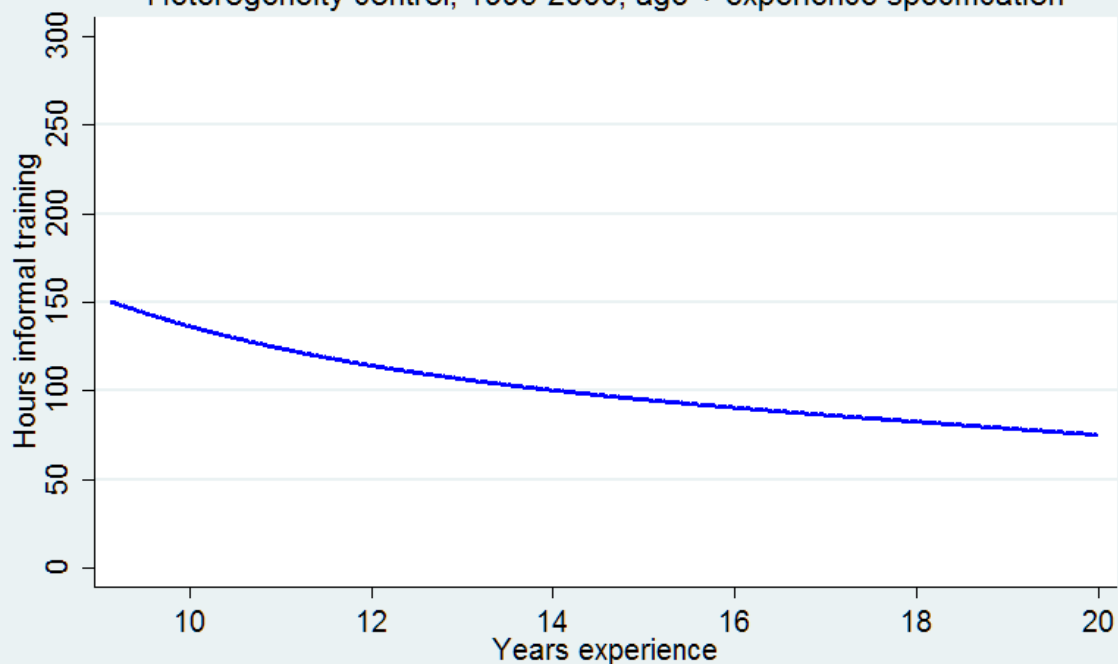
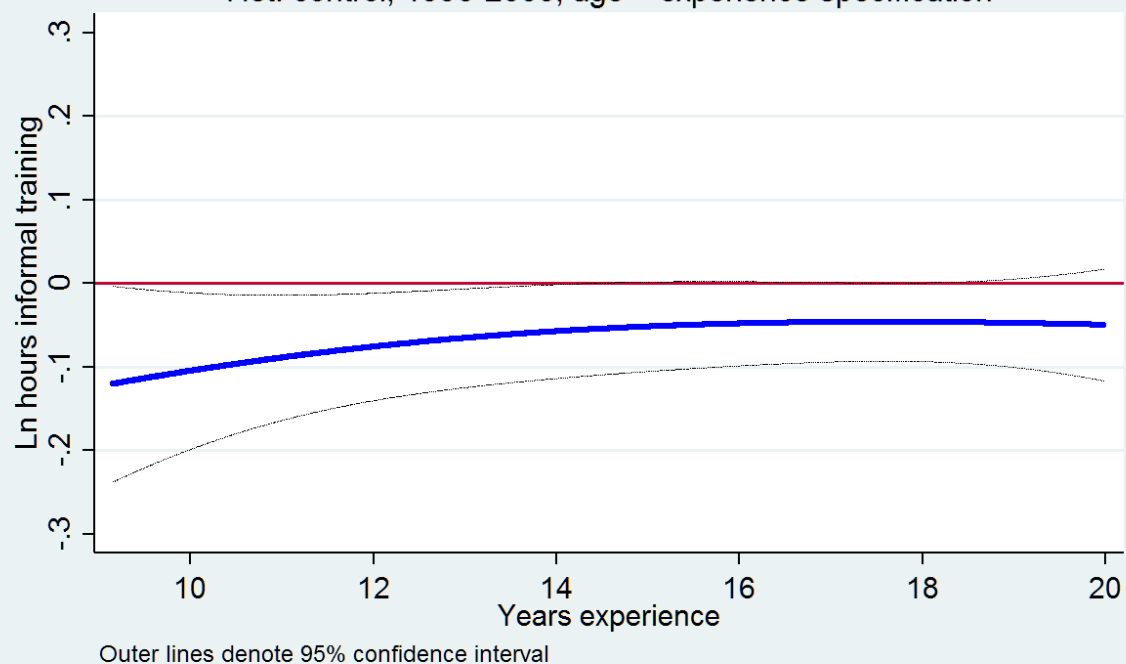
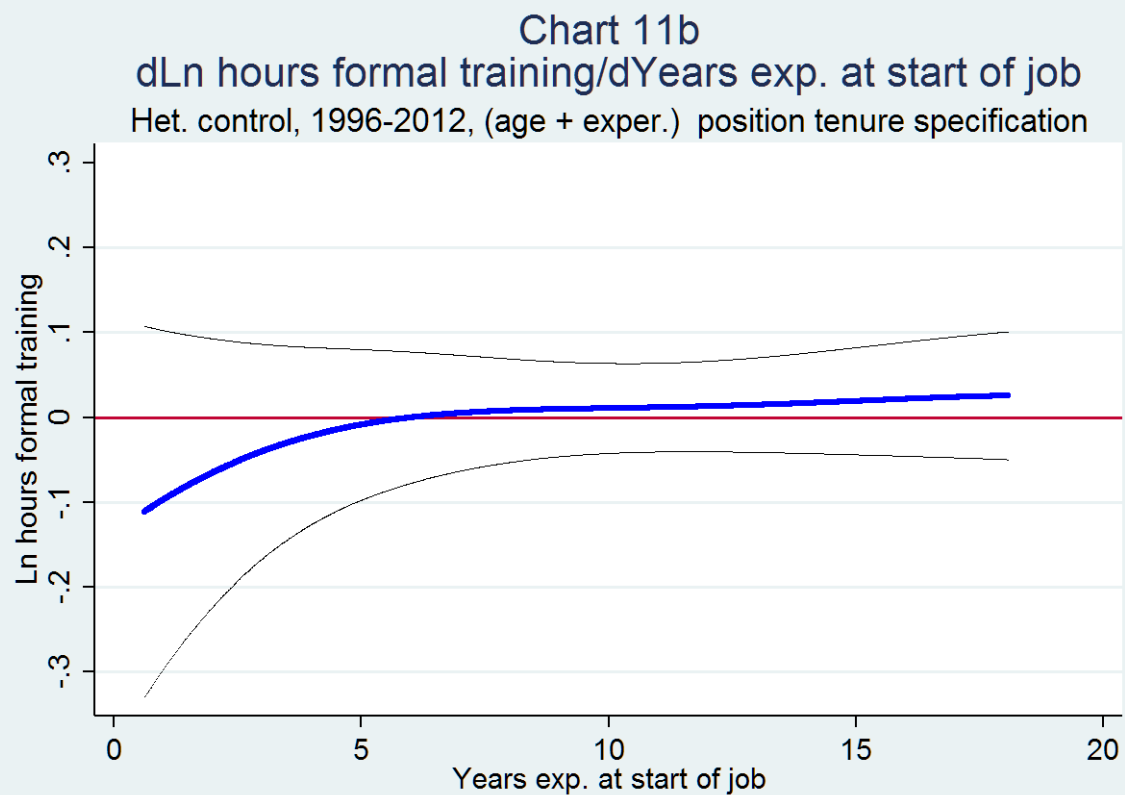
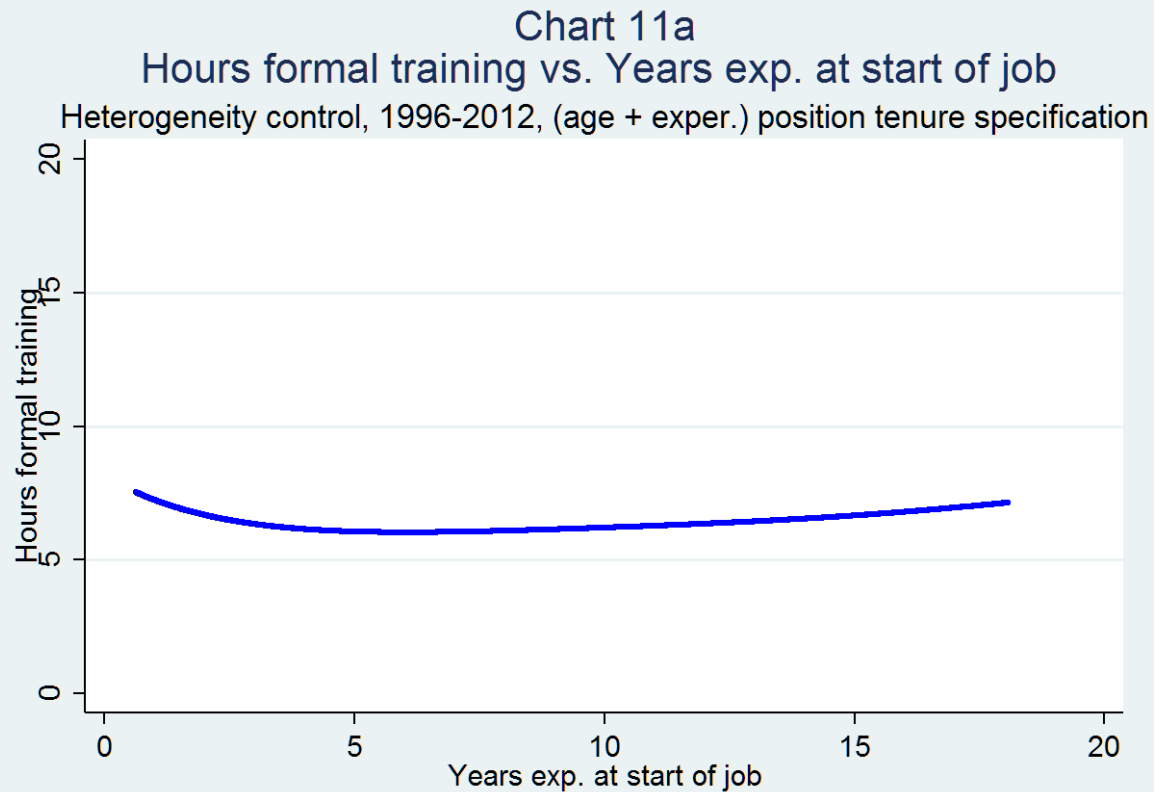


