Human Capital Measurement and Distribution

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1. Introduction

The concept of human capital has been present in the history of economic thoughts without being systematically developed within a solid theoretical framework. It becomes a main concern of economic analysis in the second half of the 20-th century with the pioneer works of Mincer (1958, 1970), Becker (1962, 1964) and Schultz (1959, 1961).

Before the middle of this century, with the exception of a few distinguished economists such as William Petty, R. Cantillon, J. von Thünen, A. Marshall, I. Fisher and J.M. Clark, who sustain the need of estimating or advancing some estimation of human capital, most economists do not go beyond the acknowledgement of the importance of skill, acquired abilities and education as sources of differential wages and salaries. Some of them go a step further, by accepting the idea that skill, acquired abilities and education contribute to determine the human capital. Others were reluctant to treat human beings as capital, based on an unclear or undefined ethical principle.

This study purports to estimate the human capital of the families using Wold's latent variables modeling with partial least squares and fitting Dagum model of income and wealth distribution to the family human capital estimates. Before this a brief analysis and assessment of the two traditional methods of estimating human capital, i.e. the retrospective and the prospective methods, is presented in Sections 2 and 3. Wold's latent variables modeling and method of estimation is discussed in Section 4. Section 5 presents the case of estimating the human capital as a single latent variable. Section 6 deals with the estimation and distribution of human capital for the U.S. in 1983 and 1986 using the Federal Reserve Board (FRB) sample surveys of wealth distribution. Section 7 presents the conclusions.

2. The Retrospective and Prospective Methods

Two methods of estimation were advanced in the literature: (i) the retrospective, which deals with the cost of production, and (ii) the prospective, which deals with the capitalized earnings approach. The former estimates the cost of producing a human being which might be either net or gross of maintenance, whereas the latter estimates the present actuarial value of a human being's expected income, also net or gross of maintenance.

Ernst Engel (1883) is credited to be the first to apply the retrospective method. He considers three (lower, middle and upper) German social classes and applied a simple formula to estimate the cost c_i $(i=1,2,3)$ at birth of each class, assuming that the first year cost is $c_i q_i$, growing afterward at an arithmetic progression of ratio $c_i q_i$. Hence, at age x, the monetary value of a human being belonging to the i-th social class becomes:

(1) $C_{ix} = c_i\,[\,1+x+q_i\,x(x+1)/2\,],\quad i = 1,2,3;\quad x\leq 26.$

Engel estimates c_i to be 100, 200, and 300 marks for the lower, middle, and upper German social classes, respectively; he makes $q_i = q = 0.10$, and assumes that at the age of 26 a human being is fully produced.

Regardless of the simplicity of Engel's assumptions, his approach should not be taken as an estimate of an individual human capital or the monetary value of a human being. It is only a historical cost estimate, that neglects to include interest, and is done within a strict marginalist approach because of the omission to impute social cost such as education, health service, sanitation, and the social cost of those that did not survive.

William Petty ([1690], 1899) is the most prominent founder of the Political Arithmetick school of economic thought and the forerunner of applied econometrics. Petty is credited to be the first to applied the prospective method to estimate the human capital of a nation.

Unlike Engel's approach that is microeconomic, since he estimates an individual human capital, Petty's approach is macroeconomic, because he purports to estimate a nation human capital without passing through the step of aggregation. However, as Engel, his assumption are extremely simple. Petty estimates England's national income and deduces from it the property income to get an estimate of the wage bill or earned income. He considers it a flow of annual income to perpetuity, hence his estimate of England human capital at a given year is its wage bill divided by the market rate of interest. Besides his interest in public finance, hence in taxation, Petty's interest in human capital was also motivated by his interest in asserting the economic power of England, the economic effects of migration and the cost of human life lost in war.

A rigorous scientific approach to estimate an individual human capital applying actuarial mathematics is developed by Farr (1853). He estimates an individual human capital as the present actuarial (weighted by the survival probability) value of the expected annual earnings, net of maintenance cost (personal living expences).

T. Wittstein (1867) combined both Farr's prospective and Engel's retrospective approaches to estimate a person human capital as a quantitative base to assess compensations for loss of life. Wittstein's approach is limited by the unacceptable assumption of equalizing lifetime earnings and lifetime maintenance.

