MEASUREMENT OF HUMAN CAPITAL INPUT ACROSS COUNTRIES: A NEW METHOD AND RESULTS

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ABSTRACT

I propose the aggregate output divided by the wage rate of the industrial labourer in a country as a measure of the aggregate human capital input for that country,. The justification is that the skills and health of industrial labourers are comparable across countries; therefore their human capital input can serve as a unit in the measurement. For international comparison, this method is better than other methods based on schooling, conceptually or in terms of applicability, given the data constraints for low-income countries. I use this method to compare the human capital inputs for 39 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 about 2. This is significant but small relative to their output difference or the results from other methods. In neoclassical output accounting, the human capital input differences across countries, even after being combined with their physical capital input differences, leave a large part of their output differences unaccounted for.

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1. INTRODUCTION

Lucas (1988) and many others have proposed 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 labour input in 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 than an hour of work by a labourer in Nigeria.

There are broadly two approaches to measuring human capital stock or input.[1] One, the cost-based approach, measures the cost of human capital investment, which is assumed to be proportional to the human capital formation. For an international comparison of human capital, the most common measure of the cost is years of schooling (see Benhabib and Spiegel 1994, for example). This method is simple and therefore applicable for many low-income countries with data constraints. However, it is conceptually problematic.[2] First, it does not measure the human capital acquired outside school: skills acquired before schooling, in job training outside school, and in the work place. A worker with no schooling clearly has human capital to the extent that he is contributing to production. Skills acquired in work place, especially, may differ greatly between workers in low-income

[1] The input is the service generated from the usage of human capital in a period, and the stock is the (discounted) sum of inputs generated from the usage of human capital over its (remaining) lifetime. It is typically assumed that inputs are proportional to stocks at the aggregate level so that we only needs the measure of one to talk about the other in comparison of human capital stocks or inputs across time or countries.

[2] There are better measures that require more data and therefore implementable only for high-income countries. For example, Kendrick (1976) measures the education, training, and child rearing costs for the US from 1929 to 1969 to derive an annual series of human capital formation, and then derives an annual series of human capital stock by assuming a constant depreciation rate.

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 labour productivity. Human capital in terms of health may differ greatly between low-income and high-income countries. Third, the measurement using 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). Fourth, the measurement using 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.

The other approach, the income-based one, uses the labour 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 to a large extent determined by the differences in their human capital inputs.[3] We could then derive the differences in human capital input from the income differences by eliminating the part of differences due to factors other than human capital

[3] Jorgenson and Fraumeni (1992) use labour incomes of workers classified by age, sex, and education level, to derive the lifetime income differences across workers of different education levels. These lifetime income differences are then taken to be the returns to human capital investment, or the market values of human capital over its lifetime. To derive the human capital input for a period, however, we only need income differences across workers for that period.

input.[4] In general, the steps in doing so are first to classify workers according to types where workers of the same type are assumed to supply the same human capital input; second, to assign a representative income[5] to each type of workers; and third, to aggregate the human capital inputs weighing a worker's input by his/her type's representative income.

For example, Krueger (1968) classifies workers by education level, age, and sector (urban or rural) where they work 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 labour incomes in the US. This is conceptually a better method than the method using years of schooling since the differences in human capital formation per year of schooling across education levels are reflected in income differences. However, it has some of the same short-comings as the method using years of schooling: differences among workers in skills acquired outside schooling and in heath are assumed to be zero and the quality of schooling is assumed to be the same across countries. Further, using US labour 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 people in low-income countries on average receive less schooling, using the incomes in a low-income

[4] One such factor is the availability of complementary or substitute inputs. A doctor in the US gets paid more than a doctor in Nigeria partially because he works with better facilities and equipment. Another such factor is the labour market conditions. A labourer in the US may get paid more than a labourer in Nigeria partially because labourers are more scarce relative to the other types of workers in the US than in Nigeria.

[5] The representative income is unavoidably arbitrary as long as the incomes of workers of the same type are not the same. This is an index number problem and in practice it comes down to picking a reasonable income.

country for the weighing purpose would result in a greater difference in measured human capital input between low-income and high-income countries.

There is a measurement method that does without some of the problems in Krueger's procedure. In their research on the changes of human capital inputs across the states of the US over time, Mulligan and Sala-i-Martin (1995) propose as a measure of aggregate human capital input for a given state in a given year the aggregate labour income divided by the average income of workers with no schooling for that year and in that state. The implicit assumptions here are then that a worker with no schooling supplies the same human capital input across states and years, but that, for any state and in any year, human capital input differences across workers are proportional to their actual income differences, not some cross-state or cross-year representative income differences.[6] For international comparison of human capital inputs, Mulligan and Sala-i-Martin's procedure requires much less data and is, therefore, more applicable than Krueger's procedure. Also, the assumption that workers with no schooling supplies the same human capital input is a weaker and more defensible one than the Krueger's assumption that workers with any given level of schooling supplies 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 workers with no schooling.

