How Much Is Phuzics Really Worth?

by

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Abstract

A simple model of productivity and salary determination for academic phuzicists is estimated from recent panel survey. We find that research productivity is increasing for the first 20 years after the Ph.d. and declines thereafter. Contrary to some published speculation, we find there is no significant difference, between the productivity of phuzicists trained before and after 1960, controlling for stage in the life cycle. A simple salary determination model implies that a 1% increase in (discounted) cumulative research output yields a .15% increase in annual salary. For typical salary-productivity profiles in phuzics this implies that an "innovation" of one published page has a present value of about 500 dollars when it occurs near the beginning of a career and declines to about 100 dollars near career end. These estimates may be compared to an estimate of 1.7 million dollars for the capitalized value (evaluated at date of Ph.d.) of the typical phuzics salary profile.

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We begin by estimating a simple model of research productivity in which annual research output depends upon lagged output, age since Ph.d., and gender. It is notoriously difficult to estimate such models in panel data with modest time dimension.[1] Given the well-known difficulties with the fixed-effects (within) estimator we have estimated the following model on the raw panel

$$\log y_{it} = \underset{(.11)}{1.00} + \underset{(.08)}{.406} \log y_{it-1} + \underset{(.015)}{.088}\, e_{it} - \underset{(.0003)}{.0022}\, e_{it}^2 + \underset{(.035)}{.048}\, x_i + \underset{(.031)}{.008}\, h_i \tag{1}$$

where e_t denotes years of experience since Ph.d. x_t takes the value 1 for women and 0 for men, and h_t is 1 if the Ph.d. was received after 1960 and 0 otherwise. To reduce the bias caused by potential correlation of the individual effects and the log y_{t-1} variable we have estimated the model using log Y_{t-1} as an instrument for log y_{t-1}. Clearly, this is not an ideal instrument. It too is undoubted correlated with the latent heterogeneity, but the result above appears more plausible than the corresponding OLS estimates which yield a coefficient of .27 on log y_{t-1}, or the within estimator which gives a negative estimate.

In Figure 1 we illustrate the estimated life cycle profile of research output in phuzics. Note that productivity is increasing for the first 20 years, and declining thereafter. Note that while women and post-1960 Ph.d.'s are seen to have a slight productivity edge over their male pre-1960 counterparts neither effect is significant at conventional levels. In future work we hope to expand the time dimension of the panel to accommodate improved instrumental variables estimators.

We propose a very simple model of salary determination based on changes in discounted cumulative research output which we take as an indicator of "research reputation".[2] Explicitly, we estimate the model

$$\log (s_{it}/s_{it-1}) = \alpha \log (Y_{it}/Y_{it-1}) + \beta_0 + \beta_1 x_i + \beta_2 d_{it} + \alpha_i + u_{it} \tag{2}$$

where s_{it} denotes annual salary in 1,000, and d_{it} takes the value 1 for individuals in a research university position in period t and 0 otherwise.

Estimating this model with the "within" sample yields,

$$\log (s_{it}/s_{it-1}) = \underset{(.023)}{.1497} \log (Y_{it}/Y_{it-1}) + \underset{(.0117)}{.0248}\, d_{it}$$

The time invariant effect of gender is obviously inestimable from the within data, but mobility between research and teaching institutions does permit estimation of an institution effect. The corresponding between regression is

$$\log (s_{it}/s_{it-1}) = \underset{(.007)}{.016} + \underset{(.023)}{.162} \log (Y_{it}/Y_{it-1}) + \underset{(.008)}{.029} d_{it} - \underset{(.009)}{.007}\, x_i$$

Here we have "corrected" for the heteroscedasticity induced by the unbalanced nature of the panel. Since $V(\alpha_i + T_i^{-1} \sum_{t=1}^{T} u_{it}) = \sigma_\alpha^2 + T_i^{-1} \sigma_u^2$ we can estimate the two variances by regressing squared OLS residuals on T_i^{-1}, and then weight the observations by the reciprocals of the fitted variances. The Balestra-Nerlove estimate is virtually identical to the between estimate in this case.

To explore the "value" of phuzics research as reflected in academic salaries we consider the consequences of a unit "innovation" in research output. We begin by constructing a typical research profile, illustrated in Figure 1, by forecasting (1) assuming an initial paper of 3 pages in period 1. The corresponding cumulative (discounted) output profile is illustrated in Figure 2. The salary profile based on this productivity profile and (2) is illustrated in Figure 3. Computing the present value of this salary profile, evaluated in the year of the Ph.d. we have.

$$w = \sum_{t=1}^{T} s_t/(1+r)^t$$

Setting $T = 50$ and $r = .03$ we obtain $w = 1.7$ million. This sounds impressive until we observe that it generates only $51,240$ income per year as an annuity, at our notional 3% interest rate.[3] An interesting exercise would involve computing an optimal time path of research activity.

Now to evaluate an "innovation" in research output occurring p years after the Ph.d. we repeat the above exercise, replacing y_p by $y_p + 1$. This has an immediate effect on salary in period p increasing it by approximately .15 s_p/Y_p. But there are further consequences as well. Given the autoregressive form of (1), an innovation in period p spawns further increases in output in subsequent periods. This new output stream is then discounted to obtain a new Y_t series, a revised salary sequence is computed, and finally this is discounted back to its capitalized value in the Ph.d. year. In Figure 4 we illustrate the present value of a one-page innovation at various stages of the career. When the innovation occurs only 3 years after the Ph.d. it is worth roughly 2600, if it occurs 30 years later its value, again discounted back to the Ph.d. year, is only about 425.

Since the coefficient on log (Y_t/Y_{t-1}) of .16 implies severe diminishing returns to research output, these numbers would be considerable smaller for more productive researchers. Women's raises are .7% smaller than men's, which over time has a substantial effect, but this differential is so imprecisely estimated we do not pursue it.

Endnotes

1. See Nickell, S. (1981) and Hsaio, C. (1986).

2. The annual depreciation rate is .08, so the half life of published work is 8.66 years. See the definitive study of Rot and Decay (1986).

3. Gibbons and Ramaswamy (1991) estimate the US long-run real interest rate as 3.04% using post war nominal US bond data.

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