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NOTASECONÓMICAS

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JOÃO PAULO CABRAL PEREIRA MEASURING HUMAN CAPITAL IN PORTUGAL

REFORMA ECONÓMICA E CONVERGÊNCIA ARGENTINO PESSSOA

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Measuring Human Capital in Portugal*

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resumo

Apesar do capital humano ser largamente utilizado como um factor produtivo nos modelos de crescimento económico, em estudos empíricos a sua capacidade explicativa é discutível. Os resultados variam desde efeitos sobre a taxa de crescimento do produto, sobre o nível do produto ou mesmo não se encontrando relação entre o capital humano e o crescimento económico. O capital humano é normalmente medido através de variáveis ligadas ao conhecimento ou à escolaridade. Estas variáveis estão sujeitas a importantes erros de medição, que podem justificar os diferentes resultados empíricos. O presente estudo reconhece a importância de uma boa medição do capital humano. Constroem--se três séries anuais para Portugal, uma delas baseada na escolaridade média para o período 1960-2001, mas com uma metodologia diferente de outros estudos disponíveis para Portugal, e outras duas séries baseadas no rendimento do trabalho para o período 1982-1998.

Bien que le capital humain soit largement utilisé comme un facteur productif dans les modèles de croissance économique, sa capacité explicative, lors d'études empiriques, est discutable. Les résultats peuvent varier des effets sur le taux de croissance du produit au niveau du produit et on peut même ne trouver aucune relation entre le capital humain et la croissance économigue. Normalement, le capital humain

résumé / abstract

est mesuré au moyen de variables liées à la connaissance ou à la scolarité. Ces variables sont soumises à d'importantes erreurs de mesure, lesquelles peuvent justifier les différents résultats empiriques. La présente étude reconnaît l'importance d'une bonne mesure du capital humain. Pour le Portugal, trois séries annuelles ont été établies : l'une d'entre elles basée sur la scolarité moyenne pour la période 1960-2001, mais avec une méthodologie différente d'autres études disponibles pour le Portugal, et les deux autres basées sur le revenu du travail pour 1982-1998.

Although human capital is widely used as an input in modern economic growth models, in empirical studies, its importance in explaining economic growth is still an open issue. In fact, results range from influence in Gross Domestic Product growth rates to just a levels effect, and there are even several studies that find no significant explaining capability of human capital in economic growth. Human capital is usually measured through a proxy related to the population knowledge or to education. These proxies are prone to important measurement errors that may be the basis for the different found results of their effects on economic growth. The present study recognizes the importance of a good measure of human capital. It builds three annual series for Portugal, one of them based on years of schooling for the period 1960 to 2001, with a methodology different from other studies available for Portugal, and two others based on the market labour income for the period 1982 to 1998.

* This article is a short version, with some modifications, of my Master Thesis in Economics. I am especially grateful to Miguel St. Aubyn, my supervisor, for his guidance and useful comments. I also would like to thank comments and suggestions made by Aurora Teixeira and Álvaro Pina. The views expressed in the article are those of the author and do not bind any institution. Of course, all errors and mistakes are my responsibility.

1. Introduction

Human Capital may be defined as the set of resources embedded in people. It has a multifaceted nature, ranging from knowledge to health. Investment in human capital can be defined as "...activities that influence future real income through the imbedding of resources in people. This is called investment in human capital" (Becker, 1962: 9).

Many authors emphasize the importance of these resources of people in economic growth (e.g., Lucas, 1988; and Romer, 1990). Empirical studies that introduce a proxy of human capital stock in modelling economic growth such as Mankiw et al. (1992), Kyriacou (1991), Benhabib and Spiegel (1994), Pritchett (2001), Temple (1999), Bassanini and Scarpetta (2002), de la Fuente and Doménech (2001b) have not been consensual in the results found in terms of sign and significance of the human capital stock.

The proxies used are related to knowledge, usually measured by the population's education, because theoretical models emphasize this dimension as a pre-requisite to the production of research and utilization of new technologies.

An argument accepted by many, as Cohen and Soto (2001) and de la Fuente and Doménech (2000), to justify these empirical disparities, are the probable measurement errors contained in the series of human capital stock. The present study recognizes the importance of improving the series of human capital. We build three annual series of human capital stock for Portugal. One is a series of average years of schooling, and two other based on the labour market value of human capital.

The average years of schooling is a measure with a widespread use, although the construction methodology differs among studies. Broadly, we can divide these studies in terms of the kind of data they use: some rely on enrolment data (Lau et al., 1991; Nehru et al. 1995), and others rely primarily on census data (Psacharopoulos and Arriagada, 1986, Barro and Lee, 1993; 1996; 2000; de la Fuente and Doménech, 2000; 2001a; 2002; Cohen and Soto, 2001).

Using data from the censuses is conceptually more correct than relying only on enrolment data, since the censuses give us directly the educational attainment of the population in a given year, which is a stock variable, while the enrolment data is a flow variable. Nevertheless, when trying to fill the years between censuses, it is necessary to use some kind of flow data.

Specifically for Portugal we emphasize the annual series built by Teixeira (1997; 1998; 2004), Teixeira and Fortuna (2003), Pina and St. Aubyn (2002) and Pereira (2004). The series constructed by Teixeira rely on the methodology of Barro and Lee (1993) to get data on a five-year basis, and then use the methodology of Kyriacou (1991) to fill in the remaining years. Pina and St. Aubyn (2002) also use the methodology of Barro and Lee (1993), but then fill the remaining years with straight interpolation.

The series of average years of schooling, constructed in the present study, is an improved version of Pereira's (2004) and covers the period from 1960 to 2001. This is done using a methodology that improves on existing series for Portugal, by using some variables that were not used in those studies and by appealing less to interpolations and estimations, as will be explained in section 2.