Chart 10b
dLn hours informal training/dYears experience
Het. control, 1996-2000, age + experience specification





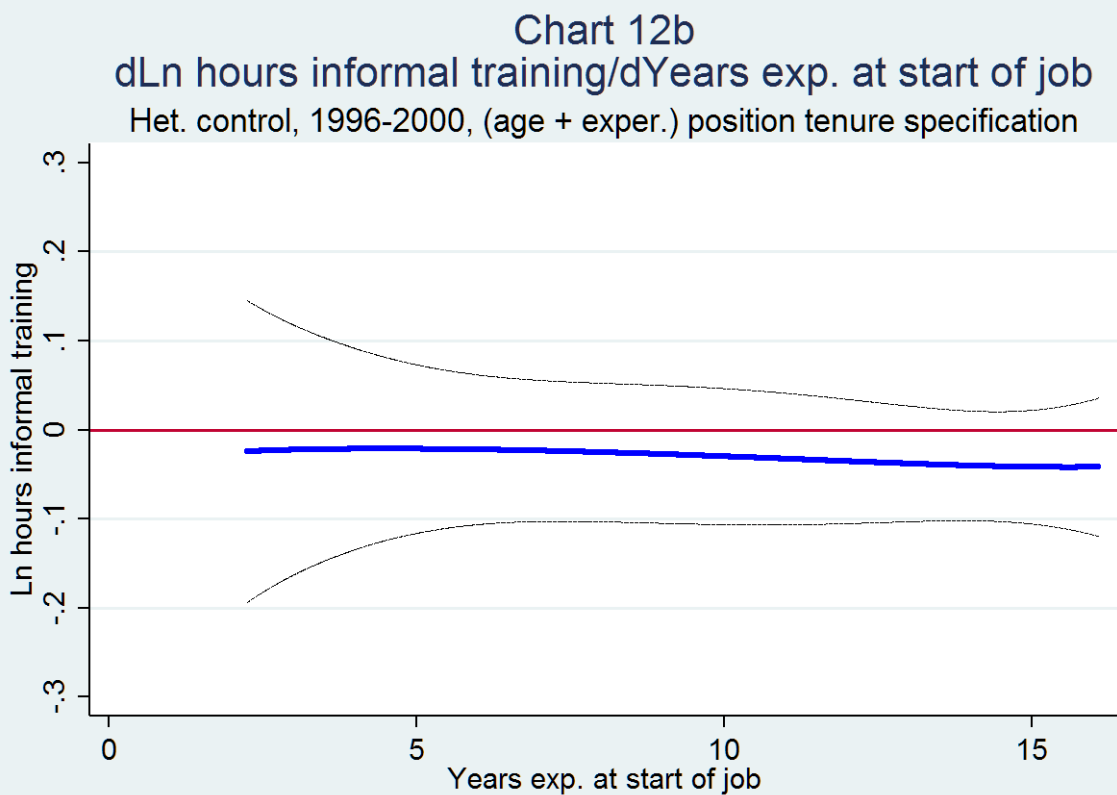
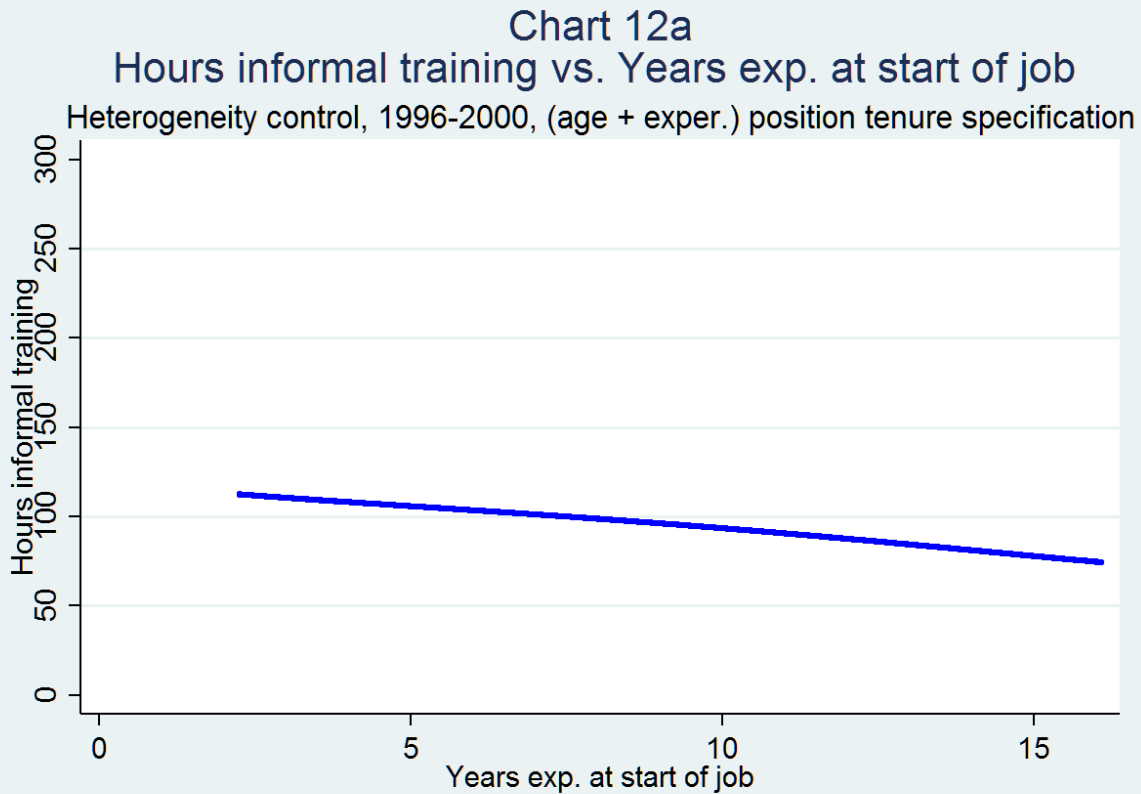


Chart 13a
Hours formal training vs. Years tenure
Heterogeneity control, 1979-86, tenure specification

