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Measurement of human capital input across countries: a method based on the laborer's income

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Abstract

I propose the aggregate output divided by the wage rate of an industrial laborer in a country as a measure of the aggregate human capital input for that country. I use this method to compare the human capital inputs for 45 countries of diverse output levels. I find that human capital input differs between the lowest-income and the highest-income countries by a factor of 2.2 or 2.8, depending on the inclusion of outlier countries. This is significant but small relative to the results from the method based on years of schooling.

JEL classification: J31; O40
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1. Introduction

Lucas (1988) and many others have proposed the differences in human capital input as a major source of output differences across countries. In order to evaluate this view, a measure of human capital inputs across countries is necessary. Conceptually, human capital input is the labor input in the production adjusted for quality in terms of skills and health. The difficulty in its measurement lies in this adjustment. It is not easy to say how much more (or less) human capital input an hour of work by a doctor in the US is when compared with an hour of work by a laborer in Nigeria. In this paper, I propose a

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method of measuring human capital input that relies on the laborer's income and conduct a measurement exercise based on this method.

Broadly, there are two approaches to measuring human capital. One, the cost-based approach, measures the cost of human capital investment. For an international comparison of the human capital, the most common measure of the cost is the years of schooling. The measurement exercises based on the years of schooling include Kyriacou (1991) and Barro and Lee (1993). In comparing human capital *input* across countries, it is assumed that the years of schooling embodied in living (and working) people are proportional to the human capital input supplied by these people. This assumption is implicit, for example, in the growth accounting exercise of Mankiw et al. (1992). The popularity of the measurement method based on the years of schooling seems to stem from the fact that it directly relies on educational investment, which is considered a key element for human capital formation. However, this method has some shortcomings. First, it does not measure the human capital acquired outside the school: skills acquired before schooling, in job training outside the school and in the workplace. A worker with no schooling clearly has a human capital to the extent that he is contributing to the production. Skills acquired in the workplace, especially, may differ greatly between the workers in low-income countries and workers in high-income countries. Second, this method does not measure human capital in terms of health, which is an important factor in labor productivity. Human capital in terms of health may differ greatly between low-income and high-income countries. Third, the measurement using the years of schooling implicitly assumes that the formation of human capital per year of schooling is the same in all countries. The quality of education may vary greatly across countries, especially between the low-income and the high-income countries, leading to different quantities of human capital formation per year of schooling. Fourth, the measurement using the years of schooling implicitly assumes that the formation of human capital per year of schooling is the same at all levels of schooling. One can conjecture that the marginal formation of human capital decreases as the duration of schooling increases and is the same as the marginal cost at the point when schooling stops. This conjecture is supported by the finding that the return to primary education is higher than the return to secondary education, which is higher than the return to tertiary education (Psacharopoulos, 1994).

The other approach, the income-based one, uses the labor income differences across workers with various levels of human capital to measure human capital inputs. Income differences across workers are the differences in the market values of their human capital inputs and are largely determined by the differences in their human capital inputs. The differences in the human capital input could then be derived from the income differences by eliminating the part of the differences due to the factors other than human capital input. For example, Krueger (1968) classifies workers by education level, age and sector where they work (urban or rural) in a sample of 21 countries, with the assumption that two workers of the same type, across countries as well as within a country, supply the same human capital input. She derives the aggregate human capital input for each country by weighing the inputs of different types of workers by their average labor incomes in the US. This method, unlike the method based on the years of schooling, allows the differences in human capital formation per year of schooling across education levels since these differences would be reflected in income differences. However, this method still assumes that differences among workers in the skills acquired outside schooling and in health are zero and the quality of schooling is the same across countries.[1]

A more recent example of the income-based approach to measuring human capital input is by Mulligan and Sala-i-Martin (1997). In a study on the changes of human capital inputs across the states of the US over time, the authors propose as a measure of aggregate human capital input for a given state in a given year of the aggregate labor income divided by the average income of the workers with no schooling for that year in that state. The implicit assumptions here are that a worker with no schooling supplies the same human capital input across the states and years, but that for any state in any year, human capital input differences across workers are proportional to their actual income differences and not some cross-state or cross-year representative income differences. If we were to adopt Mulligan and Sala-i-Martin's method for international comparison of human capital inputs, it would require less data and is, therefore, easier to implement than Krueger's method. Also, the assumption that workers with no schooling supply the same human capital input seems more defensible than Krueger's assumption that workers with any given level of schooling supply the same human capital: workers with no schooling across countries are more comparable in their human capital input than workers with positive and equal years of schooling since the differences in school quality are irrelevant to the human capital input of the workers with no schooling. However, this method would still have the shortcoming of ignoring the differences in the skills acquired outside schooling and in health among the workers with no schooling.[2]

In this paper, I adopt Mulligan and Sala-i-Martin's method, but with some modification, to measure human capital inputs across countries of diverse income levels. The modification is that I assume that the industrial laborer, as classified by the International Labor Office, rather than the worker with no schooling supplies the same human capital input across countries. I derive the aggregate human capital input for a country by dividing the aggregate labor income, which is assumed to be proportional to the aggregate income or output across countries, by the average income of the industrial laborers in that country. For international comparisons of human capital input, this method has advantages over methods based on schooling: methods using years of schooling and Krueger's and Mulligan and Sala-i-Martin's methods. By not using schooling as a way of comparing the workers altogether, this method avoids the problem of mismeasurement of human capital acquired outside schooling that is present in all methods based on schooling, the

[1] Further, using US labor incomes to weigh human capital inputs across types of workers is extreme in light of the observation that the wage profile over education level is steeper in low-income countries (Psacharopoulos, 1994). Since the people in low-income countries on the average receive less schooling, using the incomes in a low-income country for the weighing purpose would result in a greater difference in the measured human capital input between low-income and high-income countries.