The average years of schooling, has however some limitations, for example, it assumes perfect substitution between workers with different levels of schooling. By weighting the population by the level of education attained, in a linear way, it implies that a person with twice the years of schooling of another person would be twice as productive. It also does not take into account the quality dimension of educational systems, which can be very limiting, especially when the series are used in cross-country studies. For example, Lebre de Freitas (2000) in a comparative analysis of the growth sources of Ireland, Spain and Portugal, and using as a source The World Competitiveness Yearbook (1997), places, in a ranking of 46 countries, Ireland's education





quality in 2nd, Spain in 34th and Portugal in 41st. On the other hand, a measure based on average years of formal education has necessarily an upper bound.

An alternative measure of the human capital stock is based on its labour market value. The population by educational attainment is weighted by the market value of the corresponding level of education. This is a conceptually more correct proxy of the human capital stock but it is more difficult to obtain, especially when we are trying to build annual series. Some studies that follow this approach are Mulligan and Sala-i-Martin (1995), Koman and Marin (1997), Laroche and Mérette (2000), Pereira (2004) and Silva (2004).

In this study, as in Pereira (2004), we present two annual series of human capital stock based in the labour market income for the period 1982-1998. As far as we know, this study, together with Silva (2004), constitute the first attempt to build annual series of human capital stock for Portugal based on this method.

The paper is organized as follows: in the next section we calculate the educational attainment of the Portuguese population, which will serve as the basis for all the human capital series we will build, in section 3 we calculate the average years of schooling, in section 4 we compare our series of average years of schooling with others available for Portugal, in section 5 we calculate our series based on the market value of human capital, finally section 6 concludes and presents some ideas for further research.

2. Educational Attainment of the Population

In order to build these series, it is necessary, first, to calculate the educational attainment of the population. The methodology used is based on Laroche and Mérette's (2000), which we can consider as a refinement of the original contribution of Barro and Lee's (1993), in the sense that it combines data from censuses with flow variables, to build the values for the years between censuses.

The population relevant for this study is the population between 15 and 64 years old, because it mimics better the potential working force. A perpetual inventory method is used that anchors on data from censuses. We start in a census year and calculate all years until the next census, by using data on schooling completion, migration flows, mortality rates and retiring population. When we reach the next census, it is probable that the figures we have are different from those given by the census, so we include an adjustment variable.

This method introduces some improvements over that of Teixeira's (1997; 1998; 2004), Teixeira and Fortuna's (2003) and Pina and St. Aubyn's (2002) by the way that the years between censuses are filled. For example, the use of migration flows, that these other studies ignore, is an important variable to take into consideration in the Portuguese case, and it introduces an important variation dimension for the between censuses years. Another important aspect is that we use data on schooling completion instead of enrolment data, and we use a mortality rate to depreciate our human capital stock. We also present the Portuguese population divided into 10 levels of schooling, which is more than the ones presented in those studies. Due to the lack of data, however, we were not able to use different mortality rates by age and educational level, which would be theoretically more accurate.

For disaggregating the data in the censuses in additional levels of schooling than the ones available, we opted to do it by using the proportion of the level of schooling completion of the same year to determine the proportion of that level in the census data. We are aware that it is a strong assumption because we are using flow data to determine stock data in a straightforward manner. However, some other studies also combine the use of census data with flow data, like Kyriacou (1991), Barro and Lee (1993; 1996; 2000). We used this procedure for the censuses of 1960, 1991 and 2001. We also did some adjustments in census data due to classification differences.

The levels of education in which the population is divided are the following:

- Level 0: no schooling.

- Level nf: no schooling, but acquired the ability to read and write.
- Level pi: incomplete primary.
- Level 1: primary or 4 years of schooling.
- Level 2: 6 years of schooling.
- Level 3: 9 years of schooling.
- Level 4: end of secondary in a sub sample and equivalent to 11 years of schooling.
- Level 5: end of secondary in a sub sample and equivalent to 12 years of schooling.
- Level 6: "ensino médio", a sort of lower higher education.

- Level 7: higher education.

The number of individuals aged 15 up to 64 years old, whose higher level of education attained is *s* in year *t*, $L_{s,t}$ and with s = 0, *nf*, *pi*, 1, 2, 3, 4, 5, 6, 7 is given by the following formula:

$$\begin{split} & L_{0,t} = L_t - \sum_{s=1}^{7} L_{s,t} = L_{pi,t} - L_{nf,t} \\ & L_{1,t} = L_{1,t-1} \left(1 - \delta_t\right) + PE_{1,t-15+4+6} - PE_{2,t-15+6+6} - OUT_{s,t} + SM_{s,t} + AJ_{s,t} \\ & L_{2,t} = L_{2,t-1} \left(1 - \delta_t\right) + PE_{2,t-15+6+6} - PE_{3,t} - OUT_{s,t} + SM_{s,t} + AJ_{s,t} \\ & L_{3,t} = L_{3,t-1} \left(1 - \delta_t\right) + PE_{3,t} - PE_{4,t} - OUT_{s,t} + SM_{s,t} + AJ_{s,t} \\ & L_{4,t} = L_{4,t-1} \left(1 - \delta_t\right) + PE_{4,t} - PE_{6,t} - PE_{7,t} - OUT_{s,t} + SM_{s,t} + AJ_{s,t} \\ & L_{5,t} = L_{5,t-1} \left(1 - \delta_t\right) + PE_{5,t} - PE_{7,t} - OUT_{s,t} + SM_{s,t} + AJ_{s,t} \\ & L_{6,t} = L_{6,t-1} \left(1 - \delta_t\right) + PE_{6,t} - OUT_{s,t} + SM_{s,t} + AJ_{s,t} \\ & L_{7,t} = L_{7,t-1} \left(1 - \delta_t\right) + PE_{7,t} - OUT_{s,t} + SM_{s,t} + AJ_{s,t} \end{split}$$

where:

 L_t is total population between 15 and 64 years old in year t.