[6] Mulligan and Sala-i-Martin's method, as other income-based methods, has the afore-mentioned weakness that the measure of human capital input could be affected by other inputs or market conditions (see footnote 4). In particular, factors that affect the income of workers with no schooling relative to incomes of others types of workers, such as the minimum wage law, would have a large impact on the measurement since the income of workers with no schooling serves as the unit of measurement. Krueger's method is better in this respect since in her method a factor affecting the income of a type of worker would affect the measure of the human capital input only for that type of worker.

However, Mulligan and Sala-i-Martin's method still has the short-coming of ignoring the differences in skills acquired outside schooling and in health among workers with no schooling . Also, Mulligan and Sala-i-Martin's procedure is troublesome in light of the afore-mentioned Psacharopoulos (1994)'s finding 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 measured aggregate human capital input would be greater than 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.

In this paper, I adopt Mulligan and Sala-i-Martin's method and modify it to measure human capital inputs across countries of diverse income levels. The modification is that I assume that the industrial labourer, as classified so by the International Labour 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 labour income, which is assumed to be proportional to aggregate income or output across countries, by the average income of industrial labourers in that country.

For international comparison 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.[7] First, it requires much less data and is, therefore, more

[7] Similar to Mulligan and Sala-i-Martin's method (see footnote 6), this method has the weakness that a factor other than human capital input itself could have a large impact on the measure of aggregate human capital input by affecting the labourer income, which serves as a unit of measurement. This warns us to be careful in country-by-country comparison of measured human capital inputs. For comparison of human capital inputs in relation to income level, however, it matters only to the extent that such factors are related to income level. There are no obvious such factors that are related to income level.

applicable than Krueger's procedure. Second, by not using the years of schooling as a way of comparing workers all together, it avoids the problem of mismeasurement of human capital acquired outside schooling that are present in Krueger's and Mulligan and Sala-i-Martin's procedures. Third, the human capital inputs of industrial labourers across countries are 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. As will be explained further in Section 3, industrial labourers are workers who primarily supply their physical effort with little skill. Also, it is plausible to assume that these workers are physically fit to work in the industrial sector. So in terms of health as well, industrial labourers are comparable. Fourth, when we order occupations according to their incomes, the industrial labourer is not at the extreme: it commands neither high nor low income. Therefore, given the differences in wage profile across occupations across countries,[8] equating human capital inputs of industrial labourer across countries is not extreme while equating human capital inputs of workers with no schooling in Mulligan and Sala-i-Martin's method is.

The paper is organized as follows. In Section 2, I present a model world economy that analytically illustrates the concept of human capital used in this paper, and that provides the basis for its measurement across countries in Section 3. In Section 3, I introduce the wage data from the "Bulletin of Labour Statistics: October Inquiry" by the International Labour Office, and document the differences in the wage rate of the industrial labourer among 39 countries of diverse output levels. I then use these wage rate differences to derive the differences in aggregate human capital input for these countries. I find that the

[8] The wage profile across occupations ordered according to income seems steeper in low-income countries than in high-income countries. This is partially supported in Section 3.

human capital input differs between the lowest-income and the highest-income countries by a factor of about 2. This is significant, but small relative to their output difference, which is by a factor of about 20, or small relative to results from other measurement methods. In Section 4, I show that the human capital input difference between the lowest-income and the highest-income countries can account for the output difference between them by not more than a factor of 2. Even if we add the physical capital input in output accounting, the two inputs, human and physical, leave a large part 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. A MODEL WORLD ECONOMY WITH HUMAN CAPITAL INPUTS

In this section, I present a model world economy that analytically illustrates the concept of human capital used in this paper and that provides the basis for its measurement across countries in the following section. In the model, 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 in income. They differ in human capital endowment which is used to generate human capital input one-for-one. Let $h(i,j)$ denote the human capital input person (i,j) supplies. The technology is identical across countries and 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 are factors other than human capital input such as physical capital input, and $\alpha \in (0,1)$ is the human capital input share parameter.[9] The aggregate human capital input is the linear sum of individual human capital inputs and people are immobile across economies so that we can write

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

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 equations 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 labour 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

[9] The value of α is assumed to be the same across countries. This assumption allows measuring human capital input using aggregate output or income instead of human capital (labour) income, whose estimates are not available for many low-income countries. Although the estimates of labour share of aggregate income differ across countries, there are no trends in relation to output level (Gollin 1997).

can be written in the 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 equations 4 and 7, we have

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

Equation 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 workers across the two economies who supply the same human capital input, we can derive the aggregate human capital input difference across the two economies. In this paper, I assume the human capital input of industrial labourers to be the same across countries, and use the wage rates of industrial labourers to derive the aggregate human capital input differences across countries.