[2] Also, this method would be troublesome in light of the aforementioned finding by Psacharopoulos (1994) that the wage profile over the education level is steeper in low-income countries. If we assume that workers with a positive number of years of schooling, for example college graduates, supply the same human capital input across countries, the differences in the measured aggregate human capital input would be greater than that under the assumption that workers with no schooling supply the same human capital input. Mulligan and Sala-i-Martin's procedure is extreme in this sense.

problem of international comparability of schooling quality that is present in the method using the years of schooling and Krueger's method, and the problem of comparability of a school year at different levels that is present in the method using the years of schooling. Partially for these reasons, the human capital inputs of industrial laborers across countries seem more comparable than those of workers with any given years of schooling, including workers with no schooling in Mulligan and Sala-i-Martin's method. Industrial laborers are workers who primarily supply their physical effort with little skill. Further, it is plausible to assume that these workers are physically fit to work in the industrial sector. Thus, in terms of health as well, industrial laborers seem comparable.[3]

One criticism against the method used in this paper may be that there may be factors other than human capital input itself that affect the wage rate of the industrial laborer relative to the other occupations, and these factors may differ across countries or years. The same criticism applies to the method based on the wage rate of a worker with no schooling in Mulligan and Sala-i-Martin (1997) since the method in this paper is an adaptation of theirs. However, some of this criticism is really against the concept of *aggregate* human capital and not against the methods of measuring it per se. For example, it is widely held that the technological change in the US over the last couple of decades has been skill-biased, raising the skill premium. This change would have increased the measured human capital input in the US under the method based on the laborer income or on the no-schooling worker's income even if there had been no changes in the supply of human capital input. Although this may very well be the case, it is not allowed under the assumptions supporting the concept of aggregate human capital. An example of a more legitimate criticism is the laws and regulations that make wage rates differ from the marginal products. The minimum wage law may raise the wage rate of no-schooling workers beyond the marginal product in some countries, leading to inaccurate measures of human capital input. However, the minimum wage law seems unlikely to be binding for the industrial laborer since his wage rate is not low relative to the other occupations. At any rate, the main concern of this paper is the difference in the human capital input between the low-income and the high-income countries and not a country by country comparison of human capital input. Thus, any factor that unduly affects the measurement would affect the main result only to the extent that it is systematically related to the income level. There do not seem to be such obvious factors.

In Section 2, I present a model that shows the concept of human capital used in this paper and provides the basis for its measurement across countries in Section 3. In Section 3, I introduce the wage data set LABOCT from the International Labor Office (2000) and document the differences in the wage rate of the industrial laborer among 45 countries of diverse output levels. I then use these wage rate differences to derive the differences in the aggregate human capital input for these countries. I find that the human capital input differs between the lowest-income and the highest-income countries by a factor of about

[3] If we order the occupations according to their average incomes, the wage profile over the occupations seems steeper in low-income countries than in high-income countries (see Section 3). This is analogous to the pattern observed for the wage profile over education level (see Footnotes 1 and 2). The wage rate of the industrial laborer is neither high nor low relative to the other occupations. Thus, equating human capital inputs of industrial laborers across countries is not extreme, while equating human capital inputs of workers with no schooling would.

2.2. This result contrasts with the human capital input difference between the lowest-income and the highest-income based on the years of schooling, which is about 3.5 for the same sample of countries. In Section 4, I show that in neoclassical output accounting, the human capital input difference between the lowest-income and the highest-income countries can account for the output difference between them by a factor of about 1.7. This is significant but small relative to their output difference, which is by a factor of about 30. Even if we add the physical capital input in the output accounting, the two inputs, human and physical, leave a large art of their output difference unaccounted for. In Section 5, I discuss the reasons why there are human capital input differences across countries as measured in this paper. Section 6 concludes.

2. Theory behind the measurement

In this section, I present the theory that formalizes the concept of human capital used in this paper and provides the basis for its measurement across countries in the following section. Since I am borrowing from Mulligan and Sala-i-Martin (1997), I will only present the essentials relevant for the measurement in this paper. Consider a model of the world where time is static and there are many economies that are indexed by i. Each economy is populated by many people who are indexed by $j\in[0,1]$. The identity of a person in this world economy is then (i,j). All people within and across economies have utility-increasing income. They differ in the human capital endowment, which is used to generate the human capital input one-for-one. Let $h(i,j)$ denote the human input the person (i,j) supplies. The technology is identical across countries and is represented by the production function:

$$Y_i = A_i H_i^{\alpha}, \tag{1}$$

where Y_i is the aggregate output, H_i is the aggregate human capital input, A_i is the factor other than human capital input such as the physical capital input, and $\alpha\in(0,1)$ is the human capital input share parameter.[4] The aggregate human capital input is the linear[5] sum of individual human capital inputs, and people are immobile across economies, so we can write:

$$H_i = \int_0^1 h(i,j)\mathrm{d}\,j. \tag{2}$$

[4] The value of α is assumed to be the same across countries. This assumption allows the measurement of human capital input using aggregate output or income instead of human capital (labor) income, whose estimates are not available for many low-income countries. Although the estimates of the labor share of the aggregate income differ across countries, there are no trends in relation to the output level (Gollin, 1998).