 δ is the average rate of mortality in year *t*.

 $PE_{s,t}$ is the number of individuals that completed the level of schooling *s* in year *t* and that were in the level of schooling *s*-1 in *t*-1. In levels 1 and 2 we did not apply the mortality rate to the period that goes from the age of schooling completion to the 15 years old. We assumed it was zero. We considered that applying the average mortality rate to individuals with less than 15 years old, would be more biased than simply ignoring the mortality rate.

 $OUT_{s,t}$ is the variable that captures people leaving the stock, i.e. those above 64 years old. It is estimated using the population with ages between 55 and 64 years old from the previous census (because censuses are usually separated by ten years), and then the mortality rate is applied.

 SM_{st} is the migratory balance of individuals with schooling s in year t.

 $AJ_{s,t}$ is the adjustment variable of schooling *s* in year *t*, introduced in the formula in order that in the year of the census, the value returned by the formula equals the value of the census. The mortality rate was also considered.

 $L_{pi,t}$ and $L_{nf,t}$ are not associated with levels of complete schooling, so the values between the census years were obtained through linear interpolation.

The values of L_{st} are shown in Table 3 in the Appendix.





The task of calculating the schooling completion with the degree of detail that we needed for this study revealed itself a laborious one, because the Portuguese education system suffered several transformations since 1960. There is no available information for some years or for some education levels or for some territorial areas. The source of data was Education Statistics and the site of DAPP-Ministry of Education (www.dapp.min-edu.pt). The procedure used consisted in transversal cuts on the education system, corresponding to 4, 6, 9, 11, 12, 14, 15, 16 and 17 years of schooling. We adapted to changes in the duration of some courses by transferring them to the appropriate level considering the new duration of the course. We also took into account the several levels that existed within one course by classifying them into different levels of schooling when appropriate.

Whenever there was no information on schooling completion, we applied the same approval rate of the same course, in the same territorial area of the nearest previous year that had that information.

The Portuguese educational system suffered several modifications during the period between 1960 and 2001. One important change was the introduction of the 12th year of schooling as a pre university year in 1978. But, although it was necessary to have 12 years of schooling to enter university, that did not apply to level 6. To apply to this level it was only required the completion of level 4. Accordingly, the above-mentioned formulas had to be changed. Thus, for $t \ge 1978$ we now have:

$$L_{4,t} = L_{4,t-1} (1 - \delta_t) + PE_{4,t} - PE_{5,t} - PE_{6,t} - OUT_{s,t} + SM_{s,t} + AJ_{s,t}$$

and, of course: $L_{5,t} = 0$ for t < 1978

3. Average Years of Schooling

Based on Psacharopoulos and Arriagada (1986), in order to obtain our proxy for human capital stock, measured by the average years of schooling (*HS*), we multiply the fraction of population by level of schooling attained by the corresponding number of years of schooling of that level, using the formulas:

$$HS_{t} = \begin{cases} \frac{L_{nf,t} + 2L_{pi,t} + 4L_{1,t} + 6L_{2,t} + 9L_{3,t} + 11L_{4,t} + 14L_{6,t} + 16L_{7,t}}{L_{t}}, \ t < 1978 \\ \frac{L_{nf,t} + 2L_{pi,t} + 4L_{1,t} + 6L_{2,t} + 9L_{3,t} + 11L_{4,t} + 12L_{5,t} + 14L_{6,t} + 16L_{7,t}}{L_{t}}, \ 1978 \le t < 1983 \\ \frac{L_{nf,t} + 2L_{pi,t} + 4L_{1,t} + 6L_{2,t} + 9L_{3,t} + 11L_{4,t} + 12L_{5,t} + 14L_{6,t} + HE_{t}}{L_{t}}, \ t \ge 1983 \end{cases}$$

with:

$$HE_{t} = 16.L_{7,t} + PE_{7,t} + \sum_{j=1983}^{t-7} \left(PE_{7,j} \cdot \prod_{i=j}^{t-7} (1 - \delta_{i}) \right)$$

As showed above, we decided to give some weight to levels *nf* and *pi*, because we felt that it was needed to discriminate between illiterates and people that can read and write (may they have or have not been enrolled in primary school), on the grounds that, ceteris paribus, the latter have a slighter better ability, in their daily work, to interpret instructions not given on a verbal basis.

We decided to divide the period in three parts in order to accommodate the introduction of level 5 in 1978. There is a period before 1978 in which there is no level 5. A transition period between 1978 and 1983, in which people that completed level 5 and entered into higher education did not have the time to complete this last level, so level 7 receives the same weight as before. Finally, after 1983 we calculated the part of higher education (*HE*) as a weighted average of people that concluded level 7's before 1983 and people that entered to the stock after 1983 with one more year of education concluded. Data on schooling completion is presented in Table 4 in the Appendix.

4. Comparing HS with other Measures of Average Years of Schooling

At this stage we compare our measure of average years of schooling (HS) with other measures built for Portugal. Firstly we will start with other annual series. In Table 5 in the Appendix we present the series HS, the series of Teixeira (2004) and Pina and St. Aubyn (2002). Although we present the various series that Teixeira (2004) calculated, we will focus our discussion on the series H''', which considers that the population with incomplete secondary achieved at least the actual compulsory level of education, which is now 9 years of schooling. In Figure 1, we depict the profiles of these series.