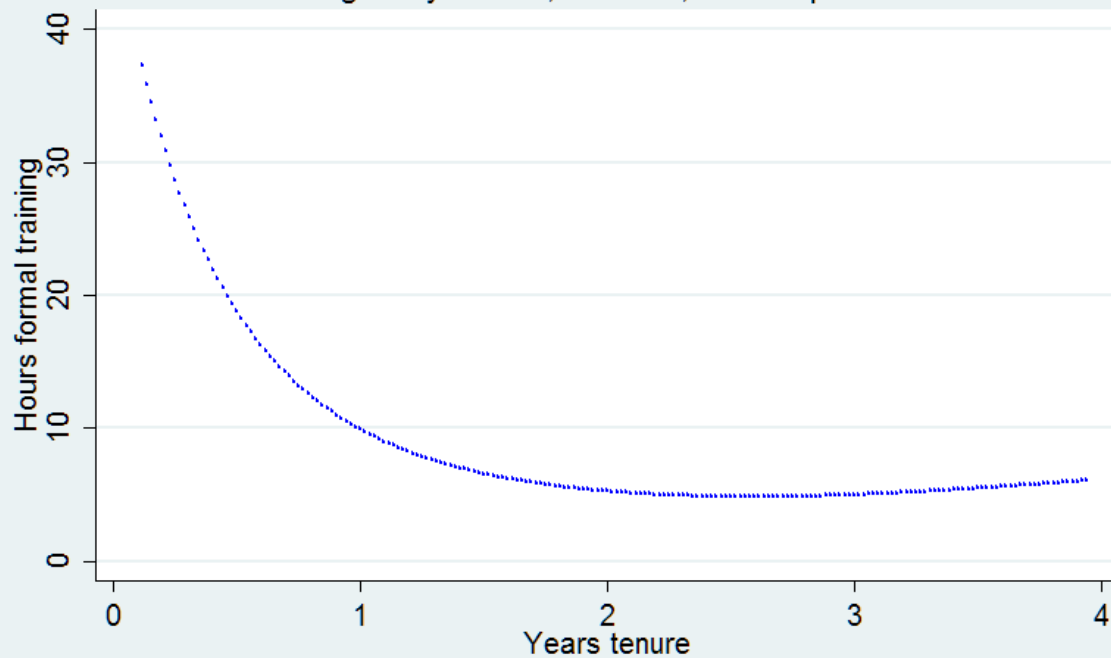
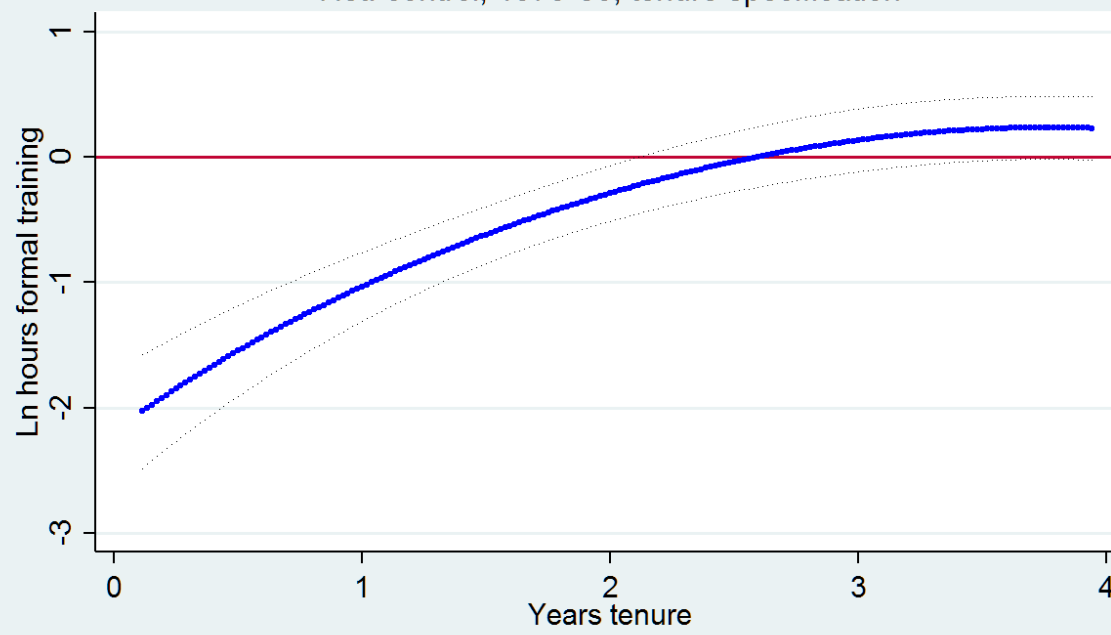


Chart 13b
dLn hours formal training/dYears tenure
Het. control, 1979-86, tenure specification



Outer lines denote 95% confidence interval

Chart 14a
Hours formal training vs. Years tenure
Heterogeneity control, 1988-2012, tenure specification

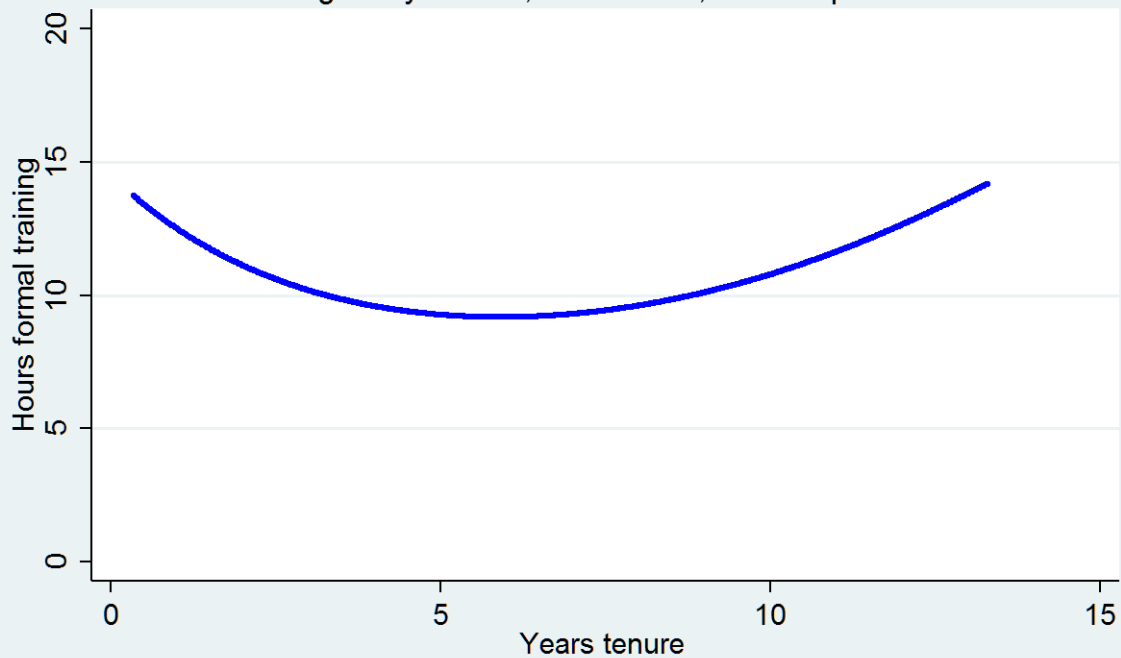


Chart 14b
dLn hours formal training/dYears tenure
Het. control, 1988-2012, tenure specification

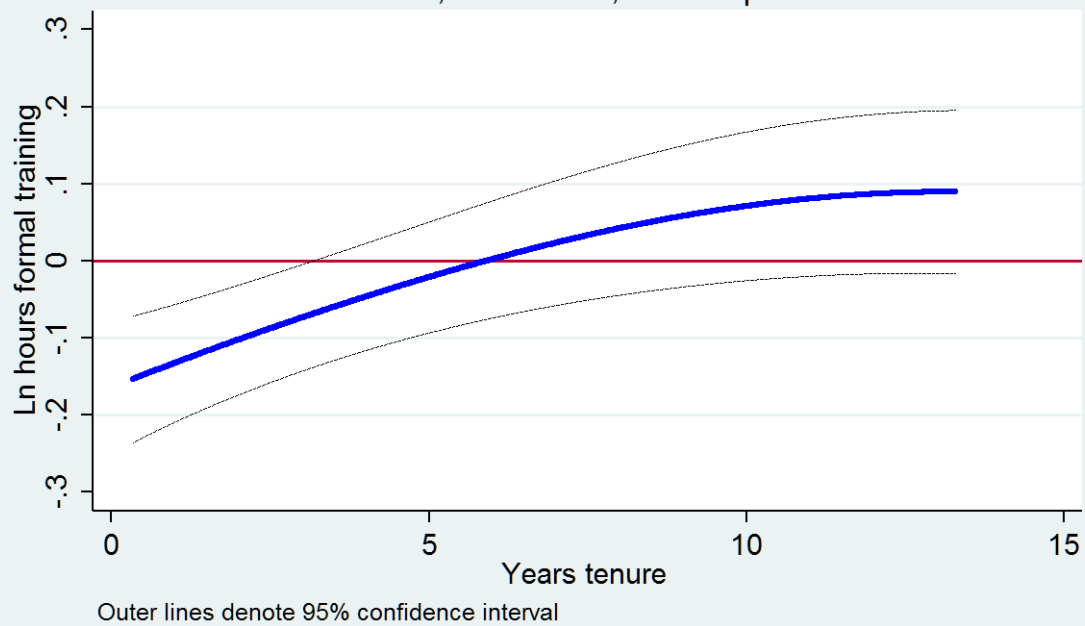


Chart 15a
Hours formal training vs. Years tenure at start of position
Heterogeneity control, 1996-2012, position tenure specification