Dublin and Lotka (1930) adopt Farr's approach and make further contributions to the cost and money value estimate of individuals. They estimate the human value at birth V_0 as the actuarial value of a flow of net earnings $y_xE_x - c_x$, where x is the age of an individual, y_x is earned income from age x to x+1, E_x is the probability of being employed at age x, i.e. the proportion of individuals employed from age x to x+1, and c_x is the cost of leaving from age x to x+1. Being i the discount rate, $p(a, x)$ the probability of surviving at age x of a person having an age $a<x$, and ω his maximum possible age, generally made equal to 100, Dublin and Lotka deduce the following net value of a human being at birth:

(2) $$V_0 = \sum_{x=0}^{\omega} v^x\, p(0,x)\left(y_x E_x - c_x\right),\quad v = 1/(1+i).$$

Hence, the present net value at age a is,

(3) $$V_a = \sum_{x=a}^{\omega} v^{x-a}\, p(a,x)\left(y_x E_x - c_x\right).$$

Since $y_xE_x - c_x$, stands for the net earnings of a person from age x to x+1, c_x, $- y_xE_x$ stands for the net costs, and

(4) $$C_a = \sum_{x=0}^{a-1}(1+i)^{a-x}\left(c_x - y_x E_x\right)/p(x,a)$$

is the net cost at age a of rearing a person from birth to age a. The denominator in (4) implies that C_a includes the per-capita net cost for the surviving population at age a of those that died at age $x<a$.

It follows from (2)-(4) that

(5) $C_a = V_a - V_0(1+i)^a / p(0,a)$.

Farr's, Wittstein's and Dublin and Lotka's contributions stem from their professional interest on life insurance. On the other hand, very often, economists acknowledge that investment in human capital contributes to increase the productive capacity of the labor force, hence, to increase earnings capacity. However, with the main exceptions of Petty, Cantillon, von Thünen, Marshall, I. Fisher and J. M. Clark, they "neither attempted an evaluation of human capital nor employed the concept for any specific purpose", as Kiker (1971, p.57) asserts. Among them we should include A. Smith, Malthus, Say, S. Stuart Mill, List, Bagehot, N. Senior and Walras. Most of them do not go much further than embracing and commenting A. Smith's thought in the Wealth of Nations. A. Smith (1776, B.I, Ch.X) advances five main circumstances which make up for differential pecuniary gain in employment. They are: (i) the agreeableness or disagreeableness of different employment; (ii) the different difficulty and expense of learning them; (iii) the different job security in them; (iv) the different amount of trustworthiness required in them; and (v) the different probability of success in them.

Commenting on the second circumstance, which directly concern the amount of human capital, A.Smith observes that: "A man educated at the expense of much labor and time to any of those employments which require extraordinary dexterity and skill, may be compared to one of those expensive machines. The work which he learns to perform, it must be expected, over and above the usual wages of common labor, will replace to him the whole expence of his education, with at least the ordinary profits of an equally valuable capital". Then he adds the following relevant observation related to the life expectancy at A. Smith's time: An educated man "must do this too in a reasonable time, regard being had to the very uncertain duration of human life, in the same manner as to the more certain duration of the machine".

In the second half of the twentieth century many researchers have estimated the earning function and the rates of return to years of schooling. Besides, three main research purporting to estimate the U.S. human capital were done by Kendrick (1976) and Eisner (1985), applying the retrospective (cost of production) approach, and by Jorgenson and Fraumeni (1988), applying the prospective approach.

3. Some Comments On The Retrospective And Prospective Methods

Section 2 presented the retrospective and prospective methods of estimating human capital. The retrospective or cost of production method is deficient mainly because of the following three reasons:

(i) It fails to account for the social cost borne by a society in the estimate of human capital, such as public investment in education;

(ii) In the cost estimation of human capital, it does not take into account variables such as home conditions (parent's occupation and education, availability of dictionary, encyclopedia, and library at home) and community environment;

(iii) The cost of production estimates completely ignores the genetic contribution to the human capital estimation, including in it health condition.

Points (i) and (ii) come under the general heading of ***nurture***, whereas point (iii) mainly belongs to ***nature*** and is independent of the human being's race, religion, gender, high, weight, etc.

On the other hand, although being scientifically rigorous and relevant, the prospective method requires information that, ex ante, are not available. Its estimates are as good as the data base used.

4. Wold Latent Variables Modeling With Partial Least Squares

This section propose a new method to estimate the humang capital applying Wold's (1982) contributions to model building with latent variables (LVs). In effect, human capital is a latent (non observable) variable (LV). Its estimation can indirectly be done, using a set of indicators (observed variables) such as parental education, occupation, income and wealth; the individual's years of schooling, experience, lagged income and wealth, age, sex, area of residence, job status, years of full time work, occupation, industry and real saving (Dagum, 1994).