As shown, our series have a smoother profile than the other two, which presumably is an advantage, as it is counterintuitive to have sharp variations in the human capital stock, in a context of absence of shocks to the variables used, or even decreases in some years in the 1980s as happens in the Teixeira (2004) series. These different profiles are associated with the methodology used, since we do not rely in interpolations or econometric estimations to fill the years between censuses (such in Pina and St Aubyn, 2002), instead we apply a perpetual inventory method to all the years and, differently from Teixeira (2004) and Pina and St Aubyn (2002), we use an adjustment variable in a way that avoids sharp variations on data.

The average annual rate of growth for HS for the period 1960-2001 was 3,0%, while the series of Teixeira (2004) achieves a higher value of 4,2%. This significant difference between growth rates





is due to differences in initial values of the series. Recall that HS gives a weight to people that have incomplete primary or that learned to read and write without going to school. In the early years of the sample, there are many people that fall into these two levels (See Table 3 in appendix). Concerning the period 1977-2001, in which it is possible to compare with the series of Pina and St. Aubyn (2002), HS presents an average annual growth rate of 2,9%, Teixeira (2004) shows a value of 3,2%, and Pina and St. Aubyn (2002) 2,7%. We can see that Teixeira (2004) presents higher average growth rates than HS for both periods and higher than the series in Pina and St. Aubyn (2002) for the comparable period. Nevertheless, the Pearson linear correlation coefficients between these series are very high, which seems to be not of great help in order to compare them. We will, therefore use the concept of reliability ratio, developed by Krueger and Lindahl (2000), for comparing the above-mentioned series. This procedure was also used previously by several other authors such as Cohen and Soto (2001), de la Fuente and Doménech (2002), Pereira (2004) and Teixeira (2004).

The reliability ratio measures the reliability of a series (X), when there are two series (X and Y) that try to measure the true series (Z), by cov(X, Y)/Var(X), and if there were no correlation between the measurement errors of (X) and (Y) it should assume values between 0 and 1 (the higher the value the more reliable will be the series).

Table 1 presents the computed reliability ratios for the series in differences. As Cohen and Soto (2001) point out, the reliability ratio of the series in levels tends to be high, and drops considerably when calculated in first differences, being the latter a better measure to distinguish between series, as it applies to the variations of the human capital proxies.

Table 1 – Reliability Ratio of annual human capital series in first differences for Portugal						
	HS	Teixeira (2004)	AP_MS (2002)			
HS	-	0.099	0.018			
Teixeira (2004)	0,768	-	0.541			
AP_MS (2002)	0.116	0.159	-			

The values in the table should be read as the reliability ratio of the series in columns when compared with the series in rows. The series HS has the highest reliability ratio of the sample, reaching its maximum when compared with the series of Teixeira (2004) (0.768). Teixeira's series has the highest value when compared with the series of Pina and St. Aubyn (2002) (0.159), and conversely this has the highest ratio when compared with Teixeira's series.

These results might be interpreted as an indicator that the series HS is a better series for proxying the average years of schooling for Portugal, than the other two series considered. However, there should be some caution when interpreting these ratios because, as pointed out by Teixeira, "...given the highly likelihood of these three data series present correlated measurement errors and the fact that Pearson linear correlation coefficients are very high for the whole set of data series, the relative performance and validity of these three proxies have to be tested against growth regression exercises." (Teixeira, 2004, p. 14).

Next we turn to a comparison with series that have a widespread use in several international studies (Barro and Lee (2000); de la Fuente and Doménech (2002); Cohen and Soto (2001)). These series are not annual but presented on a five or ten year basis.

The two series of Barro and Lee (2000) are for the population over 25 years old and 15 years old, de la Fuente and Doménech (2002) calculate the series for the population over 25 years old, and so do Teixeira (2004) and Pina and St. Aubyn (2002). Both the series HS and the series of Cohen and Soto (2001) are related to the population with ages between 15 and 64 years old.

	B_L_25 (2000)	B_L_15 (2000)	D_D (2002)	C_S (2001)	Pereira (2004)	Teixeira H''' (2004)	AP_MS (2002)
Anos	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1960	1.94	1.86	4.37	3.15	2.24	1.36	
1965	2.24	2.44	4.62		2.56	2.01	
1970	2.44	2.60	4.87	4.11	3.05	2.74	
1975	2.79	2.77	5.29		3.54	3.34	
1980	3.27	3.78	5.73	5.57	4.26	3.91	4.29
1985	3.57	3.85	6.06		4.89	4.69	5.03
1990	4.33	4.91	6.41	5.91	5.59	5.15	5.61
1995	4.54	5.47			6.50	5.90	6.60
2000	4.91	5.87		7.28	7.29	7.19	7.47
∆% 1960-2000	2.4%	2.9%		2.1%	3.0%	4.3%	
∆% 1960-1990	2.7%	3.3%	1.3%	2.1%	3.1%	4.5%	
∆% 1980-2000	2.1%	2.2%		1.4%	2.7%	3.1%	2.8%

Source: Barro and Lee (2000), Columns (1) and (2); de la Fuente and Doménech (2002), column (3); Cohen and Soto (2001), column (4); Teixeira (2004), column (6) and Pina and St. Aubyn (2002), column (7). Column (5) presents the series HS of the present study.

Comparing with the series that have values for the three sub periods, we can see that the series HS and the series of Teixeira (2004) have higher annual growth rates except for the case of the series B_L_15 for the period 1960-1990 (whose growth rate is higher than the one of the series HS). The series of Barro and Lee (2000) have significantly lower values for the year 2000 than the other series, which turns out to be more striking when we know that they share part of the methodology. This highlights our perception that not only the methodology is important, but also how direct are the sources of information used. It seems that as we use more national sources, the noise that different classifications introduce will diminish. The value that we obtain for the year 2000 is reassuring because it resembles the values obtained by other studies using different methodologies.