[5] The linearity assumption can be relaxed. We can allow the human capital of the workers other than the worker, who serves as the unit of cross-country comparison (i.e., $\bar{s}$ and $\bar{u}$ in Eq. (9)), to be summed non-linearly. However, it is essential that the human capital of the worker who serves as the unit and the human capital of the rest of the workers are summed linearly (see Mulligan and Sala-i-Martin, 1997).

Let $\tilde{w}_i$ denote the wage rate for a unit of human capital input in economy *i*:

$$\tilde{w} = \alpha A H^{\alpha - 1}. \tag{3}$$

The wage rate of person (*i*,*j*) is:

$$w(i,j) = \tilde{w}_i h(i,j). \tag{4}$$

From Eqs. (1) and (3), we can derive:

$$H_i = \frac{\alpha Y_i}{\tilde{w}_i}. \tag{5}$$

That is, the aggregate human capital input of an economy is the aggregate labor income divided by the wage rate for a unit of human capital input.

Consider two economies *s* and *u*. We have:

$$\frac{H_s}{H_u} = \frac{Y_s}{Y_u} \frac{\tilde{w}_u}{\tilde{w}_s}. \tag{6}$$

If we have the output difference and the difference in the wage rate for a unit of human capital input, we can derive the human capital input difference. The wage rate difference can be written in a form that can be matched with the data. Let $(s,\bar{s})$ and $(u,\bar{u})$ denote two people, one from each economy, who supply the same human capital input:

$$h(s,\bar{s}) = h(u,\bar{u}). \tag{7}$$

From Eqs. (4) and (7), we have:

$$\frac{\tilde{w}_s}{\tilde{w}_u} = \frac{w(s,\bar{s})}{w(u,\bar{u})}. \tag{8}$$

Eq. (6) can then be rewritten as:

$$\frac{H_s}{H_u} = \frac{Y_s}{Y_u} \frac{w(u,\bar{u})}{w(s,\bar{s})}. \tag{9}$$

If we have the output difference between two economies and the wage rate difference for the workers across two economies who supply the same human capital input, we can derive the aggregate human capital input difference across two economies. In this paper, I assume the human capital input of industrial laborers to be the same across countries and use the wage rates of industrial laborers to derive the aggregate human capital input differences across countries.

3. Measurement of human capital input

The International Labor Office annually publishes the *Bulletin of Labor Statistics: October Inquiry* which contains the wage data for 159 occupations across countries. The data set LABOCT contains the cumulative wage data since 1983. I use the data for eight occupations denoted as ‘laborer’ from 1983 to 1998. A glance at the titles of these finely classified occupations reveals that these are all industrial laborers who primarily supply their physical effort with little skill.[6] I picked 45 countries that have reasonably extensive data and represent diverse output levels and diverse regions of the world. They are listed in Table 1.

For a given country, there can be a maximum of 128 entries of labor wage data (8 occupations × 16 years). The last column in Table 1 lists the number of entries for each country. For many countries, the number of entries is quite small but all have at least 10 entries.

As would be expected from any study involving international data, there are problems with the comparability of the data across countries. First, although most countries report monthly wage data, the data for some countries are yearly, weekly, daily, hourly or mixed. For comparability, I made the data annually, assuming 1 year = 12 months = 52 weeks, 1 week = 5 days and 1 day = 8 h.[7] Second, some countries report male and female wages separately, others report gender-neutral (i.e., averaged across workers regardless of gender) wages, and a few countries report single-gender wages. Given this practice and assuming that the majority of the industrial laborers are males, I dropped the female wage data from the sample and used the male or gender-neutral wage data. Third, some countries report average wages, others report minimum wages, yet the rest do not specify the data in this respect. Fourth, some countries report wage rates whereas others report wage earnings.[8] The type of data for each country is reported in Table 1. Since it is difficult to infer the differences in the reported laborer wage across countries due to the differences in the last three aspects of the data (i.e., male vs. gender-neutral, rate vs. earnings and minimum vs. average), I made no further adjustments. This lack of adjustment cautions me in country by country comparisons of human capital input as measured in this paper. However, in assessing the differences in human capital input in relation to the income level, these differences in the type of data matter only to the extent that the types of data are related to the income level. There is no such discernable relation in the data.

After annualizing the data, I divided the wage data by the per-capita output in respective countries and years. The wage data are in units of local currency. I obtained the per-capita output figures which are also in the local currency from *IMF International Financial Statistics* (International Monetary Fund, 2000). Next, for each country, I took the arithmetic average of the wage data/per-capita output across laborer occupations and across the years, weighing each entry of the wage data/per-capita output equally. The result is in the first column of Table 1. The measure of human capital input is simply the reciprocal of the averaged wage data/per-capita output (see Eq. (9)). The second column of Table 2 presents the human capital inputs across countries with the US input normalized to 1.

The interesting question is of course how large are the differences in human capital input across countries. To compare the aggregate outputs or incomes across countries, I

[6] The eight occupations are the laborer in spinning, weaving and finishing textiles, the laborer in printing, publishing and allied industries, the laborer in the manufacture of industrial chemicals, the laborer in the manufacture of other chemical products, the laborer in iron and steel basic industries, the laborer in the manufacture of machinery, the laborer in electric light and power and the laborer in construction.

[7] *October Inquiry* also reports work hours per week for some countries. The reported work hours are around 40, and there is no systematic relation between the work hours and the income level.