3. MEASUREMENT OF HUMAN CAPITAL INPUT

The International Labour Office annually publishes its October Inquiry which contains the wage data for 159 occupations across countries. We use the data for 8 occupations[10] denoted as 'labourer' in 1995 survey[11] A glance at the titles of these finely classified occupations reveals that these are all industrial labourers who primarily supply their physical

[10] We use data for less than 8 occupations for some countries depending on the availability

[11] We use 1994 or 1996 survey for some countries depending on the availability of 1995 survey.

effort with little skill. I picked 39 countries that have reasonably good data and that represent diverse output levels and diverse regions of the world. They are listed in Table 1.

As would be expected from any study involving international data, there are problems with the comparability of data across countries. First, although most countries report monthly wage data, some data are yearly, weekly, daily, or hourly. For comparability, I made the data annual assuming 1 year = 12 months = 52 weeks, 1 week = 5 days, and 1 day = 8 hours.[12] Second, some countries report male and female wages separately, some 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 labourers 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 whereas others report minimum wages. Fourth, some countries report wage rates whereas others report wage earnings.[13]

Since it is difficult to infer the sizes of labourer income differences across countries due to these differences in type of data: male vs. gender-neutral, rate vs. earnings, and minimum vs. average, I made no further adjustments. This lack of adjustment warns us to be careful in country-by-country comparison of human capital input as measured in this paper. However, in assessing differences in human capital input in relation to income level, these differences in the type of data matter only to the extent that the types of data are

[12] "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.

[13] The wage earnings include on top of the wage rate, 'remuneration for time not worked, such as for annual vacation, other paid leave or holidays.'

related to the income level. The only discernable such relation in the data is that the type of the data for low-income countries tend to be minimum wage and wage rate somewhat more than that for high-income countries. Since, for any country, minimum wage and the wage rate are less than average wage and wage earnings, using minimum wage and the wage rate lead to higher measures of human capital input than using average wage and wage earnings. Therefore, this relation in the data implies that the measured difference in human capital input between low-income and high-income countries is biased to be large.[14]

Once the sorting and adjustments of the data are done, I took, for each country, the average of the wage rates/earnings across the labourer occupations. These figures are in current local currency. Given the way I measure the human capital input, a simple way to organize the data is to, for each country, divide the average labourer wage rate/earnings by the per-capita output also in current local currency. I obtained the per-capita output figures from "IMF International Financial Statistics". Table 1 presents the labourer rates/earnings divided by per-capita outputs across countries. It also presents the types of original wage data. The measure of human capital input is simply the reciprocal of the labourer rate/earning divided by per-capita output (see equation 9). The second column of Table 2 presents the human capital inputs across countries, with the US input normalized to be 1.

The interesting question is of course how large the differences in human capital input are across countries. To compare the aggregate outputs or incomes across countries, I used the output data in Summers and Heston (1995), which are adjusted for Purchasing Power

[14] Since the main result in this paper is that the human capital input differs between the lowest-income and the highest-income countries by a factor of about 2, and therefore they are small compared to their output difference or the results using other procedures, this bias reinforces the finding.

Parity across currencies and years. Since the output series in this data set cover only up to the 1992, for each country, I took the per-capita output of the most recent year available in the series for that country and divided it by the US per-capita output in that year. The first column of Table 2 presents the resulting figures along with their respective years. Plot 1 shows the human capital inputs against per-capita outputs across countries. We can see that low-income countries use less human capital input than high-income countries, and that the human capital input differs between the lowest-income and the highest-income countries by a factor of about 2.

How does this result compare to the measures of human capital (input) in the literature? One of the most widely used measure of human capital (input) is the mean years of schooling of the labour force. In the fifth column of Table 2 are those measures for most of the countries in the sample, as reported in Benhabib and Spiegel (1994), and Plot 2 shows them against per-capita outputs. We can see that the mean years of schooling differs between the lowest-income and the highest-income countries by a factor of about 3, which is greater than the difference in human capital inputs based on labourer wage. In other words, the measurement method based on labourer 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 years of schooling.