5. Measures Based on the Market Value of Human Capital

As said before, the average years of schooling relate worker's productivity with the level of formal education obtained in a straightforward manner, i.e. schooling differences are mapped into productivity differences in a linear way. This alternative approach to compute a proxy of human capital is based on their market value, allowing for the weighting of the population to depend on a parameter that reflects the value the market gives to schooling and therefore is conceptually more correct. This approach was followed, for example, by Mulligan and Sala-i-Martin (1995), Koman and Marin (1997) and Laroche and Mérette (2000). For Portugal we have the studies of Silva (2004) and Pereira (2004). The former follows the methodology of Mulligan and Sala-i- Martin (1995), while the latter follows the methodology of Koman and Marin (1997) and Laroche and Mérette (2000). The methodologies are similar in substance but while the former uses the



ratio between skilled workers and the zero-skilled worker, the latter uses the marginal returns to schooling.

Using the marginal returns to schooling has the advantage of being a variable that is already available on some studies. A disadvantage is the probable bias in its estimation by OLS. This parameter is the coefficient associated to schooling in a Mincer equation. This equation formulated by Jacob Mincer (1974) has underlying it an analysis between the investment in education and the return of that education during the lifetime period. In its simplest form, this equation establishes a loglinear relationship of wages with years of schooling (several other explaining variables can be included).

Consider W_s the labour income of individuals with *s* years of schooling, W_0 the labour income of individuals without any schooling, *r* the rate of return of an extra year of schooling and *s* the number of years of schooling. The resulting equation is:

$\ln W_s = \ln W_0 + r.s$

We present in this study the series of Pereira (2004) with some corrections. The data on returns to schooling are taken from Pereira and Martins (2002), which is a study of OLS estimates of returns to schooling in Portugal from 1982 to 1998. The data they use is taken from "Quadros de Pessoal", a Portuguese data set on labour data. Although Hartog et al. (2001) also supply the returns to schooling for Portugal, covering the 1980s and early 1990s, it is not computed on an annual basis.

The measure HrI (or HRL in aggregate terms) uses constant marginal returns to schooling (11%), and the measure Hr (or HR in aggregate terms) uses different marginal returns to schooling, according to the levels of schooling attainment. The formulas are:

$$HR = \prod_{s} L_{s}^{\omega_{s}} \text{ with } \omega_{s} = \frac{e^{T_{s}} \cdot L_{s}}{\sum_{s} e^{T_{s}} \cdot L_{s}}$$

$$HRL = \prod_{s} L_{s}^{\omega_{s}} \text{ with } \omega_{s} = \frac{e^{y \cdot s} \cdot L_{s}}{\sum_{s} e^{y \cdot s} \cdot L_{s}}$$

Where γ is the returns to schooling. For each individual, it follows:

$$Hr = \frac{HR}{L} = \frac{\prod_{s} L_{s}^{\omega_{s}}}{L}$$
$$= \frac{L_{0}^{\omega_{0}} \dots L_{n}^{\omega_{n}}}{L}$$
$$= \prod_{s} \left(\frac{L_{s}}{L}\right)^{\omega_{s}} \text{ because } \sum_{s} \omega_{s} = 1$$

and,

$$Hrl = \frac{HRL}{L} = \frac{\prod_{s} L_{s}^{\omega_{s}}}{L}$$

$$=\frac{L_0^{\omega_0}\dots L_n^{\omega_n}}{L}$$

$$= \prod_{s} \left(\frac{L_s}{L} \right)^{\omega_s} \text{ because } \sum_{s} \omega_s = 1$$

We also use a fixed weight W_s , which is the average of the values for the entire period of the series. The use of this fixed weight is based on the fact that annual variation of returns to schooling may reflect, not only changes on the quality of human capital, but also labour market conditions. It is not clear to what extent each of these factors influences changes in γ , but assuming that schooling quality has a more structural nature, it is reasonable to admit that yearly significant changes of γ will reflect mainly labour market conditions. The series are presented in Table 7 in the appendix.

There is one result that contrasts with the results obtained by Koman and Marin (1995) and Laroche and Mérette (2000), although these authors study other countries, like Austria, Germany and Canada. These authors find that the series built with constant marginal returns to schooling (a labour market measure of human capital) grow faster than the series of average years of schooling. Here we only see that result with the series that uses different returns to schooling for each level of schooling.

This is a consequence of the fact that the weight (years) in the average years of schooling grows faster than the weight used in the series Hrl that depends on the value of 11% for the marginal returns to schooling.

These two series are presented in Table 7. We can see that the series Hr grows faster than the series Hrl, which implies that the wage dispersion has been growing. This result can be seen on the data of the different marginal returns to schooling according to the levels of education presented in Pereira and Martins (2002), and is confirmed by the studies of Hartog et al. (2001) and Machado and Mata (2001).

Comparing these series with the values obtained by Silva (2004), we point out that this author presents values for four years (1989, 1992, 1995, 1998), using a methodology based on the ratio of the wage of the skilled worker to the wage of the zero skilled worker, and when we compare the evolution, for example between 1989 and 1998, the implicit values of the referred ratio show a decrease in the period, while both our series show an increase, which is more coherent with the results obtained in the series of average years of schooling. This result obtained by Silva (2004) may mean that his methodology is more sensible to labour market conditions that affect the distribution of wages. We may be more immune to this effect by using a fixed weight W_s in the calculation of our series.

The series built on this study do not take into account neither changes in the quality of schooling or heterogeneity. This is an important drawback because the quality and type of schooling will affect human capital. For example Lee and Lee (1995), Hanushek and Kimko (2000) and Barro (2001) find significant results of proxies of schooling quality in growth specifications. On an empirical study of schooling heterogeneity, Murphy et al. (1991) find that countries with more concentration of engineers grow faster than countries with more concentration of lawyers.