[8] The wage earnings include in addition to the wage rate the “remuneration for time not worked, such as for annual vacation, other paid leave or holidays.”

Table 1
Laborer earnings

Country	Wage	er	ra	av	mi	ma	ne	mo	we	da	ho	en
Algeria	1.34 (1.89)		●		●		●	●				35
Cameroon	1.43 (2.01)		●		●		●	●			●	16
Egypt	1.12 (1.58)	●			●	●			●			16
Kenya	2.80 (3.94)		●	●		●		●				15
Malawi	1.68 (2.37)		●	●		●		●				11
Mauritius	0.61 (0.86)		●	●		●					●	71
Mozambique	5.04 (7.10)		●		●	●		●				10
Nigeria	1.66 (2.34)	●				●		●				13
Rwanda	1.05 (1.48)		●		●	●		●				30
Sierra Leone	1.20 (1.69)		●		●	●		●	●	●		41
Sudan	1.63 (2.30)		●	●			●	●				16
Argentina	0.43 (0.61)		●		●		●	●		●	●	39
Bolivia	1.28 (1.80)		●	●		●		●				69
Costa Rica	0.81 (1.14)		●		●	●		●	●	●		10
Chile	1.69 (2.38)	●				●		●				16
Colombia	0.90 (1.27)		●		●	●		●		●		11
Dominican Republic	1.12 (1.58)		●				●	●				19
El Salvador	1.52 (2.14)	●				●		●	●			48
Guatemala	1.26 (1.77)	●				●		●			●	17
Honduras	1.44 (2.03)		●		●	●		●	●	●		60
Nicaragua	2.34 (3.30)		●	●			●	●				11
Peru	0.88 (1.24)		●	●		●		●	●	●	●	34
United States	0.71 (1.00)	●				●			●			96
Uruguay	1.28 (1.80)	●					●				●	45
Venezuela	0.66 (0.93)		●	●			●	●		●		18
Bahrain	0.43 (0.61)		●	●		●		●				76
Bangladesh	1.72 (2.42)		●		●	●		●		●		29
China	1.50 (2.11)		●	●		●		●				53
Indonesia	1.41 (1.99)		●		●		●			●		14
Korea	1.60 (2.25)	●				●		●				100
Malaysia	0.77 (1.08)	●				●		●				12
Myanmar	1.03 (1.45)		●	●			●	●				84
Philippines	1.62 (2.28)		●	●			●	●		●		73
Sri Lanka	0.87 (1.23)	●				●					●	33
Thailand	2.53 (3.52)	●				●		●				34
Austria	0.54 (0.76)		●	●			●	●	●		●	47
Belgium	0.86 (1.21)		●	●		●					●	70
Germany	0.86 (1.21)		●		●		●	●			●	112
Italy	0.81 (1.14)		●		●		●	●			●	112
Norway	1.02 (1.44)	●				●		●			●	14
Portugal	0.40 (0.56)		●	●		●				●		10
Romania	0.92 (1.30)		●	●		●		●			●	88
Sweden	1.20 (1.69)	●				●		●			●	65
Turkey	1.67 (2.35)		●	●			●				●	16
Australia	1.22 (1.72)	●				●			●			66

Wage: annualized laborer wage earnings/rate over per-capita GDP; er: earnings; ra: rate; av: average; mi: minimum; ma: male; ne: neutral; mo: monthly; we: weekly; da: daily; ho: hourly; en: number of entries.

used the output data in the Penn World Table in Summers and Heston (1995), which are adjusted for the purchasing power parity across currencies and years. For each country, I took the per-capita output of 1990, which is about the middle year of the LABOCT data set, and divided it by the US per-capita output in 1990.[9] The first column of Table 2 presents the resulting figures. Fig. 1 plots the human capital inputs against the per-capita outputs across countries.

An easily noticeable aspect of the plot is that the three countries, Argentina, Bahrain and Portugal, have implausibly high level of human capital input, each having more than 1.5 of the US level. I consider these three countries as outliers, and therefore, exclude them when drawing the summary line from running an OLS regression of human capital input on per-capita income. The summary line shows that the difference in the human capital input between the lowest-income and the highest-income countries is a factor of 2.2. If the three outliers are included in the regression, the factor becomes 2.8.

How does this result compare to the measures of human capital (input) based on the mean years of schooling? The fifth column of Table 2 contains the measures for most of the countries in the sample for the year 1985 as reported in Kyriacou (1991).[10] Fig. 2 plots them against the per-capita outputs.

The summary line, which was drawn from a regression without the three outliers, shows that the mean years of schooling differ between the lowest-income and the highest-income countries by a factor of 3.9. If the three outliers are included, we still get the same factor of 3.9. This is greater than the difference in the human capital inputs based on laborer wage. In other words, the measurement method based on the laborer's wage yields a higher measure of human capital input for low-income countries relative to the human capital input for high-income countries than the method based on the years of schooling. This finding is not an obviously expected one. The method used in this paper is an attempt to address the shortcomings of the method based on schooling. In measuring the cross-country difference in human capital input, some of the shortcomings of the method based on the years of schooling would bias the result upward, while other shortcomings will bias it downward. For example, non-inclusion of the human capital input of workers with no schooling would bias downward the measured human capital input of the lower-income countries relative to the higher-income countries. On the other hand, if the school quality is lower in lower-income countries, this would bias upward the measured human capital input of the lower-income countries. The above result suggests that the overall bias of the method based on the years of schooling is to underestimate the human capital input of lower-income countries.