Having only one latent variable, the human capital estimate becomes a particular case of Wold's general specification:

(6) $X = a + B\xi + u$

(7) $\xi = b + (\Gamma - I)\xi + v$

where X is a q-order vector of observed (indicator) variables, a is a q-order and b is an m-order vector of parameters, ξ is an m-order vector of latent variables, B is a qxm matrix, Γ is an mxm triangular matrix, I is the identity matrix, u is a q-order vector and v is an m-order vector. The components of u and v are uncorrelated among them, u is uncorrelated with ξ and v_j is uncorrelated with ξ_i, for all $i<j$. The sample size is n.

Wold's model specification is estimated applying the partial least squares (PLS) method. It proceeds in three stages. In the first two, the PLS algorithm works with indicators standardized to zero mean, leaving the location parameters to be estimated in the third stage (Wold, 1982, V.2, p.2).

Each LV is estimated as a weighted aggregate of its indicators. Wold (1982, V.2, p.10) proposes two modes of estimation plus two more that are combinations of the former.

To illustrate Wold's PLS method of estimation applying Mode A and Mode B, let us work with two latent variables and a set of q observed variables. The vector X is decomposed into the q_1-order vector X_1 and the q_2-order vector X_2, not necessarily disjoints. Hence $q_1 + q_2 \geq q$.

Writing the variables in deviation form and symbolizing them by Y_1, Y_2, η_1 and η_2 for X_1, X_2, ξ_1 and ξ_2, respectively, we have,

(8) $\eta_1 = \sum_j w_{2j} y_{2j} + \delta_2$,

(9) $\eta_2 = \sum_t w_{1t} y_{1t} + \delta_1$,

(10) $\eta_2 = \gamma_{21}\eta_1 + v_2$.

PLS Mode A

Given in (8) the initial value w_{2j}=1, for j=1,...,q_2, a first approximation for η_1 is obtained which is used in (9) for η_2 to obtain the least square estimations of w_{1t}, t=1,...,q_1. These estimated weights are used in (8) to obtain a second approximation of η_1 to be used in (9) to get new least squares estimations of w_{1t}. The iteration proceeds until the estimations of the weights w_1 and w_2 converge. At each stage estη_1 and estη_2 are standardized to give unit variance. Hence the scalar f_i of standardization of the η_i latent variable as a linear function of the q_i-order vector y_i is,

(11) $f_i = \left[\hat{w}'_i S_{Y_i} \hat{w}_i\right]^{-1/2}$

where S_{Y_i} is the variance-covariance matrix of Y_i and $\hat{w}_i$ is the column vector of estimators.

Using the LV estimated in stage one above, the second stage estimates the parameters in the block structure (Wold, 1982, p.14),

(12) $y_{1j} = c_{1j}\eta_1 + u_{1j}$, $j = 1,...,q_1$,

(13) $y_{2j} = c_{2j}\eta_2 + u_{2j}$, $j = 1,...,q_2$;

the inner relation between the two LVs,

(14) $\eta_2 = \gamma_{21}\eta_1 + v_2$,

and the causal predictive relations for the indicators in deviation form y_i as a function of the LVs η_h.

The third stage estimates the location parameters using the final estimates of the LVs $\eta_i = \xi_i - \bar{\xi}_i$ and the parameters of the model in deviation form.

PLS Mode B

As in Mode A, Mode B starts with the initial value w_{1t} = 1 to obtain the first approximation for η_2. Then the parameters of the q-order vector y are estimated by simple linear regression of each y_i on η_2. After standardizing the LV to unit variance, the first iteration is completed by estimating the linear regression

(15) $\eta_1 = \sum_{t=1}^{q_1} w_t y_t + \delta_1$.

Using estη_1 to estimate each y_i on η_1 by simple linear regression, a second standardized approximation for η_2 is obtained estimating

(16) $\eta_2 = \sum_{j=1}^{q_2} w_{2j}\, y_{2j} + \delta_2$.

The iterative process continues until the parameter estimates converge to a limit value.