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6. Conclusion

In the present study we estimated series of human capital for Portugal that could improve on existing alternatives. We appealed less to interpolations and relied on more direct sources of data than some of the alternatives, and on the use of some variables that are ignored in other studies, like migratory flows. On a first account, when comparing with other series, our series of average years of schooling performs in an encouraging manner. For example, it shows a smoother profile than other annual series for Portugal, and it presents a high reliability ratio. Comparing our annual series based on labour market income, with the other study available for Portugal, we have some evidence that the methodology we use may be more efficient in the immunization against temporary labour market conditions.

However the best test that can be made to the series built on this study is by putting them into growth regressions. We think they could be useful for further empirical studies on the Portuguese growth process. Another important outcome of this study is the estimation of the educational attainment of the Portuguese population for a period of 41 years. This information could also be useful to other researchers that wish to build different series, but that are somehow dependent on the educational structure of the Portuguese population. Also the data on schooling completion, and other variables used to compute the series for this 41 years period may be of importance for other researchers.

This line of research can be deepened and extended in several ways. In the series based on labour market income, we should correct for the probable bias of the returns to schooling. This bias stems from the fact that the equation estimated lacks unobserved variables, like the individuals ability that will be captured by the schooling coefficient. It is important to consider also knowledge acquired after formal education. We could also divide the educational structure of the population by gender. It could be made an analysis of educational heterogeneity, and, finally, we think the biggest insight we could obtain, as a complement to what was made in this study, would be to study the evolution of the quality of the Portuguese educational system, namely by the construction of a series of human capital quality, although this task seems like a huge challenge due to the lack of sufficient data on the outcomes of students test scores.



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Appendix

Table 3 – Population with ages between 15 and 64 years old by level of schooling, L_{s}							rs old b	y level c	of scho	oling, L	s, t
				Lev	els of scho	oling					Total
Years	0	Nf	pi	1	2	3	4	5	6	7	Total
1960	1,900,326	464,505	1,145,717	1,803,480	131,307	55,433	23,897		21,076	43,132	5,588,873
1961	1,908,188	447,749	1,121,013	1,830,429	170,319	61,479	26,020		21,564	43,313	5,630,074
1962	1,900,338	430,993	1,096,309	1,851,683	211,142	67,660	28,434		22,052	43,280	5,651,891
1963	1,872,408	414,237	1,071,605	1,875,036	252,448	74,893	30,842		22,615	43,329	5,657,413
1964	1,824,501	397,481	1,046,901	1,895,176	294,729	81,655	33,352		22,907	43,066	5,639,768
1965	1,752,586	380,725	1,022,197	1,911,540	334,753	87,865	37,351		22,712	43,154	5,592,883
1966	1,667,072	363,969	997,493	1,932,733	375,347	93,567	41,085		22,590	43,026	5,536,882
1967	1,593,324	347,213	972,789	1,963,726	415,528	101,114	44,356		22,505	43,536	5,504,091
1968	1,516,931	330,457	948,085	1,996,799	454,513	109,061	49,373		22,453	43,807	5,471,479
1969	1,416,407	313,701	923,381	2,011,726	485,602	116,252	55,555		22,215	43,406	5,388,245
1970	1,306,405	296,940	898,680	2,050,770	518,460	126,020	62,290		22,520	44,420	5,326,505
1971	1,278,340	275,230	896,588	2,099,873	510,508	140,426	67,069		27,209	48,049	5,343,292
1972	1,233,689	253,520	894,496	2,158,800	504,038	157,424	72,713		33,156	51,911	5,359,747
1973	1,180,544	231,810	892,404	2,195,327	515,163	173,979	80,610		38,526	56,064	5,364,427
1974	1,188,828	210,100	890,312	2,288,760	523,704	219,485	96,508		45,892	65,096	5,528,685
1975	1,248,715	188,390	888,220	2,408,981	568,352	261,285	111,730		55,981	73,739	5,805,393
1976	1,225,636	166,680	886,128	2,445,479	588,676	288,354	124,664		64,252	84,511	5,874,380
1977	1,199,297	144,970	884,036	2,459,437	643,894	311,764	142,290		68,410	95,367	5,949,465
1978	1,152,171	123,260	881,944	2,493,539	659,316	365,603	146,485	16,668	74,953	109,171	6,023,110
1979	1,100,174	101,550	879,852	2,530,519	690,464	398,941	164,911	33,896	77,643	120,906	6,098,856
1980	1,025,859	79,840	877,760	2,584,027	728,280	428,305	180,403	59,337	79,665	132,062	6,175,538
1981	903,512	58,125	875,670	2,640,191	753,849	455,372	200,290	75,763	80,894	143,449	6,187,115
1982	899,828	55,737	858,347	2,672,103	789,974	465,001	242,577	75,046	81,984	154,857	6,295,454
1983	865,011	53,349	841,024	2,685,770	816,850	485,237	260,967	90,972	83,269	166,452	6,348,901
1984	833,756	50,961	823,701	2,696,020	849,904	504,355	277,248	108,651	84,312	178,617	6,407,525
1985	793,593	48,573	806,378	2,683,610	888,208	533,188	290,321	124,422	85,893	191,103	6,445,289
1986	741,481	46,185	789,055	2,662,009	936,682	561,171	302,993	145,550	88,038	201,505	6,474,669
1987	688,113	43,797	771,732	2,632,333	984,494	600,926	306,636	160,502	90,069	213,403	6,492,005
1988	632,220	41,409	754,409	2,604,533	1,039,430	623,635	316,976	181,373	89,340	225,436	6,508,761
1989	569,023	39,021	737,086	2,572,643	1,078,740	668,914	319,932	209,313	88,558	236,160	6,519,390
1990	504,540	36,633	719,763	2,540,654	1,110,939	709,544	327,812	240,423	87,729	247,217	6,525,254
1991	451,899	34,241	702,441	2,505,699	1,145,811	753,291	331,109	278,499	87,162	261,845	6,551,997
1992	440,572	30,817	675,561	2,476,498	1,154,541	816,253	358,678	312,697	82,224	281,451	6,629,292
1993	372,235	27,393	648,681	2,447,584	1,151,534	892,908	384,766	347,064	77,539	304,030	6,653,734
1994	320,344	23,969	621,801	2,414,310	1,141,087	955,192	428,529	371,668	72,954	336,368	6,686,222
1995	282,177	20,545	594,921	2,372,836	1,116,770	1,034,096	444,908	412,667	68,385	370,563	6,717,868
1996	255,857	17,121	568,041	2,316,208	1,109,640	1,095,187	472,326	443,932	63,911	407,194	6,749,417
1997	232,640	13,697	541,161	2,255,555	1,139,662	1,144,298	495,519	458,827	59,568	446,692	6,787,619
1998	213,462	10,273	514,281	2,214,464	1,144,845	1,189,739	525,872	470,158	55,297	490,229	6,828,620
1999	209,735	6,849	487,401	2,167,865	1,150,240	1,232,982	560,710	472,324	51,081	534,549	6,873,736
2000	209,510	3,425	460,521	2,121,209	1,147,034	1,295,686	587,054	476,208	47,144	582,338	6,930,129
2001	223,994	0	433,638	2,085,442	1,145,973	1,345,540	625,131	470,357	43,329	632,618	7,006.022