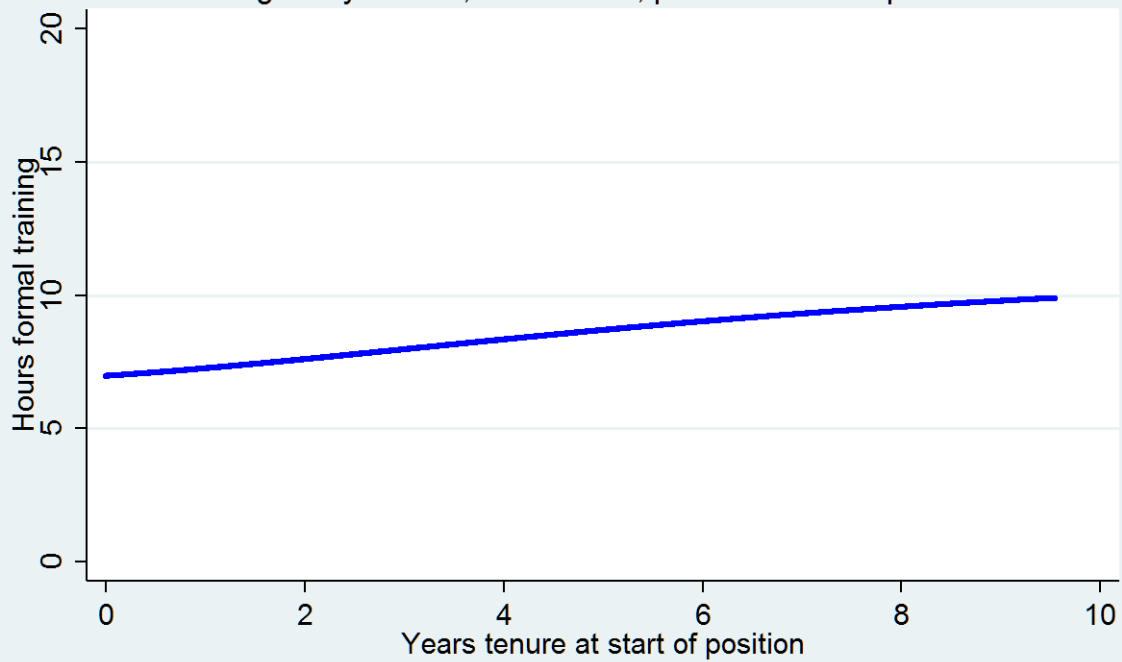


Chart 15b
dLn hours formal training/dYears tenure at start of position
Het. control, 1996-2012, position tenure specification

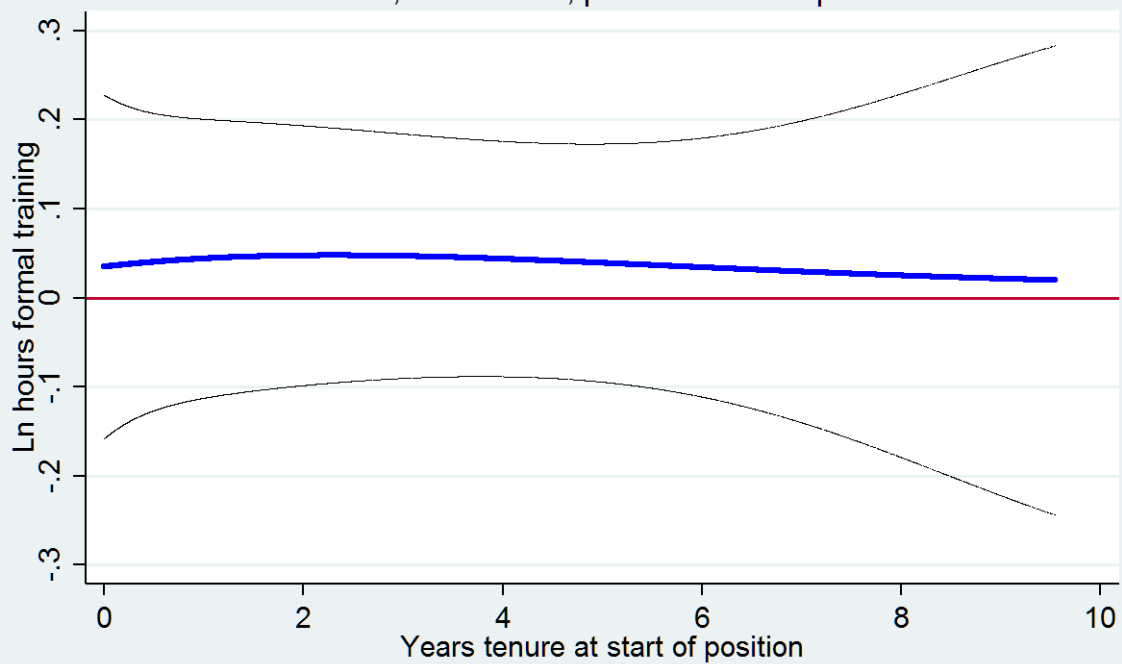


Chart 16a
Hours formal training vs. Years tenure

Heterogeneity control, 1979-86, tenure specification, all training in last year

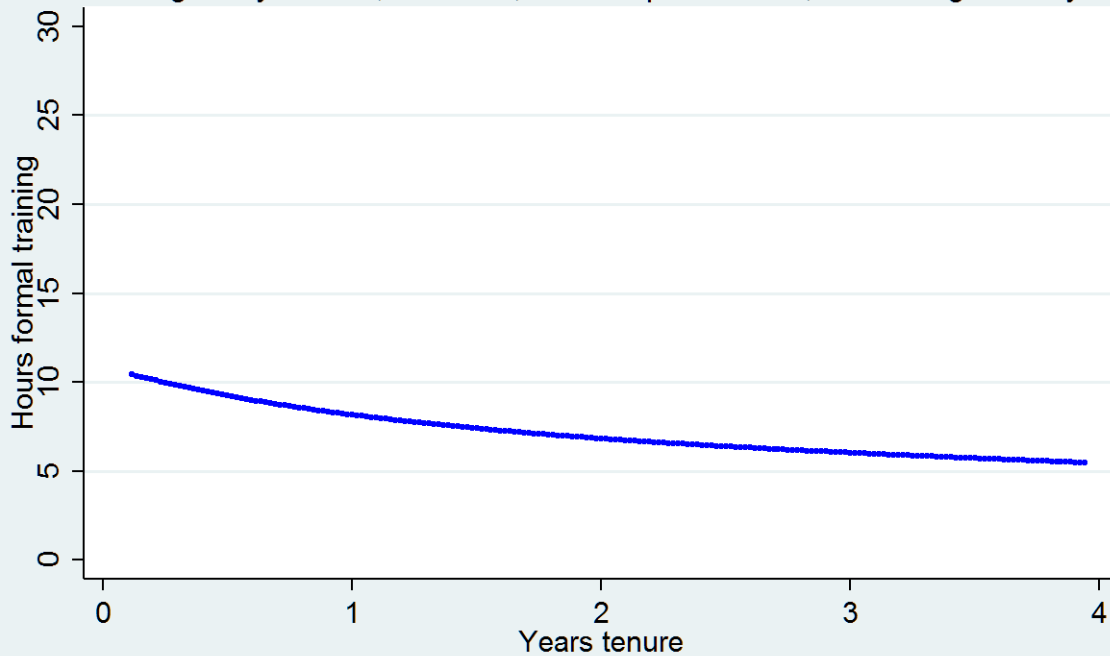
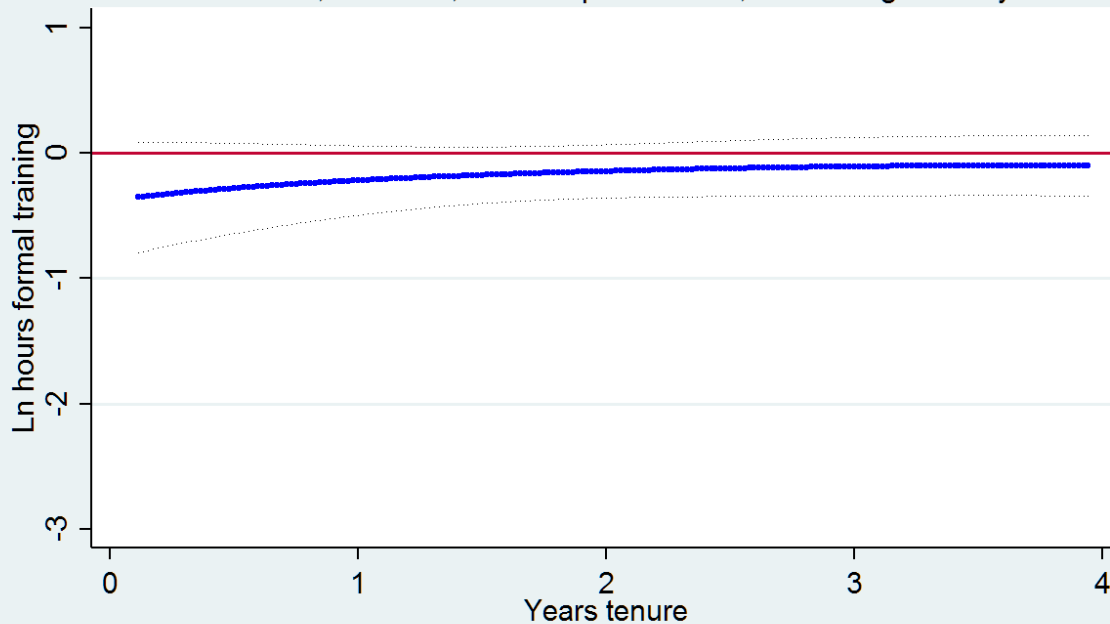


