E C O N O M I C S   B U L L E T I N

AN AGGREGATED INDEX OF HUMAN CAPITAL

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Abstract

In this paper, taking the model of Arrazola and Hevia (Applied Economics Letters, 11 – 145-8, 2004) as a starting point, we propose a homogeneous measure of human capital of individuals, which permits interpersonal comparisons. This indicator has been set up for a sample of Spanish men and women and compared to the results obtained when using Portela's proposal to construct a human capital indicator (Economics Letters, 72, 27-32, 2001). It was concluded that both from a theoretical and empirical point of view, the properties of the index proposed in this article are better than those of Portela's suggested measure.

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1. Introduction

The problem of measuring human capital has often been posed both in macroeconomics and in microeconomics. At a macroeconomic level, the literature has focussed on the proposal of aggregated measures of human capital stock for an economy which would permit intertemporal and/or interregional comparisons. In the sphere of aggregated macroeconomic indicators, works like those of Barro and Lee (1993) and (2000) and Martin et al. (2000) can be cited. These indicators usually exclusively capture the component associated with investments in regulated training, ignoring others like the learning acquired through other training routes or from job experience.

In the microeconomic context, it has been considered that the human capital of individuals is constituted by various components like, for instance, their educational level and their work experience. In spite of the interest in having a single and homogeneous measure of the human capital of individuals to make interpersonal comparisons or to analyze the relevance of human capital in different economic areas like wage determination, productivity analysis, etc. (see, for instance, Blau and Kahn, 1996), the literature on this subject is sparse.

However, it is worth highlighting the work of Portela (2001), who proposes a multidimensional index permitting the different components of human capital to be aggregated into a single variable. To be specific, for an individual with S years of studies and t years of experience, Portela (2001) suggests calculating the following human capital indicator:

$$HCP_{it} = \bar{S}\left(0,5+\frac{e^{(S_i-\bar{S})/\sigma_S}}{1+e^{(S_i-\bar{S})/\sigma_S}}\right)\left(0,5+\frac{e^{(t-\bar{t})/\sigma_t}}{1+e^{(t-\bar{t})/\sigma_t}}\right) \qquad (1)$$

where $\bar{S}$ is the mean population level of schooling, $\bar{t}$ is the mean population level of experience for each schooling level, and σ_S and σ_t are, respectively, the standard deviations of education and of experience per educational level.

The advantage of the Portela proposal is its simplicity, but it poses three problems. Firstly, it lacks any reference theoretical framework since it is generated in an *ad hoc* manner imposing a modified logistic function for the distribution of human capital components. Next, the aggregation of human capital components proposed does not take into account the different economic returns that each of those components might have. Thirdly, it does not contemplate the depreciation to which human capital is subjected and which makes, for instance, individuals with a same educational level have a different effective endowment of capital because they have carried out their studies at different moments in time.

In this context, and taking the Arrazola and Hevia (2004) model as a starting point, in this work a human capital model is proposed, which overcomes the problems of the Portela (2001) index. In addition, both indicators have been calculated for a sample of Spanish men and women and these have been compared to each other.

2. A human capital measurement proposal.

The starting point is the wage equation proposed in Arrazola and Hevia (2004), who establish for each individual i with t years of work experience the following relation:

$$\ln Y_{it} = \ln W + \beta_K \left[\sum_{j=0}^{t-1} (1-\delta)^j \, I^*_{i\,t-j} + (1-\delta)^t \, K_{i0} \right] + \beta_Z \, Z_{it} + \ln\left(1 - I^*_{it}\right) + u_{it} \qquad (2)$$

with

$$K_{it} = \sum_{j=0}^{t-1} (1-\delta)^j \, I^*_{i\,t-j} + (1-\delta)^t \, K_{i0} \qquad (3)$$

where I_{it}^* is the gross increase in human capital (K_{it}), which is measured in terms of the percentage of time devoted to the increase in the stock of human capital and, therefore, not devoted to obtaining earnings, δ is the human capital depreciation rate, K_{i0} is the initial stock of human capital acquired during the formal education stage, β_K is the human capital rate of return, Z_{it} is a set of socioeconomic variables which have an influence on potential earnings, β_Z is a vector of parameters, W is the rental price per equivalent unit of capacity to obtain potential earnings, u_{it} includes other random influences on potential earnings and Y_{it} are the observed earnings.