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 labourer, that is, under the assumptions that the human capital inputs of workers of this other occupation are the same across countries, and that in each country the human capital inputs of workers are proportional to their wage rates. To this end, I measured the human capital inputs across countries using the same method as explained above except that I used the wage data for each of 5 selected occupations different from the labourer: the accountant, the automobile mechanic, the computer programmer, the general physician, and the second-level mathematics teacher. Columns 6 to 10 of Table 2 present these measures of human capital inputs, with the US input normalized to be 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, similar to the result obtained from the measurement with the labourer 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 professionals commanding higher wage rates than the labourer, and that the wage premium for professionals as a multiple of the wage rate for a non-professional occupation is higher in low-income countries than in high-income countries.

From this finding, the measurement using the wage rate of the labourer may seem extreme since using the wage rates of the professionals would result in greater difference in measured human capital input between low-income and high-income countries. In this respect the method used in this paper compares 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 labourer differs from the procedure using the wage rate of the worker with no schooling in a crucial respect. That is, the labourer is not at the low end of 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 labourer: e.g., farm workers, shop attendants, workers in the catering business. There are many workers in these occupations, especially in low-income countries. There are not 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 labourer 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 labourer, the opposite result from using the wage rates of the professionals. Therefore, the measurement using the wage rate of the labourer 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 production, that is, the human capital input share parameter α in equation 1. However, since human capital input differs between the lowest-income and the highest-income countries by a factor of 2, human capital input can account for output difference between them by not more than a factor of 2, regardless of the value of α. This is small relative to the total output difference between them, which is by a factor of about 20. The third column of Table 2 presents the outputs across countries if these countries differed only in human capital input, assuming that α is equal to 2/3, a value commonly used in the literature,[15] and normalizing the US output to be 1. Plot 2 plots these outputs across countries against their actual per-capita outputs. We can see that human capital input differences account for sizable output differences across countries, but that these differences are nowhere near the total differences. The fourth column of Table 2 presents the outputs across countries if these countries were the same in human capital input and differed only in the other factors, that is, the values of parameter A in equation 1, with the US value normalized to be 1. We can see that the output differences across countries accounted for, by differences in factors other than human capital input, are huge, outweighing the output differences accounted for by human capital input differences by a big margin.

One factor other than the human capital input that can significantly account for output differences across countries is, of course, the physical capital input. In fact, the accumulation of physical capital input has been singled out as the primary mechanism for growth for a long time in growth literature. Therefore, it would be interesting to see how much of 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

$$\begin{aligned} Y_i &= A_i H_i^{\alpha} \\ &= \hat{A}_i H_i^{\alpha} K_i^{1-\alpha} \end{aligned} \tag{10}$$

where the subscript i indexes countries, Y_i is the aggregate output, H_i is the aggregate human capital input, A_i is factors other than human capital input, K_i is the aggregate

[15] The estimate of the human capital input (labour) share of total income varies across studies but is around 2/3. See Gollin (1997), Mankiw, Romer, and Weil (1992) and Young (1995) for example.

physical capital input, and $\hat{A}_i$ is factors 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 and its implication on the extent to which the human capital input differences can account for the output differences: the same measurement method as 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) provides measures of physical capital stock across countries.[16] One can infer from these measures that the physical capital/output ratio tends to be lower for low-income countries, the ratios for many low-income countries being less than a half of the US ratio.

Consider a hypothetical country that averages the lowest-income countries, say with one-twentieth of the US output. Let's 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 one-fortieth of the US physical capital stock. Under the assumption that the inputs are proportional to stocks across countries,[17] this country uses one-fortieth of the US physical capital input. Assuming that the human capital input share parameter α in equation 10 is equal to 2/3 as before, this physical capital input difference can account for output difference between this country and the US by a factor of 2.7. We have already seen that the human capital input difference between

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

[17] This assumption is commonly implicit in studies of output accounting using physical or human capital (see footnote 1).

the lowest-income and the highest-income countries is by a factor of about 2. Therefore, let's assume that this country uses half of the US human capital input. This difference in human capital input can account for the output difference between this country and the US by a factor of 1.6. Then, the human and the physical capital differences between the two countries together can account for their output difference by a factor of 4.3, the product of the two factors. 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 output difference between the two countries by a factor of nearly 5.

5. ACCOUNTING FOR HUMAN CAPITAL INPUT DIFFERENCES

In this section, I discuss 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 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: they take less nutrition and 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 justifies calling what the method used in this paper measures, the human capital input.

