Confirmations and Contradictions

Modeling the Earnings and Research Productivity of Academic Economists

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This paper focuses on the differences that result from employing a multi-equation system rather than the single-equation model used in previous research to explain variations in earnings of academic economists.

I. Research Productivity and Earnings Determination

Our model of the earnings process contains (1) a *job-quality* equation which describes the type of academic job one obtains; (2) a *research-output* equation; and (3) an *earnings* equation, in which research output and job quality enter causally. Underlying this model of the earnings process is, of course, a more fundamental set of relationships—that is, a set of demand, supply, and production functions which reflect utility maximization on the part of market participants. The model we develop is an intermediate-level model, more refined than a single-equation approach but not as complete as one based on demand, supply, and production considerations and not as complete as we would like.[1] A more complete model would also have separate production functions for teaching, public service, and departmental administrative outputs.

The model presented here permits testing several hypotheses. In the job-quality equation (1), the quality of institutional affiliation of a particular economist—that is, his or her "job quality"—is hypothesized to be determined primarily by (*a*) the individual's characteristics, such as intelli-

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[1] It should also be noted that the system portrayed does not deal with time explicitly. The true process involves a feedback system, in which actions and decisions made at one time determine the value of variables at later dates.

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gence and motivation; (*b*) the willingness to substitute between higher earnings and a more prestigious institutional affiliation; (*c*) the quantity and quality of the person's formal academic training; and (*d*) the quantity and quality of the person's cumulative published research. This specification of the determinants of the quality of one's academic affiliation reflects the view that economists are more likely to obtain prestigious positions if they are more willing to trade off salary for prestige, if they have graduate training from a more distinguished economics department, and if they have a strong publication record reflecting continuing involvement in research.

In the research-productivity equation (2), we include, in addition to variables *a* and *c* above, (*e*) the extent to which job quality contributes to research output by providing intellectual stimulus, time, and facilities; and (*f*) the quality and duration of the individual's on-the-job research experience.[2] Because we have actual productivity information, we can ascertain the effects of experience (representing on-the-job training) on productivity and of productivity on earnings, rather than simply the effect of years of experience directly on earnings.

In the earnings equation (3), which describes the determinants of salary, we expect the amounts of published research and the quantity and quality of teaching, public service, and departmental administrative outputs to affect earnings. Another possible determinant of salary is the extent of an academic's "maturation"; this might reflect growth, accompanying age, in the value of the person's contribution in forms other than research.[3] Age may also reflect a concept of equity that involves paying older faculty higher salaries out of a sense of justice and independent of productivity. Salaries may also be affected by "discrimination"—for example, between women and men or between blacks and whites. Finally, we hypothesize that money earnings differ among departments of various "quality"; that is, higher-quality departments pay lower salaries than do lower-quality departments for economists of comparable quality.

Our model, then, as applied to academic economists and modified on account of data availability, is:

$$J = B_{11} + B_{12}R + B_{13}\log_e E + B_{14}D + B_{15}S + e_1, \qquad (1)$$

$$R = B_{21} + B_{22}J + B_{23}D + B_{24}X + B_{25}X^2 + B_{26}S + e_2, \qquad (2)$$

[2] In addition, it might include one or more variables reflecting the selection process by which publication decisions ("research output") are reached. For example, the refereeing process might favor investigators at more prestigious institutions (Crane 1967; Berg 1971; Strauss 1971). The recent policy of the *American Economic Review*, which requires "blind" refereeing, appears to meet this objection. For an assessment of the impact of blind refereeing in economics and sociology, see Crane (1967).

[3] This is mentioned by Malkiel and Malkiel (1973). It is also a view held by Committee Z of the American Association of University Professors (1972).

and

$$\log_e E = B_{31} + B_{32}J + B_{33}R + B_{34}R^2 + B_{35}A + B_{36}A^2 + B_{37}S + e_3, \quad (3)$$

where J = job quality, that is, quality of the school where currently employed; R = research output; E = earnings; D = degree quality, that is, quality of the university where Ph.D. was obtained; S = sex; X = experience; A = age; e = error terms. The squared terms in equations (2) and (3) are included to test for diminishing returns to experience, age, and research productivity.[4]

Several comments about the model are in order. First, both experience and age are included. Experience is expected to affect research productivity, while age, as an index of maturation and, perhaps, equity, is hypothesized to affect earnings directly. Experience is thus assumed to influence earnings only through its effects on research productivity.[5] This means that research productivity is viewed as an end product of the on-the-job investment in training that occurs with added years of work experience.