Three important sets of parameters are estimated: (i) the weighting matrix (w_{ij}) given by (15) and (16); (ii) the loading matrix $C = (c_{ij})$ introduced in (12) and (13); and (iii) the matrix of correlation R_i deduced from the matrix of variance-covariance $M(X_i, \xi_i)$ corresponding to (15) and (16), where $M(X_1, \xi_1)$ is the matrix of variance-covariance of the (q_1+1)-order vector $(x_{11},..., x_{1q1}, \xi_1)$, and $M(X_2, \xi_2)$ of the (q_2+1)-order vector $(x_{21},..., x_{2q2}, \xi_2)$, such that

(17) $r(x_{ij}, x_{is}) = s(x_{ij}, x_{is}) / s(x_{ij})s(x_{is})$,

$j, s = 1,..., q_i$; and

(18) $r(x_{ij}, \xi_i) = s(x_{ij}, \xi_i) / s(x_{ij})s(\xi_i)$,

for the (q_i+1)-th row and column of the matrices of correlation R_i, i=1, 2, where $s(x_{ij}, x_{is})$ is the entry in the j-th row and s-th column, j, s = 1, 2,..., q_i; and $s(x_{ij}, \xi_i)$ is the entry in the (q_i+1)-th row and column, for j = 1, 2,..., q_i, of the square matrix $M(X_i, \xi_i)$, i=1,2.

Let S_i be the (q_i+1)-diagonal matrix such that $s(x_{ij})$ is the j-th entry on the diagonal, for j=1,..., q_j, and $s(\xi_i)$ the q_i+1 diagonal entry of S_i; it can be proved that

(19) $M(X_i, \xi_i) = S_i R_i S_i$, and

(20) $R_i = S_i^{-1} M(X_i, \xi_i) S_i^{-1}$.

The scale values of the i-th latent variable ξ_i is obtained from (15) and (16). In effect, passing to the variables with values around their origins, we have

(21) $E(\xi_i) = \sum_j w_{ij} E(X_{ij})$.

5. A Single Latent Variable: The Case Of Human Capital h

When there is a single LV, as is the case of this research, PLS Mode B is applied because PLS Mode A is not feasible (it becomes circular).

It can be proved that the estimate of the LV h is equivalent to the first principal component, and the "first principal component and the first canonical correlation are interpreted as special cases of soft [latent variables] modeling" (Wold, 1982, V.2, p.3).

The multiple linear regression model of human capital as a function of q indicators, in deviation form, is:

(22) $\eta = \sum_j w_j y_j + \delta$

As in the general case, the first iteration gives the initial value w_j=1, j=1,2,...,q, to obtain the first estimates of η. After standardizing to unit variance, the resulting estimates of η are used to estimate w_j in the simple linear regression model $\eta = w_j y_j + \delta_j$, j = 1,2,...,q. Replacing the parameter estimates w_j in (22), new estimates of η are obtained. After standardization, they are used to make a second round of estimation of w_j, j=1,2,...,q, one at a times, from the corresponding simple linear regression model, until the iteration converge to a limit value.

Using the final estimates of η, the "factor loadings" c are estimated from the regression equation

(23) $y_j = c_j \eta + u_j$, $j = 1,2,...,q$.

Using (22), the location parameter w_0 is estimated. Hence, the scale value of the latent variable h is obtained, i.e.

(24) $E(h) = w_0 + \sum_j w_j E(X_j)$.

6. Applications To The U.S. Federal Reserve Board Sample Surveys

Wold's contribution to model building with latent variables and method of estimation was applied to estimate the family human capital from the 1983 and 1986 U.S. FRB sample surveys on wealth distribution applying Lohmöller's (1984) software for PC. These estimates are mainly experimentals purporting to test the validity of Wold's approach, working with a single latent variable and a small set of indicators given in monetary values.

Based on the information provided by the FRB sample surveys and limiting the selection of the observed variables to those given in monetary values, model (22) is specified as a function of four (q=4) indicators for the 1983, and six (q=6) for the 1986 sample surveys. For 1983, the indicators are: X_1=paper assets; X_2=real assets; X_3=1983 household annual income; and X_4=total debt. For the 1986 U.S. sample survey, the six indicators are: X_1=paper assets; X_2=real assets; X_3=1985 household income; X_4=1984 household income; X_5=1983 household income; and X_6=total debt. The indicators in both years are weighted by the education attainment of the head of the household. It takes values from 1 to 5, corresponding to non-completed elementary school, completed elementary school, completed high school, post-secondary and university studies, and university degree, respectively.