There is 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. That is, 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 equation 5. If two countries differ in some factor that is included in parameter A in that equation, the physical capital input for example, then the difference in this factor affects the differences in output and in the wage rate proportionately, and therefore has 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 output, this difference will affect the difference in measured output without affecting the wage rate, and thereby proportionately affect the measured human capital input difference between the two countries.[18] Good examples are the informal sector output and the output of home production, both of which are typically excluded in the measurement of output. The low-income countries tend to have larger outputs of both types than the high-income countries,

[18] A way of characterising this feature of the measurement method in this paper is that the method measures only the human capital input used in the production of 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 measured output across countries.

and this leads to larger difference in measured human capital input between low-income and high-income countries.[19]

6. CONCLUSION

In this paper, I proposed the aggregate output divided by the wage rate of the industrial labourer in a country as a measure of aggregate human capital input for that country. The assumptions that support this method of measuring human capital input are that the human capital inputs of industrial labourers are the same across countries, that the human capital inputs of workers within a country are proportional to their wage rates, and that the human capital input (labour) share of the aggregate output is the same across countries. I showed that, for international comparison, this measurement is better than other measurements based on schooling in the literature, conceptually or in terms of applicability given the data constraints for low-income countries.

I used the wage data from the International Labour Office "Bulletin of Labour Statistics: October Inquiry" to measure human capital inputs for 39 countries. I found that, as one may expect, the low-income countries use less human capital input in production, and that human capital input differs between the lowest-income and the highest-income countries by a factor of about 2. This is significant but small relative to their output difference, or compared to the results from other measurement methods. In neoclassical growth theory, this implies that the human capital input difference between the lowest-income and the highest-income countries can account for their output difference by not more than a

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

factor of 2. 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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Table 1: laborer earnings