Table	4 – Schoo	ling compl	etion, $PE_{s,t}$			-		1	6	
			Lev	els of schooli	ng		-		0	
Years	1	2	3	4	5	6	7	Total		
1956	87,743									
1957	93,858									
958	103,913	17,197								
959	113,968	21,791								
960	122.308	25.682	10.842	4,674		2.854	2,287	168,647		
961	132.920	29.464	11.975	5.341		3,408	2.184	185,292		
962	134,586	32,159	12.956	5,819		3,466	2,121	191,107		
963	137.801	34.550	14.702	6.228		3,564	2.278	199,123		
964	138.646	35,182	14.880	6.315		3.377	2,164	200,564		
965	141.452	37.164	16.878	8.254		2.970	2.704	209.422		
966	140,139	37.110	16.586	8,120		3.050	2,542	207,547		
967	138,586	37.572	17,919	7,891		2,956	2,959	207,883		
968	142.818	39.247	19.989	9,441		2,949	2.683	217,127		
969	147.049	40.922	22.058	10.990		2.941	2.406	226,366		
970	141.100	62.640	24.771	12.244		3.213	3.321	247.289		
971	147,875	73,917	20,789	13,718		4,573	3,068	263.940		
972	151 933	85 124	24 616	15 459		5 750	3.082	285,964		
973	150 459	88 689	27 805	18 230		5.347	3 613	294 143		
974	153 986	119 168	58 697	26.374		6 252	6 4 1 4	370 891		
975	176 677	100.483	46.008	22 372		8,066	4 339	357 945		
976	176 929	103,870	50 594	31,338		8 109	9 764	380 604		
977	181 743	110,874	47 206	31 783		3 982	9,805	385 393		
978	167 174	98.406	68 746	23 045	12 260	6.328	12 725	388 684		
979	165,356	104 432	57 238	31 944	11.061	2 445	10.643	383 119		
980	164 336	103,366	57 762	36.318	19.064	1 759	10,010	392 706		
981	173 721	107,607	54 600	33 534	11 246	1,266	10.942	392 916		
982	171 814	123 958	52 429	63.078	13 544	1 241	8 581	434 645		
983	175.004	140 415	58 896	57 711	30,956	1,596	9 209	473 787		
984	180 618	143,098	57 569	57 554	33 282	1 293	9,775	483 189		
985	181 140	144 976	66,519	55 160	32 717	2 021	10.658	493 191		
986	175 445	153 720	71 489	59 801	36 717	2 688	8.962	508 822		
987	182 604	153 637	72 784	47,743	33.085	2 732	10.969	503,554		
988	176.923	159.075	66.974	58.231	39.539	0	11.316	512.058		
989	168,602	155.005	90,039	57,699	46,079	0	10,370	527.794		
990	160.281	154,497	96.000	67.126	50.353	0	11.034	539.291		
991	148.573	151,574	101.742	71.188	59.877	0	14.039	546.993		
992	148.507	149.872	115.897	76,198	68.666	0	21.449	580,589		
993	148,755	154.287	129.507	76,828	70,999	0	23.981	604.357		
994	140,932	160.812	134,456	95,254	71.336	0	33.913	636,703		
995	123.353	142.100	145.865	88.269	90.684	0	36.410	626,681		
996	118.836	139.480	133.681	92.902	83.941	0	39.116	607.956		
997	124.092	131.592	104.155	75.255	70.381	0	42.014	547.489		
998	120,793	119.902	110.009	83,895	71,362	0	46.478	552.439		
999	117,758	117.757	106,787	81,616	63,831	0	47,929	535,678		
000	122.675	120.606	112.398	72.408	65.021	0	49.380	542,488		<i>[</i>
001	117 002	114 696	100 507	74 774	56 261	0	51 224	514 464		

Source: Education Statistics (INE) and (DAPP - Ministry of Education).