The estimated equation (22) for the LV h , with zero mean and unit variance (i.e. η), the vectors c of "factor loadings " in (23), and the vectors of the percentages of the variance of each indicator X_j explained by the LV h are, for 1983:

(25) $\eta_{83} = 0.211y_1 + 0.782y_2 + 0.039y_3 + 0.054y_4 + \delta$,

(26) $c_{83} = (0.220\ \ 0.822\ \ 0.044\ \ 0.052)$,

(27) (40%, 97%, 17%, 23%);

and for 1986:

(28) $\eta_{86} = 0.350y_1 + 0.677y_2 + 0.052y_3 + 0.060y_4 + 0.034y_5 + 0.069y_6 + \delta$,

(29) $c_{86} = (0.405\ 0.778\ 0.052\ 0.0063\ \ 0.042\ \ 0.085)$,

(30) (35%, 88%, 20%, 19%, 18%, 26%).

Passing from η to h, i.e., applying (24), the 1983 and 1986 U.S. family human capital distribution are obtained. They were fitted by the model specified by Dagum (1977,1983,1993,1994),

(31) $F(h) = \alpha + (1-\alpha)(1+\lambda h^{-\delta})^{-\beta}, \; h \geq 0,$

$\alpha<1, (\beta,\lambda)>0, \delta>1,$

applying Dagum and Chiu's (1991) EPID software that minimizes the non-linear sum of the square deviations of the actual from the fitted values. Table 1 presents a selection of statistics given by EPID, i.e., the parameter estimates, sum of the squared errors (SSE) of both cumulative distribution (CDF) and probability density (PDF) functions, Kolmogorov-Smirnov (K-S) statistic, Gini ratio, number m of class intervals for the sample distributions, estimated residual variance (s^2), observed and estimated sample mean and median, the value of h_0, when $h \in (h_0,\infty)$, $h_0>0$, i.e. $\alpha<0$, and the product $\beta\delta$, which determines if the model is zeromodal ($0<\beta\delta\leq 1$) or unimodal ($\beta\delta>1$). The sample size of the responses are, n=4103 families for 1983 (Avery and Elliehausen, 1985) and n=2822 families for 1986 (Avery and Kennickell, 1988).

TABLE 1

STATISTICS OF DAGUM MODEL FITTED TO THE 1983 AND 1986 U.S. FAMILY HUMAN CAPITAL

CONCEPT	1983	1986
α	0.02184	-0.01066
β	0.20505	0.26547
λ (in \$ 10000)	34485.85	7781.29
δ	2.67998	2.32929
h_0 (in \$ 10000)	0	298.0
$\beta\delta$	0.5495	0.6184
SSE (CDF)	0.0095	0.0027
SSE (PDF)	0.0031	0.0008
m	44	46
s^2=SSE/(m-1)	0.00022	0.00006
K-S	0.027	0.018
Gini ratio	0.597	0.591
Estimated mean	238015	282133
Observed mean	301444	330735
Estimated median	135691	161183
Observed median	153857	165135
Sample size n	4103	2822

It follows from Table 1 that:

(i) Since $\beta\delta$ < 1, the fitted human capital probability density functions in 1983 and 1986 are strictly decreasing (zeromodal);

(ii) The very low SSE and K-S statistics and the closeness of the estimated to the observed medians are excellent indicators of the goodness-of-fit of Dagum model. It has to be remembered that for "large" samples sizes in classical statistical inference, the X^2 goodness-of-fit test break down;

(iii) The human capital distributions in 1983 and 1986, with a Gini ratio of 0.597 and 0.591, respectively, present a much more unequal distribution than income and a smaller inequality than total and net wealth;

(iv) The mean values of human capital in 1983 and 1986 are more than twice the corresponding values of total wealth and almost 2.4 times the net wealth.

7. CONCLUSIONS

After a brief discussion and assessment of the retrospective and prospective methods of estimating the LV human capital, Wold's contributions to latent variables modeling and estimations by partial least squares are presented as an alternative. Wold's method requires that each specified LV be estimated with the help of a set of observed variables (indicators). A particular case of Wold's method is presented when there is a single LV, as in this research is the case of human capital.

Applying Wold's method to the 1983 and 1986 U.S. Federal Reserve Board sample surveys on wealth distributions, the human capital is estimated. Dagum four-parameter model is fitted to the resulting family human capital distributions. The fits obtained are very good, which is a supporting evidence in favor of Wold's method.

Some of the indicators identified to estimate human capital are not necessarily the best to be considered, but there was not an alternative because the lack of better indicator in the sample surveys that economic theory would recommend.