It is worth noting that neither I_{it}^* nor K_{i0} are observable, so that if (2) is to be estimated, some identification restrictions must be introduced. In this respect, it would seem appropriate to assume, as is usual in this literature, that during the schooling age all the available time is employed in increasing human capital stock, and that after the conclusion of studies, I_{it}^* decreases linearly with experience, until it becomes zero at the moment of retirement. Namely:

$$K_{i0} = S_i$$

$$I^*_{it} = \alpha - \frac{\alpha}{J - S_{i0}} t$$

where S_i are the years of formal education, J is retirement age (usually 65), t are the years of professional experience, and S_{i0} is the age at which the individuals finish their formal education. Thus, (3) is transformed into what will be our human capital index:

$$HCAH_{it} = K_{it} = (1-\delta)^t \, (S_i) + \left[\frac{1-(1-\delta)^t}{\delta} \right] \left[\alpha + \frac{\alpha}{J - S_{i0}} \left(\frac{1-\delta}{\delta} \right) - \frac{\alpha \, t}{\left(J - S_{i0}\right)\delta} \right] \qquad (4)$$

The problem is that this measure depends on unknown parameters. However, from (2) and (4) we obtain:

$$\ln Y_{it} = \ln W + \beta_K \left\{ (1-\delta)^t (S_i) + \left[\frac{1-(1-\delta)^t}{\delta} \right] \left[\alpha + \frac{\alpha}{J - S_{i0}} \left(\frac{1-\delta}{\delta} \right) - \frac{\alpha t}{(J - S_{i0})\delta} \right] \right\}$$

$$+ \ln \left(1 - \left(\alpha - \frac{\alpha}{J - S_{i0}} \right) \right) + \beta_Z Z_{it} + u_{it} \qquad (5)$$

By making the usual assumptions about the disturbances, equation (5) can be estimated by non-linear techniques, and constitutes the basis for the estimation of the human capital measure proposed in (4)[1].

It is important to point out the following four issues when comparing our proposal to that of Portela (2001). First, the parameters on which the suggested indicator depends have a clear economic interpretation. Secondly, the indicator aggregates different components like education and experience, taking into account that each of these components has a different economic return. Third, the indicator contemplates the existence of human capital depreciation. Finally, this measure could include other human capital components, making the post-school investment and/or depreciation depend on those other components.

However, it should be noted that the proposal made in this article also has some limitations. The first of these is that for its application it would be necessary to estimate the parameters by non linear estimation techniques, although this should not pose a serious problem. The second limitation is that the quality of the indicator depends on the assumptions made about the functional forms, as well as on the quality of the estimation of the model's parameters. In any case, this last drawback also affects the Portela (2001) proposal, since, to carry it out, the population parameters have to be estimated **(**$\bar{S}$ **,** $\bar{t}$ **,**σ_S and σ_t **).**

3. Results and comparison

Taking a set of 1994 Spanish data proceeding from the European Household Panel, the *HCAH* and *HCP* were calculated. For the construction of the indicators, the human capital components considered were education and experience. The sample was made up of wage-earners aged between 16 and 65 years, who worked over 15 hours per week and from whom all the necessary information to set up the variables used in the estimation was available. In all, data were obtained from 1690 women and 3360 men. The variables employed in the analysis were: the hourly net wages, the highest educational level completed by individuals and their work experience (both measured in years), and a set of dummy variables which specified the individual's area of residence.

Table 1, column 1, shows the results of the estimation by Non Linear Least Squares of the equation (5) for men and women, from which the *HCAH* was calculated using the equation (4). For the estimation it was assumed that individuals retire at 65 and that they do not work while studying, or before the age of 16. To approximate the *HCP*, the population

[1] Note that the identification in the equation (5) is achieved thanks to the assumptions made about the functional form of I_{it}^* and K_{i0}. For more details, see Arrazola and Hevia (2004).

mean and the standard deviation were estimated, respectively, by the sample mean and the standard error.

Table 2 shows the mean and the standard error of the *HCAH*, of the *HCP*, and of the variables Education and Experience, calculated for the men and women. As can be seen, the *HCP* has a lower mean and lesser dispersion than the *HCAH*.