Chart 16b
 $d\ln \text{ hours formal training} / d\text{Years tenure}$

Het. control, 1979-86, tenure specification, all training in last year



Outer lines denote 95% confidence interval

Chart 17a
Hours formal training vs. Years tenure

Heterogeneity control, 1988-2012, tenure specification, all training in last year

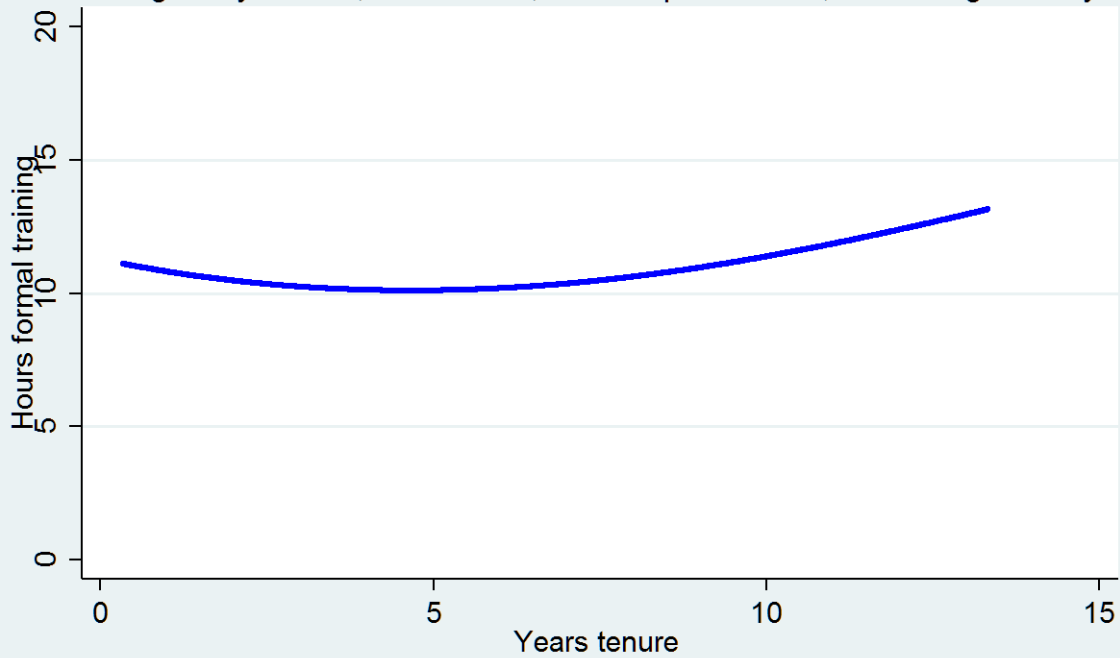
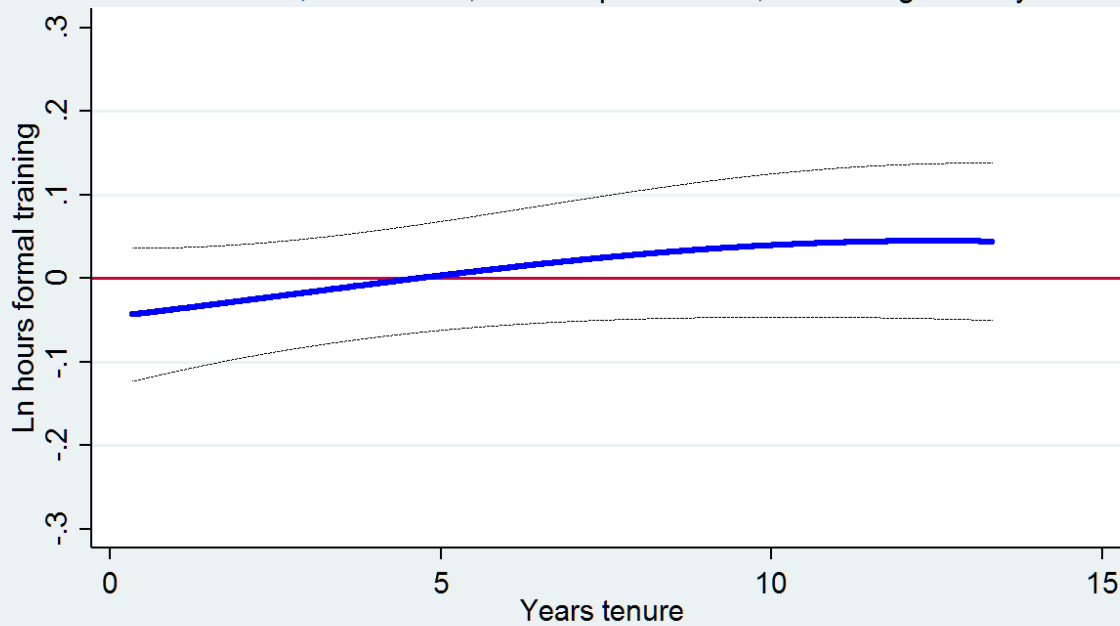


Chart 17b
 $d\ln \text{ hours formal training} / d\text{Years tenure}$

Het. control, 1988-2012, tenure specification, all training in last year



Outer lines denote 95% confidence interval

Chart 18a
Hours formal training vs. Years before final tenure
Heterogeneity control for exper., 1988-2012, tenure specification

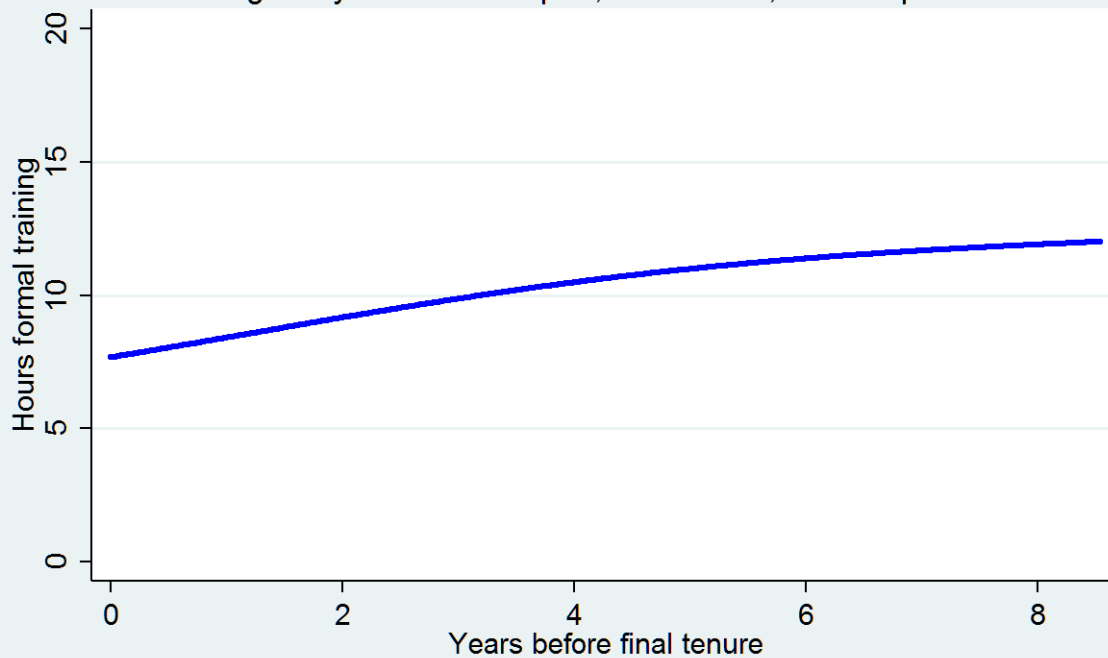
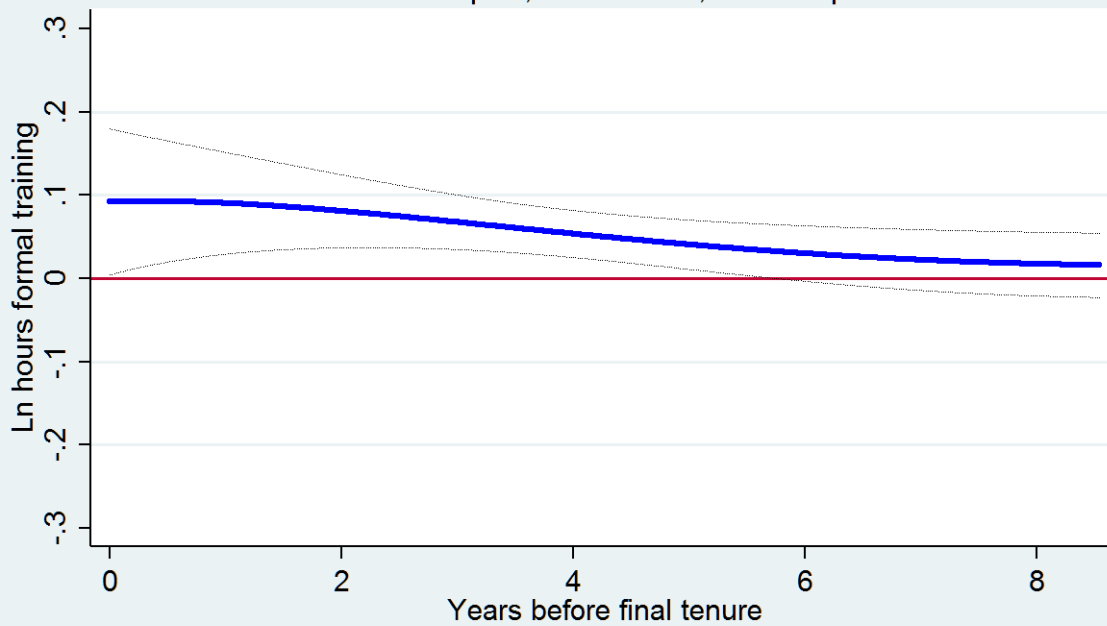