Second, teaching skill, public service, and administrative outputs are omitted from the earnings equation simply because of data unavailability. Whether the omission of these variables leads to biased estimates for the included variables is unclear. It should be noted, however, that the single-equation estimates, with which we wish to compare our findings, also generally omit those variables.

Third, sex is included in all three equations. It is in the job-quality equation to ascertain whether women experience differential access to jobs at higher-quality institutions; it is in the research-productivity equation to determine whether the research output of women differs from that of comparable males; and it is in the earnings equation to allow for the possibility that a person's sex affects earnings in ways other than through job quality and research output. The estimated effect of sex on earnings (eq. 3) may be thought to be the "true" partial effect, holding constant the indirect effects (if any) of sex on job quality and research output. Whether this partial effect is pure discrimination depends on how one interprets differences in job quality and research output due to sex.[6]

[4] Our theory with regard to the form of eq. (2) is that the stock of research output, R, is a function of, among other variables, the quality of all jobs held previously. Thus, we believe that research output at time t, R_t, is a distributed lag function of all previously held jobs, $J_t, J_{t-1}, \ldots, J_{t-n}$. Given that we have data only for J_t, however, we have excluded the data subscripts.

[5] This differs somewhat from the human capital formulation found in the works of Ben-Porath (1967, 1970) and Mincer (1974).

[6] One's sex might also influence the probability of admission to a high-quality training program and the probability of completing the program. We have not dealt with these possibilities in our model.

For purposes of contrast we estimate what we consider to be a "typical" single-equation earnings function that is representative of the literature (Katz 1973; Koch and Chizmar 1973; Malkiel and Malkiel 1973; Siegfried and White 1973; Johnson and Stafford 1974*a*, 1974*b*; Tuckman and Hagemann 1976; Tuckman, Gapinski, and Hagemann 1977). This permits us to compare the estimated coefficients from that function with the coefficients obtained from our three-equation structural model.

Our representation of this typical earnings equation includes all of the variables usually employed in past studies and also embraces all of the explanatory variables used in our three-equation model:

$$\log_e E = B_{41} + B_{42}R + B_{43}R^2 + B_{44}D + B_{45}J + B_{46}X + B_{47}X^2 + B_{48}A + B_{49}A^2 + B_{410}S + e_4. \quad (4)$$

II. Data

The basic source for all our data except research productivity is the 1966 survey of economists undertaken by the National Register of Scientific and Technical Personnel, under the auspices of the National Science Foundation (NSF) and in cooperation with the American Economics Association (AEA).[7] This survey provides a file of 13,150 individuals who called themselves economists in 1966 and who were identified by, among other things, name of employing institution, highest degree attained, year of highest degree, name of institution awarding highest degree, age, and sex. Our attention here is concentrated on academic economists holding a Ph.D. degree who were, in 1966, employed by institutions that granted economics Ph.D.'s. By limiting our analysis to academic economists, we are able to estimate the impact of job quality on productivity and the trade-off between earnings and job quality. Excluded are economists who did not seek university positions and those who were not retained or who voluntarily left university positions. Thus, we cannot estimate, for example, the monetary value of research productivity for people who did not remain in universities or who never had university positions.

For each Ph.D. holder employed by an academic institution we gathered data from the *Index of Economic Journals* (*IEJ*) on the total number of articles published. We also obtained data on total books published from the *Cumulative Book Index* (*CBI*).[8] The quality of graduate training and the quality of employing institutions were determined by matching the values

[7] For a description of the data, see National Science Foundation (1968) and Tolles and Melichar (1968).