Figures 1 and 2 exhibit, respectively, the profiles *HCAH*-Experience and *HCP*-Experience per level of education for men and women, these profiles being completely different. The *HCP* ignores the human capital depreciation, with the result that the profiles obtained with this measurement are always growing, while, conversely, the *HCAH* does take it into account so that its profiles reach a maximum for a number of years of experience, which, in turn, depends on the study level. The S-shape of the curves for the case of the *HCP* is due to the implicit assumption of a logistic distribution in its calculation.

As previously mentioned, from a theoretical perspective, the *HCAH* is preferable to the *HCP*. However, it would also be of interest to compare both indicators from an empirical point of view. Given the income generation dimension of human capital, it would be helpful to analyse which measure has a better wage prediction capacity. For this, three wage models were considered: the model (5) which includes the *HCAH* measure, a model relating the logarithm of the wages to the *HCP*, and the Mincerian model which relates the logarithm of the wages to the educational level and a quadratic function of experience. The results of the estimations appear in Table 1, columns I, II and III, respectively. The standard error, the root mean squared error and the mean absolute error of the three models suggest that the model with the *HCAH* (column I) has a greater wage prediction capacity than the model with the *HCP* (column II) and a similar prediction capacity to that of the Mincerian model (column III).

To confirm this result, we measured, by using different statistics, the relationship of actual wages with the series of fitted wages. The series of fitted wages were obtained from the three models in Table 1 using our sample. The results are shown in Table 3.

Firstly, it should be noted that the χ^2 of Pearson for the existence-of-relation test shows evidence of the existence of a relationship between actual wages and the predictions of wages made with the three models. Furthermore, the phi coefficient, the Cramer's V and the Contingency coefficient are measures analogous to the correlation coefficient, and these three measures are bounded between 0 and 1, a higher number indicating a stronger relationship between the variables. While the correlation coefficient only measures the linear association between two variables, these nonparametric measures are robust to departures from linearity. The degree of association between the observed wages and the prediction made with the *HCP* was lower than that of the *HCAH* case, which can be interpreted in the sense that the HCAH has a greater ability to explain human capital as a generator of income than the HCP. As can be seen, on general lines, the predictions made taking the model incorporating the HCAH are also better than those made with the Mincerian model.

4. Conclusions

The human capital of individuals is made up of various elements, so that disposing of a measure including all those elements is highly important when comparing the human capital endowments of individuals. In this context, the aim of this work was to propose a human capital index which permits the homogenization of the different components of which human capital consists. Also, when our indicator was compared to that of Portela (2001), one of the few indicators proposed in the literature, it was concluded that ours had better properties.

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Table 1. Wage equations
(Dependent variable: log(hourly wage))

	Arrazola and Hevia I		Portela II		Mincer III	
	Men	**Women**	**Men**	**Women**	**Men**	**Women**
Constant	5.789 (0.033)	5.582 (0.046)	5.449 (0.039)	5.168 (0.050)	5.466 (0.033)	5.250 (0.047)
Return to human capital (β_K)	0.085 (0.004)	0.081 (0.005)	-	-	-	-
Skill function (α)	0.387 (0.025)	0.277 (0.031)	-	-	-	-
Depreciation rate (δ)	0.012 (0.003)	0.003 (0.003)	-	-	-	-
Portela's index	-	-	0.127 (0.004)	0.127 (0.004)	-	-
Schooling	-	-	-	-	0.064 (0.002)	0.074 (0.003)
Experience	-	-	-	-	0.040 (0.002)	0.042 (0.003)
Experience^2/100	-	-	-	-	-0.054 (0.005)	-0.067 (0.010)
χ^2_6 **variables of region of residence**	87.689	15.482	98.504	28.545	92.204	108.237
Standard error	0.420	0.440	0.435	0.454	0.420	0.435
Root Mean Squared Error	360.161	318.415	381.335	342.672	363.567	328.549
Mean Absolute Error	232.765	216.875	245.002	230.723	232.858	228.329
N	3,360	1,690	3,360	1,690	3,360	1,690

Note: White Standard errors in parentheses.