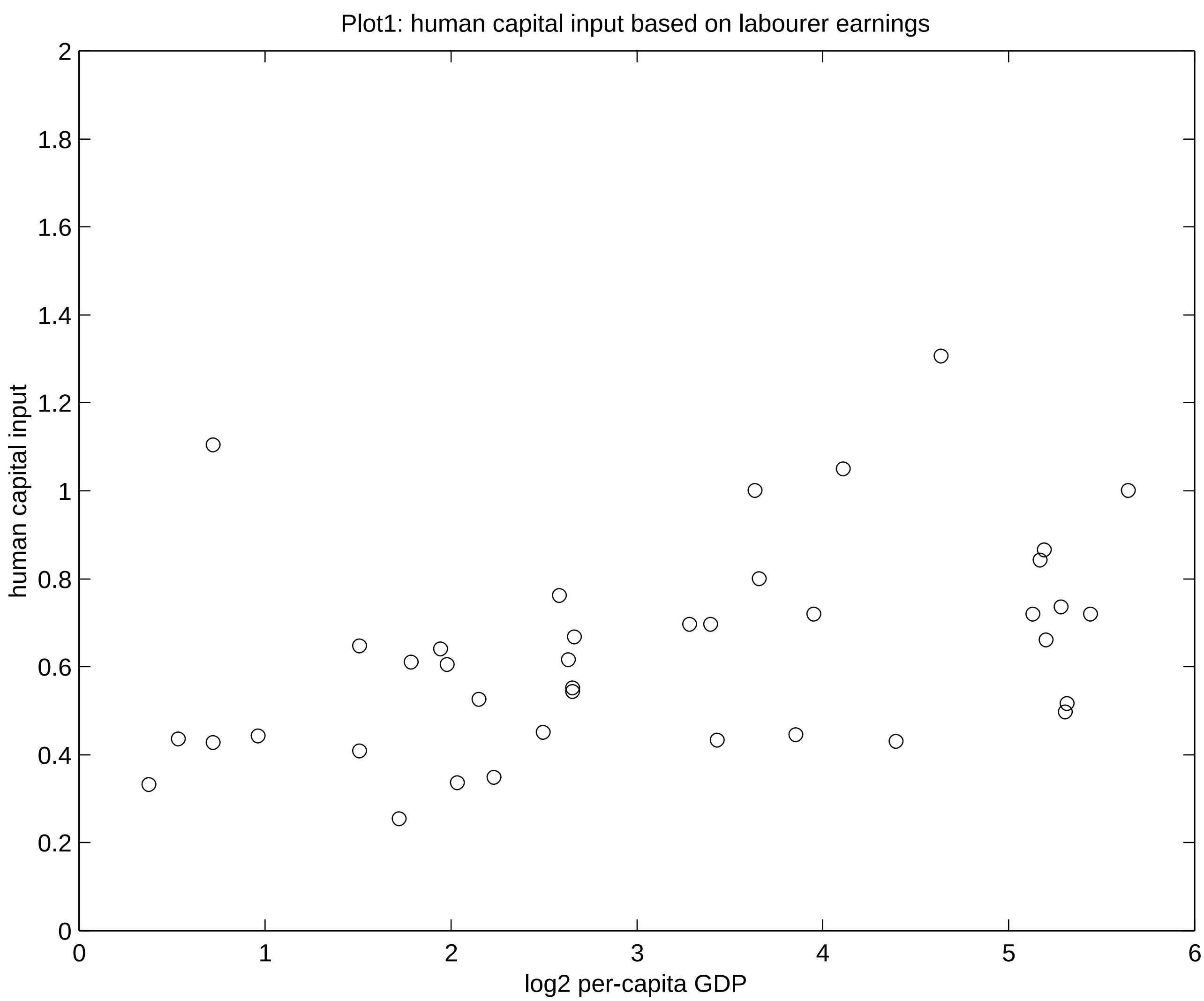
country	**earnings**	**er**	**ra**	**av**	**mi**	**ma**	**ne**	**mo**	**we**	**da**	**ho**	**ye**
Ivory coast	1.57(2.47)		•		•		•	•				94
Gabon	.99(1.56)	•		•			•	•				95
Madagascar	1.50(2.35)		•	•			•	•				95
Malawi	1.93(3.03)		•		•	•		•				95
Mauritius	.61(.96)	•		•			•				•	95
Sierra Leone	1.45(2.28)		•		•	•		•		•		95
Togo	1.47(2.30)		•	•			•	•				95
Argentina	.80(1.25)		•		•		•	•				95
Bolivia	1.22(1.91)		•		•	•		•				95
Costa Rica	.92(1.45)	•		•		•		•				95
Dominican Rep	1.18(1.85)		•	•			•	•				95
El Salvador	1.16(1.82)		•	•			•	•				95
Guatemala	1.04(1.63)	•		•			•	•				94
Honduras	1.00(1.57)		•	•		•			•			95
Nicaragua	2.52(3.95)		•	•			•	•				95
Peru	1.42(2.22)		•	•		•			•			94
United States	.64(1.00)	•		•		•			•			95
Uruguay	1.44(2.26)	•		•			•				•	95
Bahrain	.49(.77)		•	•			•	•				95
Bangladesh	1.91(2.99)		•		•	•		•				95
China	1.06(1.67)		•	•		•		•				95
India	1.05(1.64)		•		•		•			•		95
Korea	1.49(2.33)	•		•		•		•				95
Malaysia	.89(1.39)	•		•			•	•				95
Myanmar	.58(.91)		•	•			•	•				95
Philippines	1.84(2.89)		•		•	•		•				95
Sri Lanka	.84(1.31)	•		•			•				•	95
Syria	1.48(2.32)		•	•			•			•		95
Austria	.74(1.15)	•			•		•	•				95
Belgium	.87(1.37)		•		•		•				•	95
Germany	.89(1.40)		•		•		•	•				95
Hungary	.64(1.01)	•		•			•	•				95
Italy	.76(1.20)		•		•		•	•				95
Norway	.97(1.53)	•		•			•	•				95
Poland	.92(1.45)	•		•		•		•				96
Romania	.96(1.51)	•		•		•		•				95
Sweden	1.29(2.02)	•		•			•	•				95
United Kingdom	.89(1.39)		•	•		•			•			95
Australia	1.24(1.94)	•		•		•			•			95

Note: **earnings**: 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; **ye**: year