Chart 18b
 $d\ln \text{ hours formal training} / d\text{Years before final tenure}$
Het. control for exper., 1988-2012, tenure specification



Outer lines denote 95% confidence interval

Chart 19a
Hours informal training vs. Years tenure
Heterogeneity control, 1996-2000, tenure specification

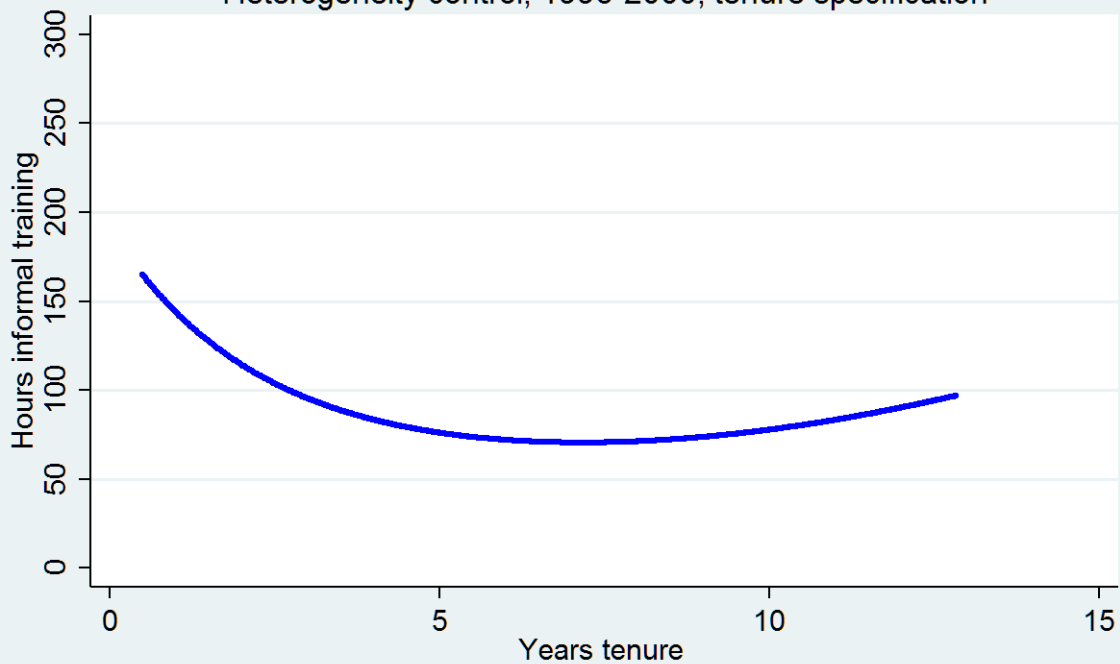


Chart 19b
dLn hours informal training/dYears tenure
Het. control, 1996-2000, tenure specification

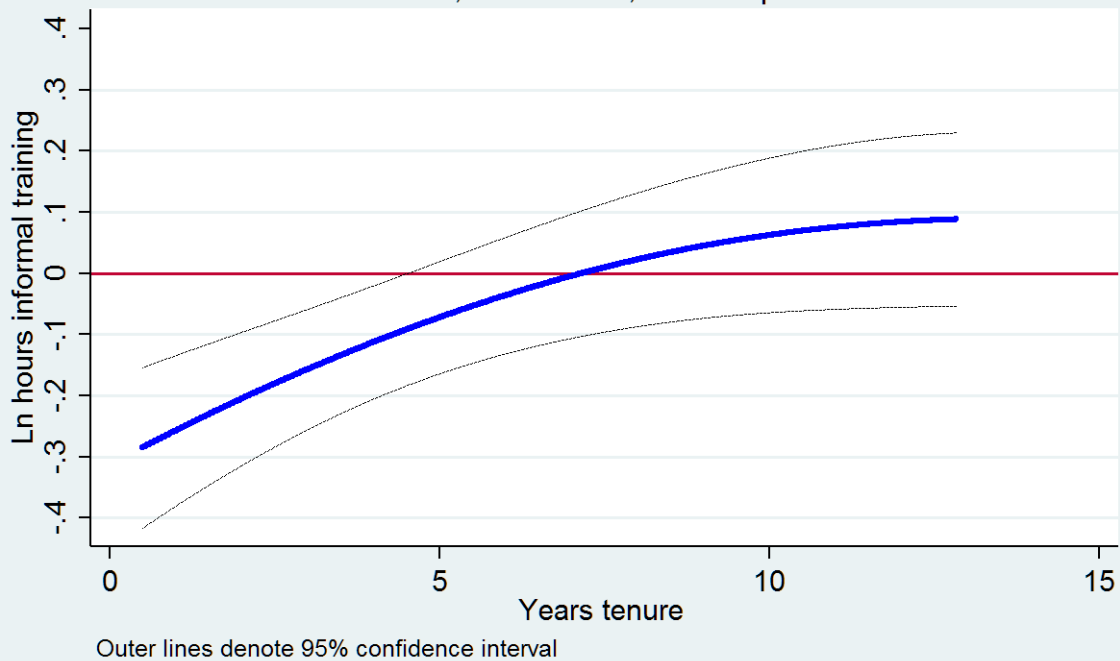


Chart 20a
Hours informal training vs. Years tenure at start of position
Heterogeneity control, 1996-2000, position tenure specification

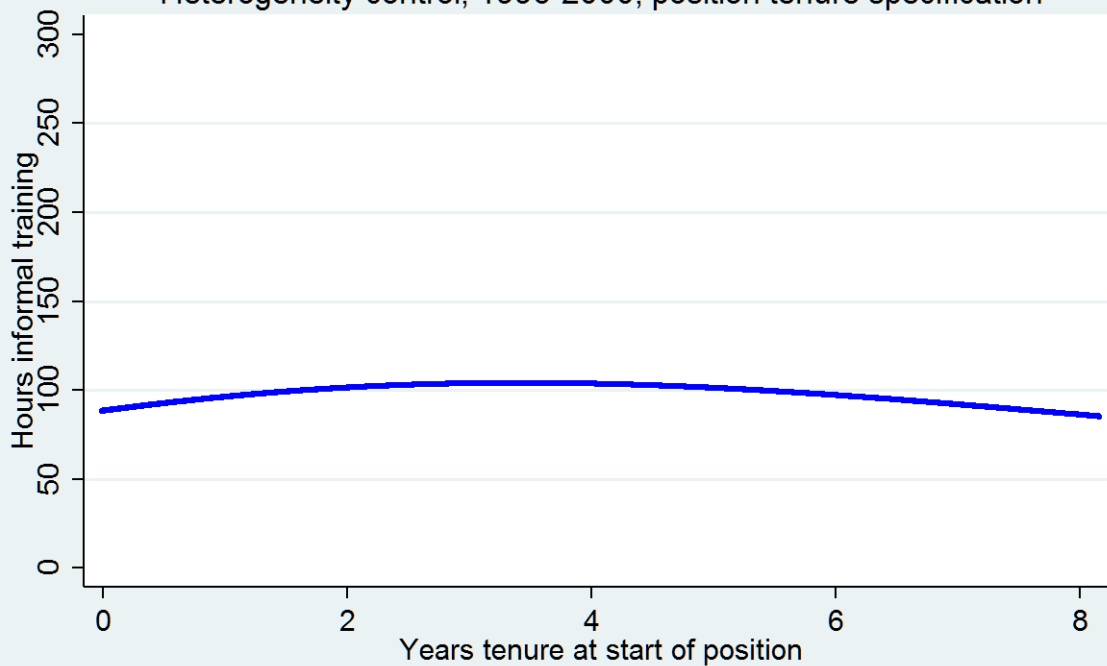


Chart 20b
 $d\ln \text{ hours informal training} / d\text{Years tenure at start of position}$
Het. control, 1996-2000, position tenure specification