[8] Data on books are complete only for those people who published at least one article. To avoid the Herculean task of examining the *CBI* for all doctorate holders at academic institutions offering Ph.D.'s, required to build up information on lifetime book publication, we made the assumption that anyone who had published zero articles had also published zero books.

of Allan Cartter's unpublished index of departmental quality to both the department from which the degree was obtained, D, and the department of current employment, J.[9] After this information was assembled, NSF personnel added salary data for each individual for 1966, and at the same time they deleted the identifying names and record numbers for each individual. This produced a file of 863 economists for whom full information was available.[10]

The data at hand can be described as follows. The self-reported salaries, E, refer to the basic annual salary associated with full-time professional employment as of January 1966; respondents indicated whether their salary was for 9–10 months or 11–12 months.[11]

The article and book information covers all years through 1965. An entry in the *IEJ* is counted as an "article," with full credit given to each author for jointly written papers. The same approach is used for book entries from the *CBI*. Thus, we ignore (on grounds of cost, not conceptual purity) distinctions based on the quality and length of publications.[12] The research-productivity measure, R, used is the simple sum of published articles and books.[13] It might have been preferable to treat articles and books as separate variables; however, we have no theory concerning the determinants of article vis-à-vis book publication. Having decided to aggregate articles and books, we faced the question of how to weight them. The decision to give them equal weight, while arbitrary, was adopted on the pragmatic ground that a publication is a publication; just as some articles are lengthier than others, so books are not different "in kind" from

[9] The quality measures—which are continuous, not discrete, and range from a high of 4.81 to a low of 0.61 on a five-point scale—are described by Cartter (1966). We are indebted to the late Allan Cartter for providing us with his unpublished data.

[10] One cause of incomplete information was our inability to identify the school of Ph.D. for some economists. This information could not be obtained from the National Register file because of NSF's concern about confidentiality. However, prior to the addition to the tape of salary and income information, we had already coded the school of Ph.D. for everyone listed in the AEA *Handbook* and similar sources.

[11] Annual salary is defined in the National Science Foundation (1966) survey as "annual salary before deductions for income tax, social security, retirement, etc., but does not include bonuses, overtime, summer teaching, or other payments for professional work. Do not include rental or subsistence allowances" (p. 207). Our data do not disclose hours worked per week. Thus, we do not know whether, for example, men and women economists who worked "full time" worked equal numbers of hours, and so we cannot be certain that any observed differentials in earnings between men and women reflect differences in pay for equal hours. (This was pointed out, correctly, by a referee.) In our model, however, we focus on rates of remuneration per unit of "output" rather than per unit of input.

[12] A growing literature exists on journal quality and what this implies, as illustrated by the work of Billings and Viksnins (1972) and Moore (1972).

[13] We do not distinguish among edited, original, and textbooks for several reasons. First, such distinctions would have complicated the data collection because the *CBI* does not make the latter two distinctions. Second, and more important, it is not clear that one type of book necessarily adds differentially to an economist's prestige, marketability, and remuneration.

articles. (Other weighting schemes were tried, however, with a book being counted as the equivalent of up to six articles. Coefficients for the earnings equation using the 6:1 ratio are presented below in n. 22.)

The Cartter quality rankings of economics departments refer to 1964. While they seem reliable in reflecting the quality of employment and of training for recent Ph.D.'s, they may be misleading in reflecting the quality of training obtained earlier because of changes in the rankings over time.[14]

Age, A, is measured in calendar years. Length of experience, X, is number of years since receipt of the Ph.D. degree. Sex refers to being male ($S = 1$). Not available were data on such individual characteristics as ability and motivation and on nonresearch outputs.[15] Also unavailable were data on unpublished research and on research which, while published, was in forms other than journal articles and authored books—for example, chapters in books. Earnings are expressed in natural log form, as is customary in the work on earnings functions.[16]

Table 1 displays the means and standard deviations for the data.

III. Empirical Results

A. Structural Model

The structural equation results, estimated by three-stage least squares, and the "typical" single-equation earnings function are provided in table 2.[17]

The bulk of the coefficients in the three structural equations is highly significant.[18] In equation (1), which determines job quality, the expectation of a negative coefficient for earnings is confirmed. It appears that a 1-point increase in the log of salary—which amounts to a 10 percent

[14] Johnson and Stafford (1974*b*) attempted to remedy this problem by using the graduate school rankings for earlier years; however, the irregularity of these earlier rankings (1925 and 1957) makes this an imperfect solution. We opted for the more recent (1964) rather than prior rankings on the grounds that the recent rankings would be most well known and hence most useful.