Fig. 3 plots the human capital inputs based on the mean years of schooling against those based on laborer earnings.[11]

[9] There are three countries, Bahrain, Myanmar and Romania, for which the 1990 per-capita output is not available in the Penn World Table. For each of these countries, I took the per-capita output of the most recent year available and divided it by the US per-capita output in that year. The most recent years are 1988, 1989 and 1989, respectively.

[10] There are three countries, Bahrain, China and Romania, for which the mean years of schooling are not given in Kyriacou (1991).

[11] Again, the plot is without the three countries, Bahrain, China and Romania, for which we do not have the mean years of schooling.

Table 2
Human capital input

Country	Y	H	H_s	H/H_s	H_{ac}	H_{am}	H_{cp}	H_{gp}	H_{mt}
Algeria	0.14	0.53	4.7 (0.39)	1.36	0.26		0.62		
Cameroon	0.06	0.50	5.4 (0.45)	1.11	0.30	0.29	1.82	0.25	0.40
Egypt	0.10	0.63	5.7 (0.47)	1.35	0.62	0.63	0.80	1.12	1.65
Kenya	0.05	0.25	3.4 (0.28)	0.90	0.08	0.19	0.05	0.14	0.44
Malawi	0.03	0.42	2.0 (0.17)	2.56	0.03	0.12	0.06	0.05	
Mauritius	0.33	1.16	6.3 (0.52)	2.24		0.94			
Mozambique	0.04	0.14	2.1 (0.17)	0.81	0.09	0.09	0.09		0.10
Nigeria	0.05	0.42	2.0 (0.17)	2.59		0.29	0.19		
Rwanda	0.04	0.68	3.2 (0.26)	2.56		0.17			
Sierra Leone	0.05	0.59	2.0 (0.17)	3.58	0.21	0.43		0.61	0.81
Sudan	0.04	0.44	2.1 (0.17)	2.51				0.66	
Argentina	0.25	1.65	8.0 (0.66)	2.50		1.23	1.29		1.90
Bolivia	0.09	0.55	5.7 (0.47)	1.18	0.18	0.66	0.31	0.54	0.58
Costa Rica	0.19	0.88	8.2 (0.68)	1.29	1.53	0.76	1.56	1.57	
Chile	0.24	0.42	7.0 (0.58)	0.73					
Colombia	0.18	0.79	6.5 (0.54)	1.47					
Dominican Republic	0.12	0.63	6.7 (0.55)	1.14	1.32		1.38	0.81	1.25
El Salvador	0.10	0.47	4.2 (0.35)	1.35	0.21	0.36	0.31		
Guatemala	0.12	0.56	3.7 (0.31)	1.84		0.86			0.34
Honduras	0.08	0.49	5.6 (0.46)	1.07	0.24	0.35	0.24	0.21	0.27
Nicaragua	0.07	0.30	6.0 (0.50)	0.61	0.20	0.22		0.33	0.27
Peru	0.12	0.81	7.9 (0.65)	1.24	0.40	0.89	0.86	1.35	0.95
United States	1.00	1.00	12.1 (1.00)	1.00	1.00	1.00	1.00	1.00	1.00
Uruguay	0.25	0.55	7.7 (0.64)	0.87				0.28	0.44
Venezuela	0.31	1.08	6.9 (0.57)	1.89	0.73		0.71	0.78	0.71
Bahrain	0.50	1.65			0.73	0.94	1.01	0.71	0.78
Bangladesh	0.08	0.41	3.5 (0.29)	1.43	0.41	0.32	0.19		
China	0.07	0.47			0.66	0.66		1.34	1.03
Indonesia	0.11	0.50	4.5 (0.37)	1.35	1.01				
Korea	0.38	0.44	7.9 (0.65)	0.68	0.48	0.58	0.55	0.50	0.44
Malaysia	0.28	0.92	5.7 (0.47)	1.96	0.25				
Myanmar	0.03	0.69	4.9 (0.40)	1.70	0.39		1.09	0.66	0.76
Philippines	0.10	0.44	8.9 (0.74)	0.60	0.40	0.42		1.29	0.63
Sri Lanka	0.11	0.82	6.0 (0.50)	1.65	0.75				
Thailand	0.20	0.28	5.5 (0.45)	0.62	0.39	0.69	0.38	0.42	0.95
Austria	0.71	1.31	8.6 (0.71)	1.85	0.86		1.06	1.39	
Belgium	0.76	0.83	9.4 (0.78)	1.06		0.97			
Germany	0.85	0.83	10.3 (0.85)	0.97	0.90	0.84	1.13	1.01	0.73
Italy	0.70	0.88	9.1 (0.75)	1.17	0.74	1.04	1.43	0.81	1.09
Norway	0.75	0.70	9.2 (0.76)	0.92	1.16	0.85			1.00
Portugal	0.41	1.78	6.5 (0.54)	3.30					
Romania	0.13	0.77			0.49	0.38	0.84	0.53	0.97
Sweden	0.83	0.59	9.6 (0.79)	0.75	0.91	0.80		0.91	1.02
Turkey	0.21	0.43	6.3 (0.52)	0.82	0.88				
Australia	0.80	0.58	8.7 (0.72)	0.81	0.99	0.76	0.91	0.87	0.91