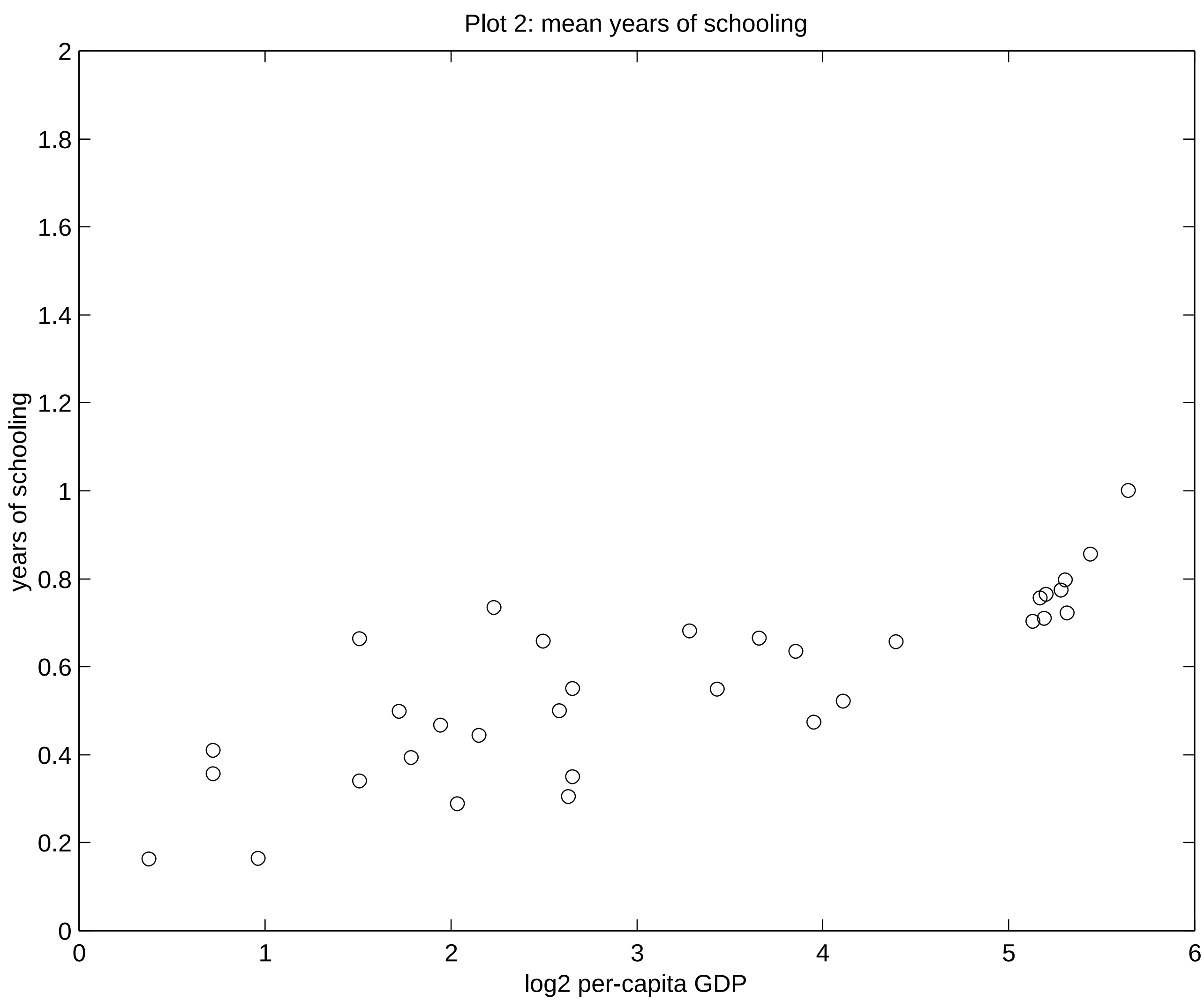
Table 2: human capital input

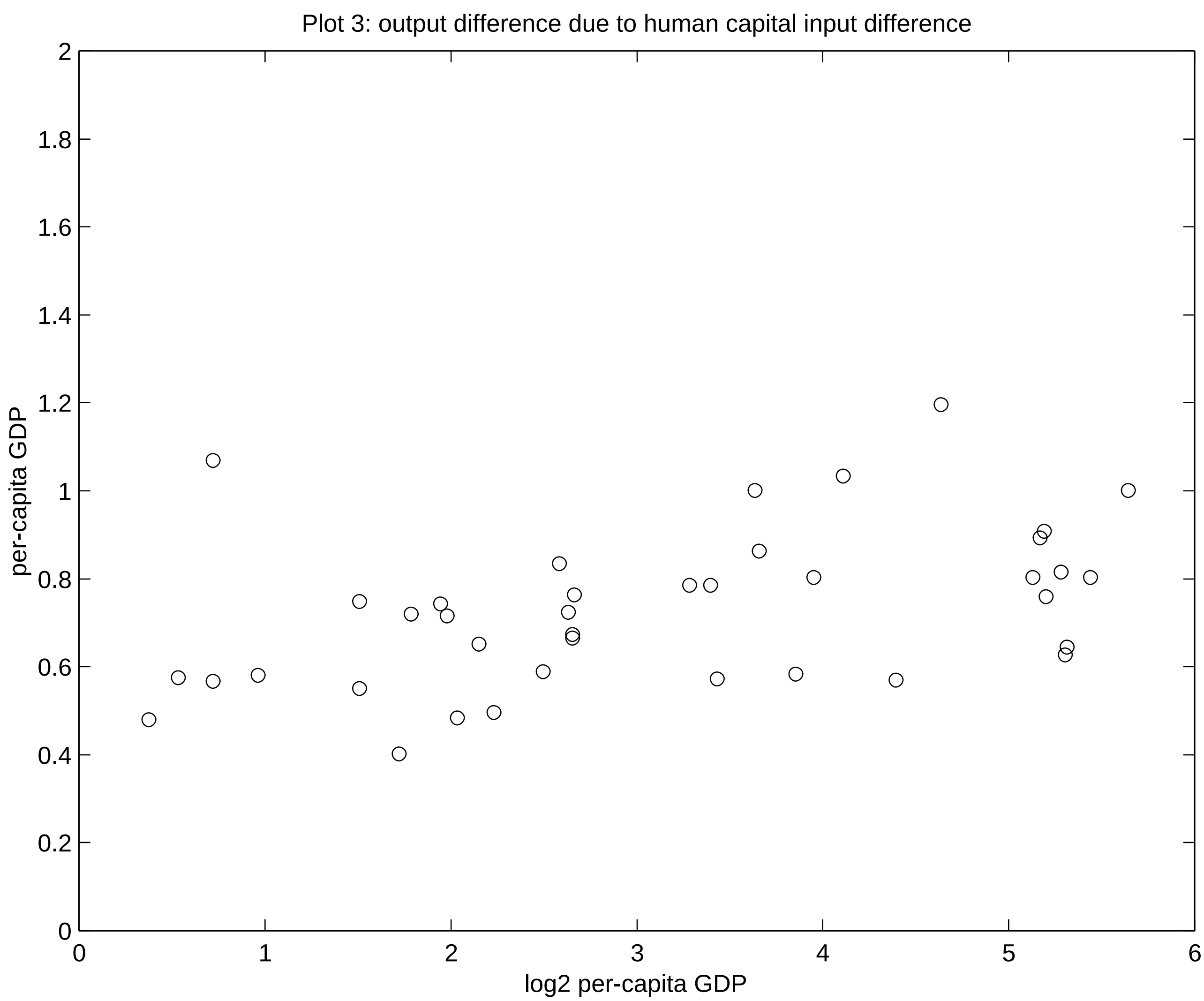
country	**Y**	**H**	$\mathbf{H^{2/3}}$	**A**	**Hs**	**Hac**	**Ham**	**Hcp**	**Hgp**	**Hmt**
Ivory coast	.06(92)	.41	.55	.10	4.1(.34)	.57	.84	.37		
Gabon	.06(92)	.65	.75	.08	8.0(.66)	.18	.79			
Madagascar	.03(92)	.43	.57	.06	4.3(.36)	.35	.34	.45	.41	.29
Malawi	.03(92)	.33	.48	.05	2.0(.16)		.11		.09	
Mauritius	.35(92)	1.05	1.03	.34	6.3(.52)	.37	1.06	.79	.90	.55
Sierra Leone	.04(92)	.44	.58	.07	2.0(.16)	.07	.35		.55	.88
Togo	.03(92)	.43	.57	.05		.09				
Argentina	.25(90)	.80	.86	.29	8.0(.66)		1.06	1.18		.51
Bolivia	.09(92)	.53	.65	.14	5.4(.44)	.12	.84	.28	.67	.57
Costa Rica	.20(92)	.70	.79	.25	8.2(.68)	.49	.69	.60	.48	