To our understanding, it is the first time that Wold's method is applied to estimate the human capital of a population and fitting Dagum model of income and wealth distribution to the corresponding estimates of h. Subject to the availability of better indicators, further research should be done to identify the main variables that account for the stock and the distribution of human capital. Besides, some non-monetary indicators such as year of schooling of the family head and spouse, and their home conditions and social environment before entering into the labor market should have a high priority.

REFERENCES

Avery, R.B. and Elliehausen, G.E. (1985): *1983 Survey of Consumer Finances: Technical Manual and Codebook*, Washington, D.C.: U.S. Federal Reserve System.

Avery, R.B. and Kennickell, A.B. (1988): *1986 Survey of Consumer Finances: Technical Manual and Codebook*, Washington, D.C.: U.S. Federal Reserve System.

Becker, G.S. (1962): "Investment in Human Capital: A Theoretical Analysis", *Journal of Political Economy* LXX (5), Part 2, 9-49.

Becker, G.S. (1964): *Human Capital*, New York: Columbia University Press and NBER, 2nd edition, 1975.

Dagum, C. (1977): "A New Model of Personal Income Distribution: Specification and Estimation", *Economie Appliquée*, XXX, 3, 413-436.

Dagum, C. (1983): "Income Distribution Models", in *Encyclopedia of Statistical Sciences*, Vol.IV, S.Kotz, and N.L. Johnson, Editors-in-Chief, New York: John Wiley and Sons, pp.27-34.

Dagum, C. (1993): "A General Model of Net Wealth, Total Wealth and Income Distribution", *Proceedings of the American Statistical Association, Business and Economics Section*, 153th Meeting, 80-85.

Dagum, C. (1994): "Human Capital, Income and Wealth Distribution Models and Their Applications", *Proceedings of the American Statistical Association, Business and Economic Statistics Section*, 154th Meeting, 253-258.

Dagum, C. and Chiu, K. (1991): *User's Manual for the program 'EPID' (Econometric Package for Income Distribution) for Personal Computers.* Revised Version, Ottawa: Statistics Canada.

Dublin, L.I. and Lotka, A. (1930): *The Money Value of Man.* New York: Ronald Press Co..

Eisner, R. (1985): "The Total Incomes System of Accounts", *Survey of Current Business*, January 1985.

Engel, E. (1883): *Der Werth des Menschen.* Berlin: Verlag von Leonhard Simion.

Farr, W. (1853): "Equitable Taxation of Property", *J.Royal Statist.Soc.*, XVI, March 1853, 1-45.

Jorgenson, D.W. and Fraumeni, B.M. (1989): "The Accumulation of Human and Nonhuman Capital, 1948-84", in *The Measurement of Saving, Investment, and Wealth*, R.E.Lipsey and H.Stone Tice, eds., NBER Studies in Income and Wealth, V.52, Chicago: The University of Chicago Press, pp.227-282.

Kendrick, J.W. (1976): *The Formation and Stocks of Total Capital*, New York: Columbia University Press.

Kiker, B.F. (1971): "The Historical Roots of the Concept of Human Capital", in *Investment in Human Capital*, B.F.Kiker ed., Columbia: University of South Carolina Press, 51-77.

Lohmöller, J.B. (1984): *Latent Variable Path Modeling with Partial Least Squares*, Berlin: Heidelberg Physica-Verlag.

Mincer, J. (1958): "Investment in Human Capital and Personal Income Distribution", *Journal of Political Economy*, LXVI, 281-302.

Mincer, J. (1970): "The Distribution of Labor Incomes: A Survey", *Journal of Economic Literature*, VIII (1), 1-26.

Petty, W. ([1690], 1899): *Political Arithmetick*, reprinted in C.H. Hull, *The Economic Writings of Sir William Petty*.

Schultz, T.W. (1959): "Investment in Man: An Economist's View", *Social Science Review*, XXXIII (2), 109-117.

Schultz, T.W. (1961): "Investment in Human Capital", *American Economic Review*, LI (1), 1-17.

Smith, A. ([1776], 1937): *The Wealth of Nations*, New York: The Modern Library.

Wittstein, T. (1867): *Mathematische Statistik und deren Anwendung auf National-Ökonomie und Versicherung-wissenschaft.* Hanover: Hahn'sche Hofbuchland-lung.

Wold, H. (1982): "Soft Modeling: The Basic Design and Some Extensions", in *System Under Indirect Observation: Causality, Structure, Prediction*, K.G. Jöreskog and H.Wold, eds., V.2, 1-54.