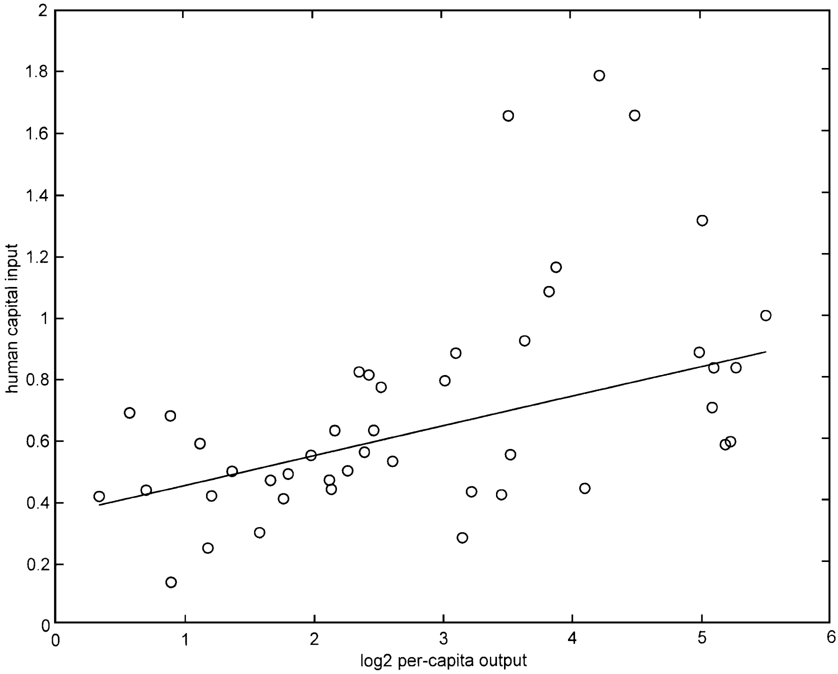

Fig. 1. Human capital input based on labourer earnings.

We can see that the two measures of human capital input are overall positively correlated, but for some countries, one measure of human capital input is significantly different from the other measure. One way of seeing this is to calculate the ratio of the two measures (i.e., the laborer earnings-based measure over the schooling year-based measure) for each country. These ratios are listed in the fourth column of Table 2. When the countries are sorted in the decreasing order of the ratio, the top five countries are Sierra Leone, Portugal, Nigeria, Malawi and Rwanda. The bottom-right dotted line in Fig. 3 separates these five countries from the rest. For these countries, the laborer's earnings-based measure of human capital input is much higher than the schooling year-based measure. The lowest five countries in the order are Philippines, Nicaragua, Thailand, Korea and Chile. The top-left dotted line in Fig. 3 separates these five countries from the rest. For these countries, the laborer's earnings-based measure of human capital input is much lower than the schooling year-based measure. Note that among the countries with the highest ratios, Portugal is one of the outliers mentioned earlier and the remaining four countries are some of the lowest-income countries. On the other hand, the countries with

Notes to Table 2:
Y: Per-capita output over US per-capita output; *H*: human capital input based on laborer earnings; H_s: mean years of schooling in 1985; H/H_s: the ratio of the two measures of human capital input; H_{ac}: human capital input based on accountant earnings; H_{am}: human capital input based on automobile mechanic earnings; H_{cp}: human capital input based on computer programmer earnings; H_{gp}: human capital input based on general physician earnings; H_{mt}: human capital input based on second-level mathematics teacher earnings.

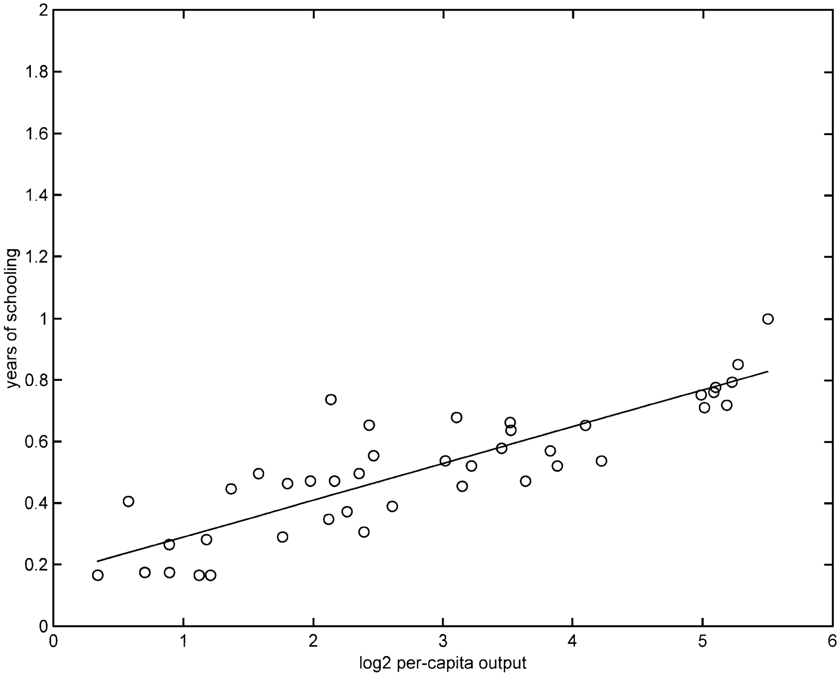

Fig. 2. Mean years of schooling.

the lowest ratios are mostly middle-income countries. This repeats the point that the method based on years of schooling yields a lower measure of human capital input for the low-income countries than the method based on the laborer's earnings.