[15] Some of these outputs are reflected in recent single-equation estimates of Koch and Chizmar (1973), Tuckman and Hagemann (1976), and Tuckman, Gapinski, and Hagemann (1977), as well as Katz (1973) and Siegfried and White (1973).

[16] See, for example, Heckman and Polachek (1974).

[17] The structural model was estimated by three-stage least squares, with instruments for J, R, R^2, and $\log_e E$ being obtained in the first stage, and the typical earnings model was estimated by ordinary least squares. The presence of R^2 in (3) might be thought to complicate identification of the structural parameters; however, the reader will note that exclusion of R^2 results in a linear and identified model under the usual rank and order conditions. Moreover, Fisher (1966, chap. 5) points out that the introduction of nonlinearities cannot hinder identification.

[18] Readers are cautioned that interpretation of the regression coefficients as percentage effects requires the correction $[100(e^{.1497} - 1.0)]$ for the three-stage least squares and $(e^{.275} - 1.0)$ for the ordinary least squares.

TABLE 1

MEANS AND STANDARD DEVIATIONS OF VARIABLES FOR ACADEMIC ECONOMISTS WITH PH.D'S AT PH.D.-GRANTING SCHOOLS, 1966
($N = 863$)

Variable	Symbol Used	Mean	Standard Deviation
Research productivity*	R	6.9	11.9
Degree quality†	D	3.5	1.1
Job quality†	J	2.8	1.2
Age (years)	A	42.6	10.1
Age squared	A^2	1915.2	916.7
Experience (years since Ph.D.)	X	11.0	9.7
Experience squared	X^2	214.6	320.9
Sex (% male) (male = 1; female = 0)	S	.97	.17
Earnings (Log_e) ($ thousands/year)	E	9.5	.3

* Sum of articles and books.

† Defined on a continuous five-point scale, in which the questionnaire categories of "distinguished," "strong," "good," "adequate," and "marginal" were assigned, by Cartter, numerical weights of 5, 4, 3, 2, and 1, respectively. The job quality of economists employed at other than Cartter-ranked departments was arbitrarily set at 1.

increase around the mean—is traded off for a 0.84-unit improvement in job quality. Job quality is enhanced by additional research productivity, R, with an additional 10 publications (around the mean) raising a person's J rating by 0.44 of a unit—which is nearly halfway between, say, a "good" and an "excellent" university.[19] The positive value of the D coefficient indicates that the quality of the job held rises with the quality of the school from which the economist's Ph.D. degree was obtained. This coefficient, however, must be (and is) less than unity, meaning that job quality rises less than degree quality, because all degree recipients cannot end up on the faculties of the relatively small number of Ph.D.-degree-granting departments. Finally, the negative (albeit nonsignificant) sex coefficient means that women tend to be placed and employed at more prestigious institutions than men; this could indicate that the average female economist employed at a Ph.D.-granting school is brighter and more able than the average male economist or that she is a beneficiary of discrimination.[20] Our findings concerning the importance of the sex variable should be tempered with caution, however, since only 26 females are in the 863-person sample.

Turning to equation (2), we find that length of experience, X, as measured by years since receipt of the Ph.D., has a significant impact on research productivity, a result that comes as no surprise inasmuch as time is a crucial input to research and its resultant publications. Each year of experience is associated with an addition of nearly two-thirds of a publica-

[19] For more on the relationship between school rankings and publications, see Cartter's analysis (1966, chap. 4).

[20] For some evidence on this point as it applied to women Ph.D.'s generally, see Harmon (1965, pp. 27–28).