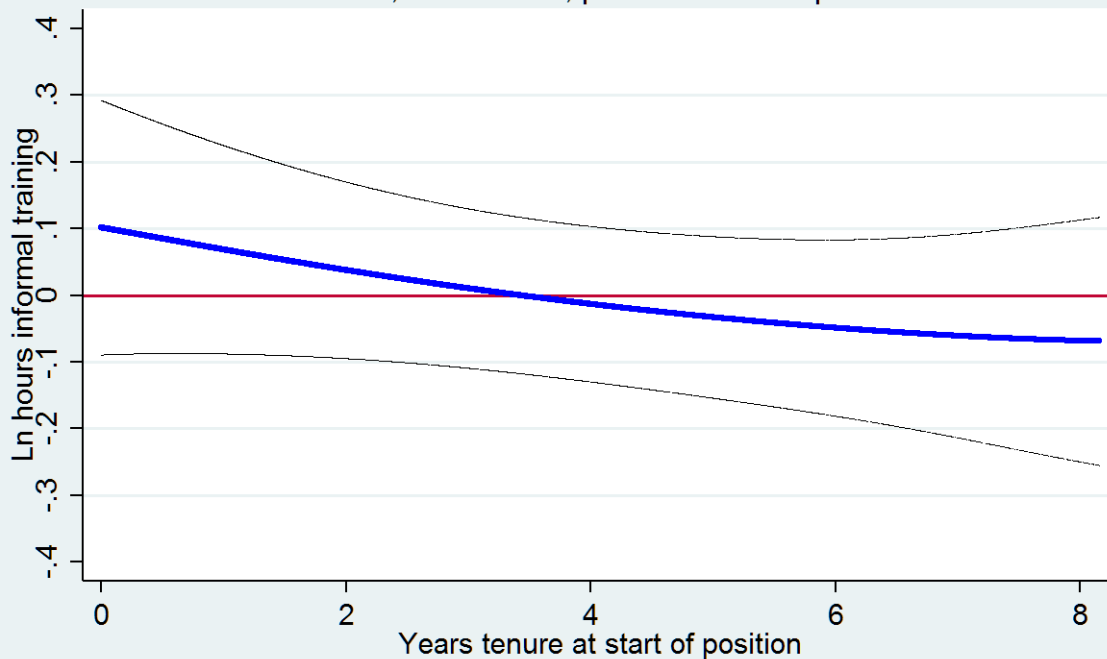


Chart 21a
Hours formal training vs. Years position tenure
Heterogeneity control, 1996-2012, position tenure specification



Chart 21b
dLn hours formal training/dYears position tenure
Het. control, 1996-2012, position tenure specification

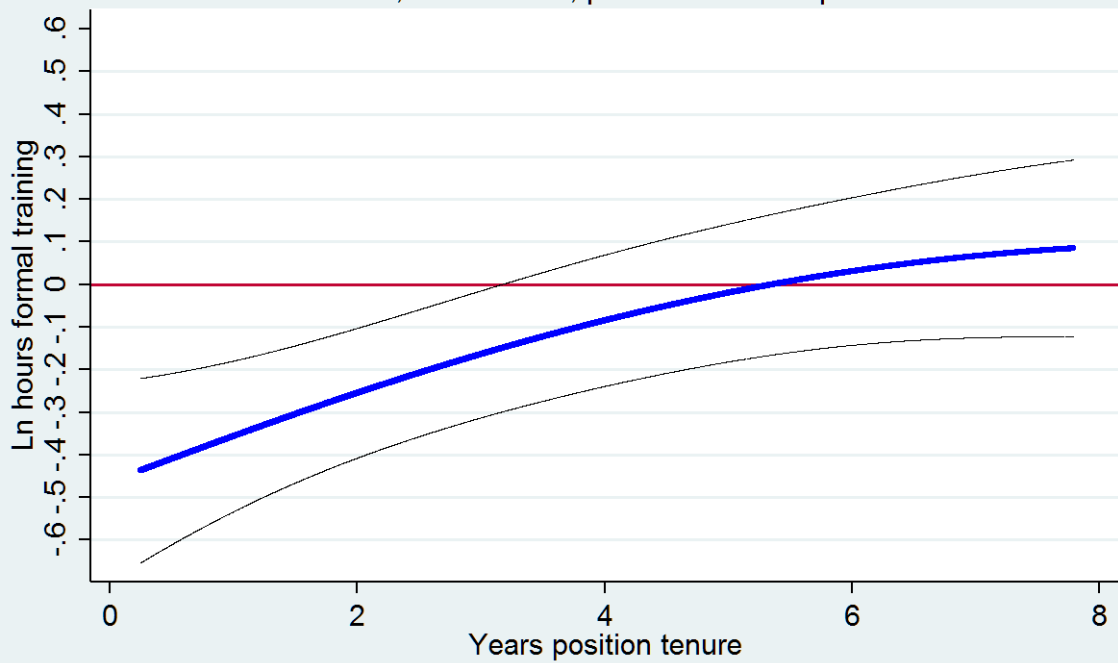


Chart 22a
Hours informal training vs. Years position tenure
Heterogeneity control, 1996-2000, position tenure specification

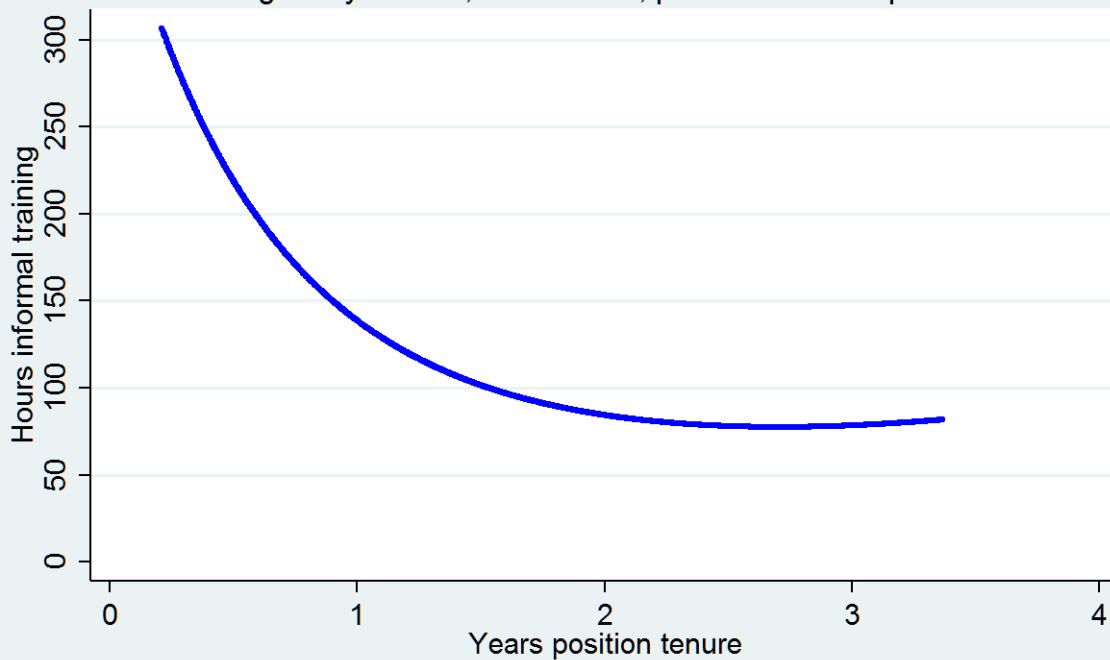


Chart 22b
 $d\ln \text{ hours informal training} / d\text{Years position tenure}$
Het. control, 1996-2000, position tenure specification