Table 2. Descriptive Statistics

	Men		Women	
	Mean	**SE**	**Mean**	**SE**
HCAH	11.650	3.163	12.821	4.060
HCP	8.480	2.141	9.818	2.562
Schooling	8.710	4.164	10.051	4.456
Work experience	21.366	13.007	16.577	11.77
N	3,360		1,690	

Table 3. Wage: Predicted versus actual

	Arrazola and Hevia		Portela		Mincer	
	Men	**Women**	**Men**	**Women**	**Men**	**Women**
χ^2 **(degree of freedom)**	1169.928 (12)	563,830 (9)	871.631 (16)	352.659 (12)	1122.707 (12)	523.681 (9)
Correlation coefficient	0.629	0,668	0.556	0.591	0.627	0.675
Phi coefficient	0.590	0,578	0.509	0.457	0.578	0.557
Cramer´s V	0.341	0,333	0.254	0.264	0.334	0.321
Contingency coefficient	0.508	0,500	0.454	0.415	0.500	0.487
N	3,360	1,690	3,360	1,690	3,360	1,690

Figure 1. HCAH-Experience profiles

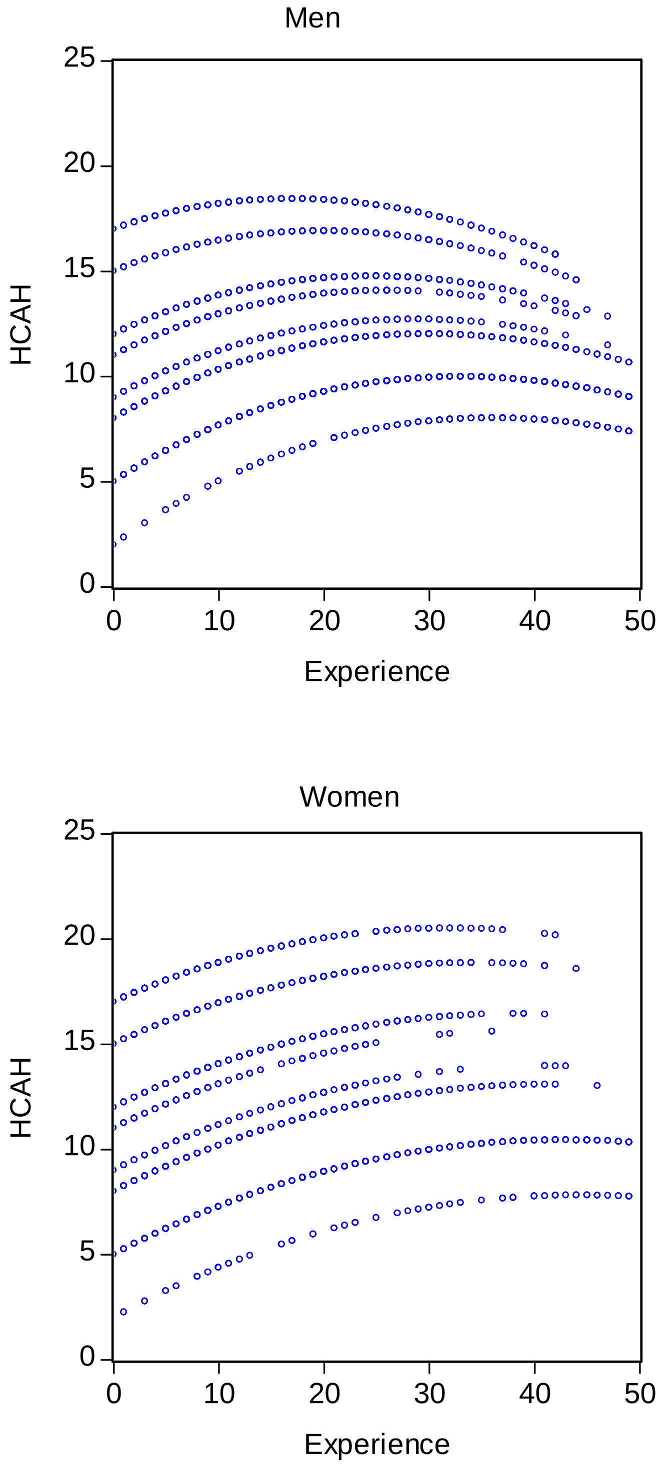

Figure 2. HCP-Experience profiles