TABLE 2

ESTIMATES OF STRUCTURAL MODEL AND OF "TYPICAL" EARNINGS FUNCTION

Dependent Variable	Constant Term	Earnings (Log_e) E	Coefficient of: Research Productivity R	R^2	Degree Quality D	Job Quality J	Length of Experience X	X^2	Age A	A^2	Sex (Male) S
Structural Model											
(1) J	9.07	−.8384	+.0441	...	+.4833	...	...	...	...	...	−.2946
	(4.15)	(3.56)	(4.63)		(13.66)						(1.41)
(2) R	−21.05	...	...	...	−3.456	9.844	.6395	−.0059	...	...	7.038
	(6.03)				(3.10)	(5.07)	(5.98)	(1.87)			(3.07)
(3) $\text{Log}_e E$	8.863	...	.0762	−.00118	...	−.1229	...	...	.0148	−.0000652	.1497
	(14.68)		(3.49)	(2.71)		(1.82)			(.71)	(.29)	(1.26)
"Typical" Earnings Function											
(4) $\text{Log}_e E$	8.22	...	+.00853	−.0000457	+.00726	+.0291	+.0294	−.000515	+.0268	−.000264	+.275
	(41.5)		(5.50)	(2.24)	(.816)	(3.40)	(7.66)	(4.71)	(2.92)	(2.56)	(5.74)

NOTES.—t-statistics are shown in parentheses. All eqq.control for the fact that some academic economists are on 11–12 month contracts while others are on 9–10 month contracts. The dummy variable used indicates that salaries are about 20 percent higher (t = 4.50) for the 11–12 month group.

tion to the individual's stock of publications, but the negative coefficient for X^2 indicates diminishing marginal returns to experience. We note that economists employed at more prestigious institutions produce an additional 9.8 articles per unit on the job-quality scale. Surprisingly, quality of training, D, has a depressing effect on research output, indicating that academics trained at higher-quality schools produce less published research than do those trained at lower-ranked schools, *ceteris paribus*. This result could, however, reflect the omission of a quality dimension in the measurement of research output. Finally, we note that men are more productive than women. The lower research productivity of females—the estimated seven fewer total publications—is particularly interesting in light of their higher average job quality, which presumably gives them an opportunity to be more productive in research. What causes female research productivity to be smaller is an unanswered question. To the extent that females in the sample have spent more time outside the labor market because of marriage and childrearing, the length of their effective experience is shorter than for males.[21]

The results from the earnings equation (3) indicate that an additional unit of research productivity yields an almost 8 percent increase in annual earnings which, however, diminishes at an increasing rate with the number of publications, reaching a zero increase in earnings at 32 publications.[22]

[21] Women economists are more likely to have "career gaps" in connection with raising a family. Such gaps, involving intermittent professional activities, might be expected to reduce research productivity even during those years in which women were employed. For further discussion of women economists' career patterns, see Reagan (1975). For information on women doctorates in general, see Centra (1974). The mean duration of experience (years since award of Ph.D.) in our sample is 9.5 years for females as compared to 11.1 years for males. However, a difference-in-means test between males' experience and females' experience failed to reveal significant differences in our sample. In various trial regressions that contained sex-experience interaction terms, none of the interaction terms were statistically significant.

[22] $\partial E/\partial R = 0 = 0.076 - 2(0.0018)R$; $R = 32$. The structural earnings equation, comparable to eq. 3 but based on viewing one book as equal to six articles, yields the following estimates:

$$\underset{(16.26)}{\text{Log}_e E =}$$

$$\underset{(3.78)}{8.5307} + \underset{(2.73)}{0.0352R^*} - \underset{(1.85)}{0.000282R^2} + \underset{(1.32)}{0.1880S} + \underset{(0.98)}{0.02544A} - 0.0002026A^2 - \underset{(-1.48)}{0.0764J}. \qquad (3')$$

Comparing these results with those in eq. (3), table 2, we see that the 6:1 assumption produces a considerably higher estimate of the earnings effect of a single book, since $R^* = 6$ for a book in eq. (3′), and a considerably lower estimate for a single article. Because of the effects of the squared research-productivity term in eq. (3′), however, the increment in annual earnings eventually diminishes at a less rapid rate per added unit of publication than is estimated in eq. (3), but at a more rapid rate for each book published. The following illustrates the differences between the estimates in eqq. (3) and (3′), for a person who published one article and one book. In eq. (3), R would equal two publication units, and so we estimate the earnings effect as $0.0762(2) - 0.00118(22) = 0.1477$. By contrast, in eq. (3′), R^* equals seven publication units (six for the book and one for the article), and

Job quality has the expected negative effect on earnings; salaries at "excellent" schools are apparently some 12 percent lower, *ceteris paribus*, than at "good" schools. Thus, combining the results from equations (2) and (3), we conclude that higher-quality jobs yield benefits principally through the greater research productivity they facilitate and stimulate, rather than by enhancing salary directly.