One may wonder what would be the human capital inputs across countries if we measure them using the wage data for an occupation other than the industrial laborer, that is, under the assumptions that the human capital inputs of the workers of another occupation are the same across countries and that in each country, the human capital inputs of the workers are proportional to their wage rates. To this end, I measured the human capital inputs across countries using the same method explained above except that I used the wage data for each of five selected occupations different from the laborer: accountant, automobile mechanic, computer programmer, general physician and second-level mathematics teacher. Columns 6–10 of Table 2 present these measures of human capital inputs with the US input normalized to 1. We can see that under these alternative measurements of human capital inputs, low-income countries use less human capital input than high-income countries, which is similar to the result obtained from the measurement with the laborer wage. However, the human capital input difference between low-income and high-income countries is greater in general under these alternative measurements. This probably reflects that these occupations are mostly professional, commanding higher wage rates than that of the laborer and that the wage premium for professionals as a multiple of the wage rate for non-professionals is higher in low-income countries than in high-income countries.

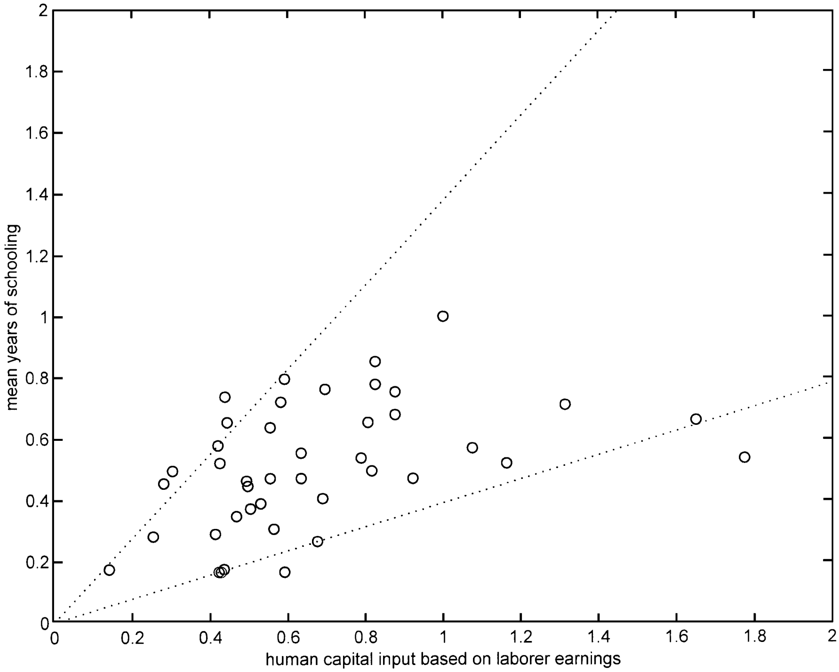

Fig. 3. Labourer earnings vs. mean years of schooling.

From this finding, the measurement method using the wage rate of the laborer may seem extreme since using the wage rates of the professionals would result in a greater difference in the measured human capital input between low-income and high-income countries. In this respect, the method used in this paper is compared to Mulligan and Sala-i-Martin's method: using the wage rate of the college graduate rather than the wage rate of the worker with no schooling would result in lower measures of human capital inputs for low-income countries. However, the measurement using the wage rate of the laborer differs from the procedure using the wage rate of the worker with no schooling in a crucial respect. That is, the laborer is not at the low end of the workers ordered by their wage rates as the worker with no schooling is. There are many occupations that command lower wage rates than the industrial laborer, e.g., farm workers, shop attendants and workers in the catering business. There are many workers in these occupations, especially in low-income countries. There are no good wage data for these occupations across countries, but given that the wage premium for professionals is higher in low-income countries, by extension, I suspect that the wage rates for these occupations as multiples of the wage rate of the industrial laborer are lower in low-income countries. If this is the case, then using the wage rates of these occupations would result in higher measures of human capital input for low-income countries than using the wage rate of the laborer, the opposite result from using the wage rates of the professionals. Therefore, the measurement using the wage rate of the laborer is not extreme.

4. Accounting for output differences

The extent to which human capital input differences across countries account for their output differences depends not only on the human capital input differences themselves but also on how important the human capital input is for the production, that is, the human capital input share parameter α in Eq. (1). Recall from the previous section that the human capital input differs between the lowest-income and the highest-income countries by a factor of 2.2 if the outlier countries are excluded in the calculation and by a factor of 2.8 if they are included. This implies that even under any reasonable combinations of the cross-country human capital input difference and the value of α, the human capital input can account for the output difference between the lowest-income and the highest-income countries by less than a factor of 3. To make a sharper statement, let us assume that the human capital input differs between the lowest-income and the highest-income countries by a factor of 2.5, the average of the two values above, and assume that α is equal to 2/3, a value commonly used in the literature.[12] Under this combination of values, the human capital input can account for the output difference between the lowest-income and the highest-income countries by a factor of 1.8. This is small relative to the total output difference between them, which is by a factor of about 30.