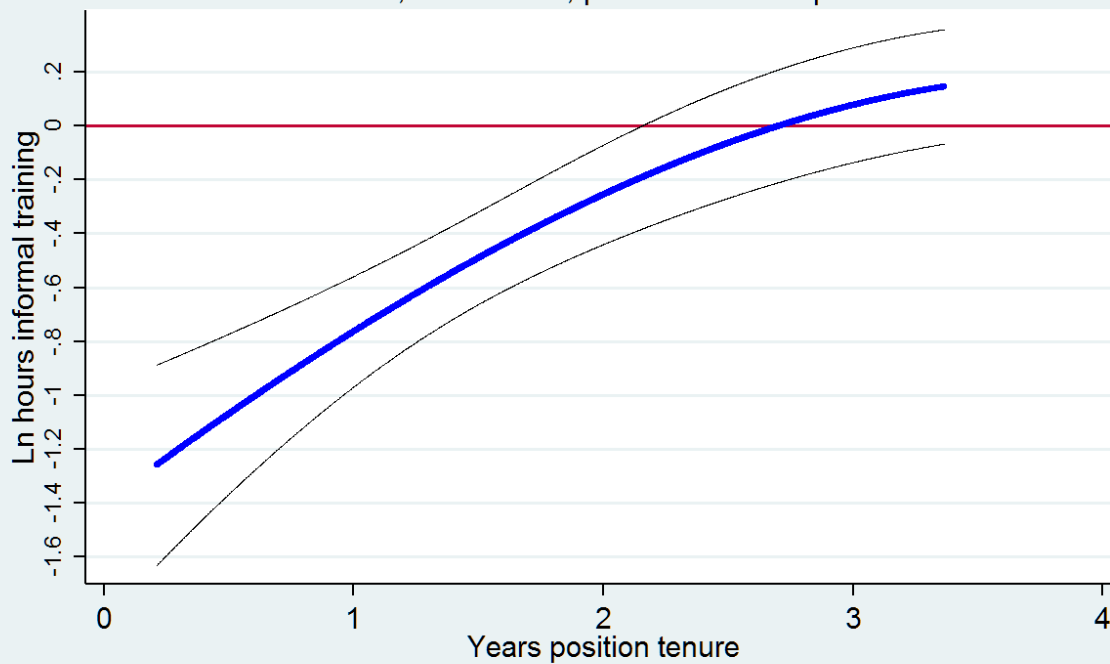


Chart 23a
 Prob. formal training vs. Years tenure
 Heterogeneity control, 1988-2012, tenure specification

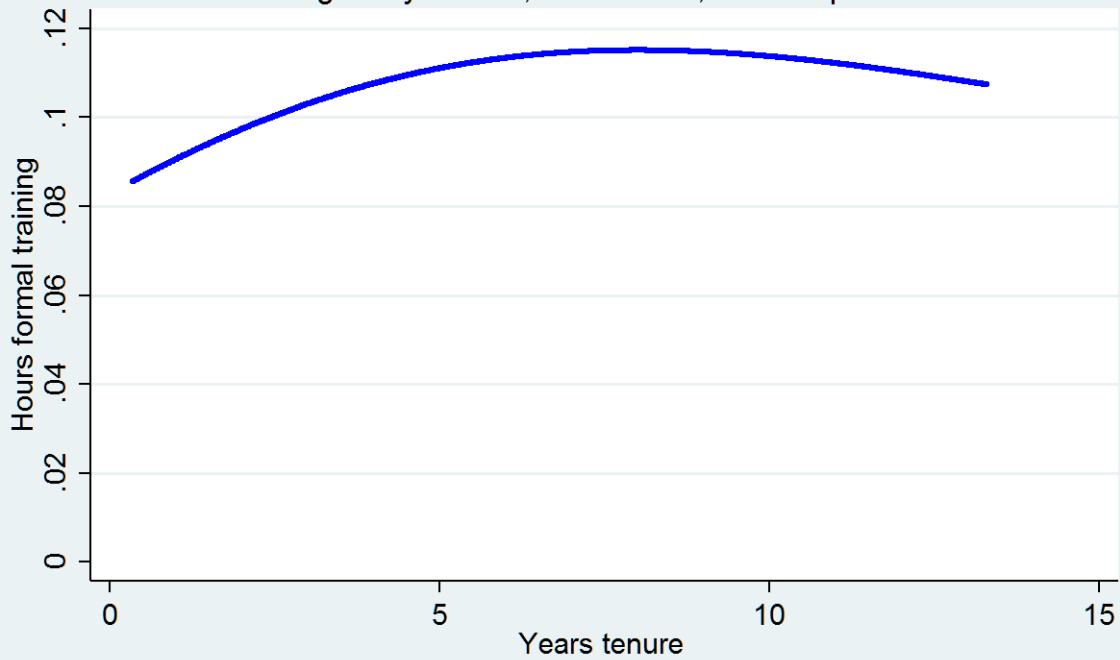


Chart 23b
 dProb. formal training/dYears tenure
 Het. control, 1988-2012, tenure specification

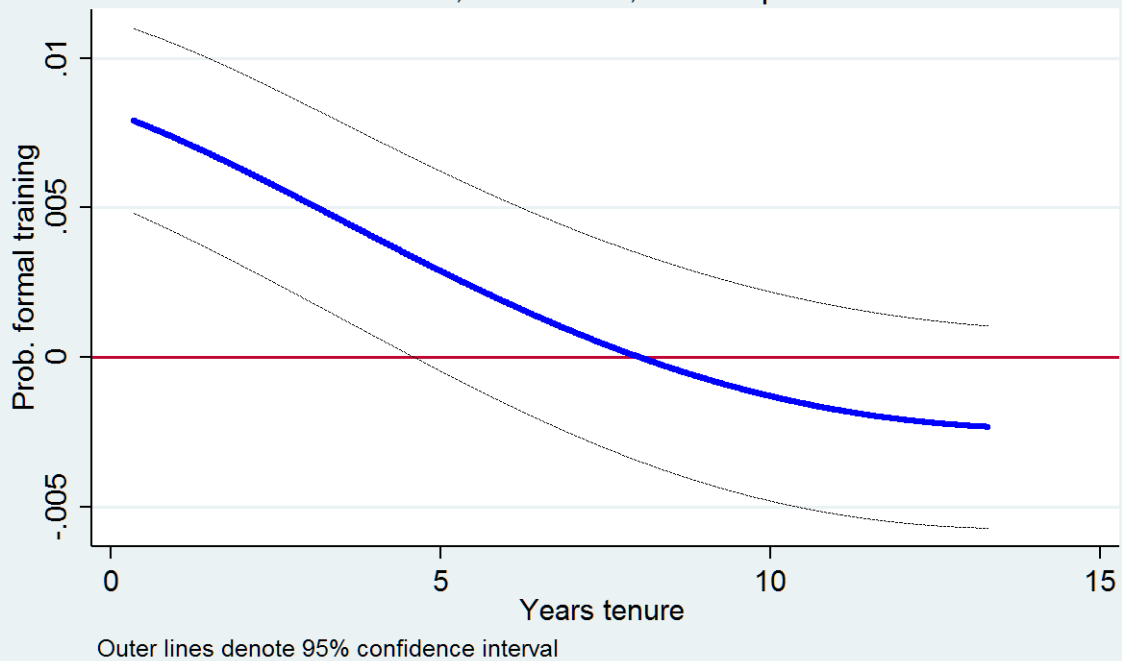


Chart 24a
Hours form. trg. (Tr.>0) vs. Years tenure
Heterogeneity control, 1988-2012, tenure specification

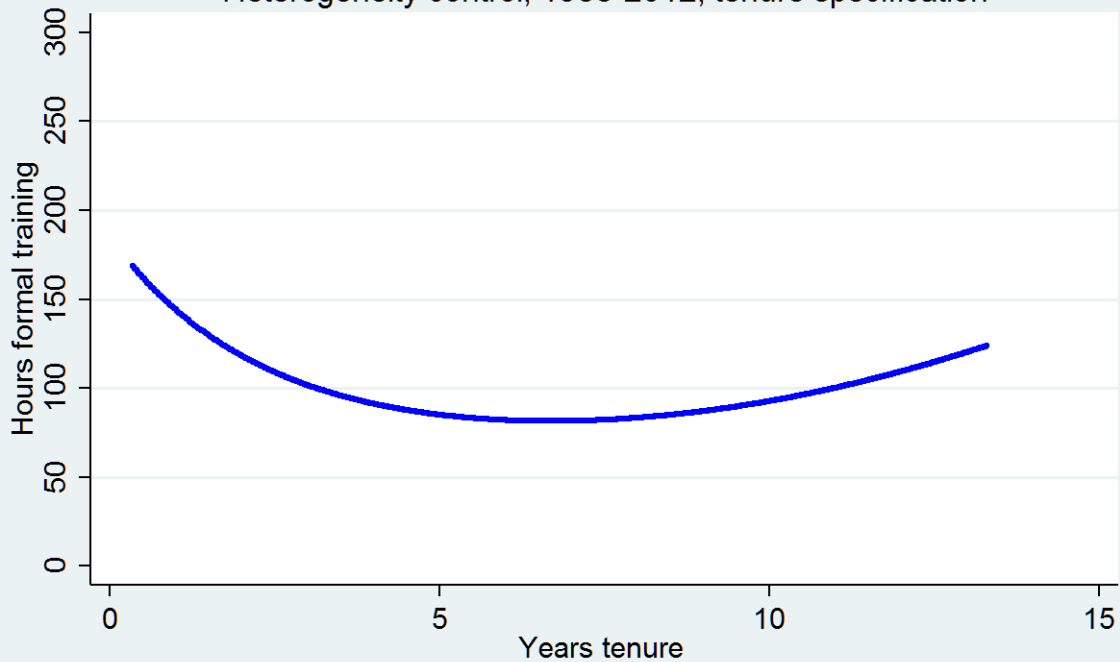


Chart 24b
 $d\ln \text{ hours formal training} | \text{Tr.} > 0 / d\text{Years tenure}$
Het. control, 1988-2012, tenure specification