Of related interest is the insignificant effect of age on earnings. Its presence in the earnings equations was based on an equity hypothesis that cannot be accepted, however, at any reasonable confidence level. In addition, the sex coefficient indicates an adverse differential against women—males receive 16 percent more in earnings—although the coefficient is not statistically significant; readers are reminded that only 26 women are in the sample. It should be emphasized that this effect of sex in the earnings equation is a partial effect; it holds constant the indirect effects of sex on earnings through its effects on job quality and on research productivity.

B. The Earnings Function: Comparison of Structural Equation and Typical Earnings Equation Results

The type of single-equation earnings function estimated in previous studies, and which we have termed typical, can be viewed as a reduced form, representing one part of a complete structural system with the other parts not specified. By contrast, our structural earnings equation (3) is estimated simultaneously (by three-stage least squares) in what we believe to be a more fully specified structural system. Thus, it is informative to compare the estimates from our structural system with the estimates from a typical earnings equation, using the same data set. To the extent that the results differ, we believe those obtained from our system are less susceptible to specification error than those obtained from the typical equation.

Consider the effect of research productivity. Over most of the observed range of publications, our model estimates a substantially larger effect on earnings than does the typical single-equation estimate (table 2, eqq. [3] and [4]); indeed, it is more than seven times the effect around the mean number of publications, 6.9. We also find that the rate at which the incremental value of a publication falls is much greater in our model.

Our coefficient for sex is nearly 50 percent smaller than that derived from the typical model (.15 vs. .28), and the level of statistical significance of that coefficient is sharply lower in our model. Note, however, that in our model sex not only affects earnings directly, but it also affects re-

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so we estimate the earnings effect as $0.0352(7) - 0.000282(49) = 0.2326$. Or, suppose a person had published two articles. Because articles and books are of equal value in eq. (3), we would again estimate a 0.1477 earnings effect. However, in eq. (3′), R^* would now equal two publication units, and the earnings effect would be 0.0693. We should also note that associated with the increased weighting of books are changes in the coefficients for the nonresearch variables; A, A^2, and S all increase in absolute magnitude, but J decreases in absolute magnitude.

search productivity and job quality which, in turn, affect earnings. Thus, some of the effect attributed to sex in the typical earnings equation is shifted to these other two variables.[23]

The effects of age are also found to be quite different when our structural system is used, as can be seen in equations (3) and (4). Around the sample mean of 42.6 years, we find that an incremental year of age is associated with an increase of earnings of about 1 percent, whereas the typical earnings equation (4) yields less than half that effect (0.4 percent).[24] The typical function estimates imply that earnings peak at around age 51—holding other variables constant—while our model estimates that each year of age continues to add to earnings until age 57.

The typical equation discloses a positive effect on earnings of an increment in job quality—a 3 percent differential between, for example, a "good" and an "excellent" department. We find, by contrast, that in our model higher job quality is associated with a (13 percent) lower level of earnings, as was hypothesized. This, together with our earlier finding regarding the importance of research, suggests that the frequently observed higher salaries at higher-quality departments are probably the consequence of two opposing forces—(1) the greater research productivity of the faculty, which increases market demand and hence earnings, and (2) the attractiveness of the better departments, which increases the supply of faculty and thus leads to reduced earnings, with the effect of 1 dominating 2.

IV. Conclusion

Salaries of academic economists are determined as part of an interdependent system. When our three-equation model is fitted to a set of data for U.S. economists associated with Ph.D.-degree-granting departments, we obtain substantially different estimates of the earnings function than are obtained from a single-equation function of the type employed in previous studies. In particular, published research has a far greater effect on earnings than has been found from a typical single-equation estimate—about 10 times as great in the vicinity of the mean number of publications.

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[23] The reduced-form earnings equation from eqq. (1)–(3) would show the total effect of sex on earnings; that equation cannot be calculated, however, because its nonlinearity leads to a term in the reduced-form equation that includes a square root of a negative term.

[24] It should be noted that the significant coefficients for both age and experience in the typical function also characterize the results of Klevmarken and Quigley (1976), who use a similar function.

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