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	Pereira	1-10-2	Teixeira	(2004)		AP_MS (2002)
Years	HS	Н	H'	H"	H'''	Н
	(1)	(2)	(3)	(4)	(5)	(6)
1960	2.237	1.623	1.337	1.286	1.362	
1961	2.286	1.729	1.425	1.374	1.450	
1962	2.339	1.863	1.534	1.482	1.560	
1963	2.403	2.009	1.653	1.599	1.680	
1964	2.474	2.200	1.810	1.752	1.838	
1965	2.555	2.403	1.978	1.919	2.008	
1966	2.644	2.544	2.096	2.030	2.128	
1967	2.734	2.690	2.215	2.143	2.251	
1968	2.829	2.787	2.295	2.221	2.332	
1969	2.929	3.018	2.484	2.395	2.528	
1970	3.051	3.276	2.690	2.581	2.744	
1971	3.122	3.423	2.823	2.708	2.880	
1972	3.212	3.523	2.919	2.803	2.978	
1973	3.314	3.672	3.058	2.937	3.119	
1974	3.438	3.783	3.169	3.048	3.229	
1975	3.541	3.886	3.279	3.162	3.337	
1976	3.655	3.913	3.325	3.216	3.379	
1977	3.777	3.994	3.414	3.310	3.467	4.073
1978	3.937	4.074	3.500	3.398	3.551	4.145
1979	4.092	4.239	3.664	3.563	3.715	4.217
1980	4.262	4.439	3.851	3.741	3.906	4.289
1981	4.450	4.781	4.179	4.061	4.239	4.510
1982	4.540	4.960	4.354	4.232	4.415	4.641
1983	4.654	5.144	4.518	4.383	4.585	4.772
1984	4.765	5.316	4.671	4.523	4.744	4.903
1985	4.887	5.248	4.616	4.473	4.688	5.034
1986	5.022	5.466	4.825	4.675	4.899	5.294
1987	5.153	5.527	4.886	4.733	4.962	5.374
1988	5.285	5.665	5.018	4.861	5.097	5.454
1989	5.432	5.453	4.841	4.698	4.912	5.534
1990	5.585	5.700	5.078	4.928	5.152	5.614
1991	5.739	5.982	5.322	5.150	5.408	6.041
1992	5.887	6.024	5.369	5.194	5.457	6.181
1993	6.093	6.198	5.530	5.343	5.624	6.322
1994	6.299	6.370	5.710	5.524	5.804	6.462
1995	6.497	6.463	5.811	5.624	5.904	6.602
1996	6.683	7.132	6.422	6.202	6.532	6.743
1997	6.847	7.263	6.559	6.339	6.668	6.923
1998	7.006	7.411	6.713	6.493	6.822	7.104
1999	7.146	7.579	6.886	6.666	6.996	7.284
2000	7.289	7.770	7.080	6.861	7.190	7.465
2001	7.409	7.985	7,296	7.076	7.405	7.645

Source: Teixeira (6), columns (2) to (5); Pina and St. Aubyn (2002), column (6). Column (1) contains the series calculated in the present study.

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Table	6 – Popula	ation by lev	el of schoo	sing, $L_{s,t}$, re	or Hr and H					
Verre	Levels of schooling									
rears	0	1	2	3	4	5	6	lotai		
1981	1,837,307	2,640,191	753,849	455,372	276,053	112,690	111,653	6,187,115		
1982	1,813,912	2,672,103	789,974	465,001	317,623	118,937	117,904	6,295,454		
1983	1,759,384	2,685,770	816,850	485,237	351,939	125,369	124,352	6,348,901		
1984	1,708,418	2,696,020	849,904	504,355	385,899	131,406	131,523	6,407,525		
1985	1,648,544	2,683,610	888,208	533,188	414,743	138,185	138,811	6,445,289		
1986	1,576,721	2,662,009	936,682	561,171	448,543	145,429	144,114	6,474,669		
1987	1,503,642	2,632,333	984,494	600,926	467,138	151,571	151,901	6,492,005		
1988	1,428,038	2,604,533	1,039,430	623,635	498,349	155,302	159,474	6,508,761		
1989	1,345,130	2,572,643	1,078,740	668,914	529,245	159,231	165,487	6,519,390		
1990	1,260,936	2,540,654	1,110,939	709,544	568,235	164,497	170,449	6,525,254		
1991	1,188,581	2,505,699	1,145,811	753,291	609,608	170,645	178,362	6,551,997		
1992	1,146,950	2,476,498	1,154,541	816,253	671,375	168,841	194,834	6,629,292		
1993	1,048,309	2,447,584	1,151,534	892,908	731,830	168,389	213,180	6,653,734		
1994	966,114	2,414,310	1,141,087	955,192	800,197	170,607	238,716	6,686,222		
1995	897,643	2,372,836	1,116,770	1,034,096	857,575	172,677	266,272	6,717,868		
1996	841,019	2,316,208	1,109,640	1,095,187	916,258	175,493	295,613	6,749,417		
1997	787,498	2,255,555	1,139,662	1,144,298	954,346	178,901	327,360	6,787,619		
1998	738,016	2,214,464	1,144,845	1,189,739	996,030	183,376	362,151	6,828,620		

Table 7 – Series of human capital based on labour market earnings						
Years	Hr	Hrl				
1982	0.04240	0.11831				
1983	0.04403	0.12137				
1984	0.04567	0.12420				
1985	0.04743	0.12713				
1986	0.04893	0.13008				
1987	0.05073	0.13278				
1988	0.05240	0.13531				
1989	0.05390	0.13792				
1990	0.05530	0.14043				
1991	0.05703	0.14282				
1992	0.05950	0.14527				
1993	0.06245	0.14799				
1994	0.06622	0.15048				
1995	0.06996	0.15245				
1996	0.07369	0.15399				
1997	0.07733	0.15510				
1998	0.08109	0.15600				

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Table 8 – Equivalence of the levels of Schooling between the two types of series						
Series Hr and Hrl Seres HS						
0	0 + <i>nf</i> + pi					
1	1					
2	2					
3	3					
4	4 + 5					
5	6 + "bacharelato"					
0	7 "bacharolato"					