One factor other than the human capital input that can significantly account for the output differences across countries is, of course, the physical capital input. In fact, the accumulation of the physical capital input has been singled out as the primary mechanism for growth for a long time in the growth literature. Therefore, it would be interesting to see how much of the output differences across countries can be accounted for by the human and the physical capital input differences together. To that end, consider a world economy that is identical to the one considered in Section 2 of this paper, except that the physical capital input is an input of production. The production function is:

$$Y_i = A_i H_i^{\alpha} = \hat{A}_i H_i^{\alpha} K_i^{1-\alpha}, \tag{10}$$

where the subscript i indexes the countries, Y_i is the aggregate output, H_i is the aggregate human capital input, A_i is the factor other than human capital input, K_i is the aggregate physical capital input, and $\hat{A}_i$ is the factor other than human and physical capital inputs. This modified production function makes no difference as far as the measurement of human capital inputs across countries is concerned, and its implication on the extent to which the human capital input differences can account for the output differences: the same measurement method in Section 3 is applicable and yields the same results. Then, we only need to find out how much output differences across countries can be accounted for by the physical capital input differences. It depends on how large the physical capital input differences are across countries. Summers and Heston (1995) provide measures of physical capital stock across countries.[13] One can infer from these measures that the physical capital/output ratio tends to be lower for low-income countries with the ratios for many low-income countries being less than a half of the US ratio.

[12] The estimate of the human capital input (labor) share of the total income varies across studies but is around 2/3. See Gollin (1998), Mankiw et al. (1992) and Young (1995) for example.

[13] They measure as physical capital stock the sum of the producer durables and structures excluding housing.

Consider a hypothetical country whose income level is the average of the lowest-income countries, say with 1/30 of the US output. Let us assume that the physical capital/output ratio for this country is a half of the US ratio, which is consistent with the stylized fact mentioned above. This implies that this country has 1/60 of the US physical capital stock. Under the assumption that the inputs are proportional to the stocks across countries,[14] this country uses 1/60 of the US physical capital input. Assuming that the human capital input share parameter α in Eq. (10) is equal to 2/3, as before, this physical capital input difference can account for the output difference between this country and the US by a factor of 3.9. We have already seen that under the assumption that the human capital input differs between this country and the US by a factor of 2.5, the human capital input difference can account for their output difference by a factor of 1.8. Then, the human and the physical capital differences between the two countries together can account for their output difference by a factor of 7.0, the product of 3.9 and 1.8. This is significant, but falls far short of the total output difference between the two countries: factors other than the human or the physical capital input account for the output difference between the two countries by a factor of more than 4.

5. Accounting for human capital input differences

In this section, I discuss the reasons why human capital input in low-income countries, as measured in this paper, is less than in high-income countries. One reason is that the percentage of the workers who work in low-paying occupations is greater in low-income countries than in high-income countries. This results in lower per-worker wage income in low-income countries when the wage income is measured in units of the wage rate in the respective country for a given occupation, and this leads to lower measures of human capital input in low-income countries. Among the reasons why the percentage of workers who work in low-paying occupations is greater in low-income countries than in high-income countries is that the workers in low-income countries have less skills: they receive less schooling or other job training, and therefore, are less qualified to work in high-paying occupations. Another reason is that the workers in low-income countries have poorer health: their diet contains less nutrition and they receive less health care, and therefore, are less qualified to work in occupations that are physically demanding but rewarding in terms of wages, such as the construction or the heavy-industry worker. These two reasons are in fact what justify the method used in this paper for measuring the human capital input.

There is yet another reason why the measurement method in this paper may yield lower measures of human capital input for low-income countries than for high-income countries. The method has the feature that any factors that affect the measured output, as long as they do not affect the wage rate proportionately, also affect the measured human capital input. We can see this from Eq. (5). If two countries differ in some factor that is included in parameter A in Eq. (5), the physical capital input for example, then the difference in this factor affects the differences in the output and wage rate proportionately, and therefore, has

[14] This assumption is commonly implicit in studies of output accounting and is analogous to the common assumption that human capital input is proportional to the years of schooling.

no impact on the measured human capital input difference between the two countries. This is of course a desirable feature since we do not want the measures of human capital input to be affected by such factors. However, if there is a difference between the two countries in terms of what is measured as the output, this difference will affect the difference in the measured output without affecting the wage rate, and thereby, affect the measured human capital input difference between the two countries.[15] Good examples are the informal sector output and the output of home production, both of which are typically excluded in the measurement of the output. The low-income countries tend to have larger outputs of both types than the high-income countries do, and this leads to a larger difference in the measured human capital input between low-income and high-income countries.[16]

6. Conclusion

In this paper, I proposed the aggregate output divided by the wage rate of the industrial laborer in a country as a measure of the aggregate human capital input for that country. The assumptions that support this method of measuring the human capital input are that the human capital inputs of the industrial laborers are the same across countries, that the human capital inputs of the workers within a country are proportional to their wage rates, and that the human capital input (labor) share of the aggregate output is the same across countries. The main advantage of this method over the methods based on schooling is that it takes into account cross-country differences in the skills acquired outside the school and in health status.

I used the wage data set LABOCT from the International Labor Office to measure human capital inputs for 45 countries of diverse output levels. I found that, as one may expect, the low-income countries use less human capital input in the production and that the human capital input differs between the lowest-income and the highest-income countries by a factor of 2.2 or 2.8, depending on the inclusion of the outlier countries. This is significant but small relative to their output difference or compared to the results from the method based on the years of schooling. In neoclassical output accounting, this implies that the human capital input difference between the lowest-income and the highest-income countries can account for their output difference by a factor of about 1.8. Even if we add the physical capital input as an additional input of production, we need factors other than the human or the physical capital input to account for a large part of their output difference.

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[15] A way of characterizing this feature of the measurement method in this paper is that the method measures only the human capital input used in the production of the measured output. This feature is desirable if we are interested in the human capital input differences across countries that account for their measured output differences and not in the issue of comparability of the measured output across countries.

[16] This bias reinforces the finding that the human capital input difference between the lowest-income and the highest-income countries is small.

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