Dominican Rep	.13(92)	.54	.67	.19	6.7(.55)	1.16			.95	1.12
El Salvador	.13(92)	.55	.67	.19	4.2(.35)	.16	.51	.34	.57	.65
Guatemala	.12(92)	.62	.72	.17	3.7(.30)					
Honduras	.08(92)	.64	.74	.10	5.6(.47)	.36	.44	.22	.34	.46
Nicaragua	.07(90)	.25	.40	.16	6.0(.50)	.18	.24	.19	.30	.24
Peru	.11(92)	.45	.59	.19	7.9(.66)					
United States	1.00(92)	1.00	1.00	1.00	12.1(1.00)	1.00	1.00	1.00	1.00	1.00
Uruguay	.29(92)	.44	.58	.50	7.7(.63)				.24	.35
Bahrain	.50(88)	1.31	1.19	.42		.65	.84	.88	.73	.73
Bangladesh	.08(92)	.34	.48	.17	3.5(.29)	.31	.25	.16	.38	.30
China	.08(92)	.60	.71	.11		.85			1.11	.95
India	.07(90)	.61	.72	.10	4.8(.39)	.23	.84	.36		
Korea	.42(91)	.43	.57	.74	7.9(.66)	.50	.44	.56	.79	.40
Malaysia	.31(92)	.72	.80	.39	5.7(.47)					
Myanmar	.03(89)	1.10	1.07	.03	4.9(.41)	.81		1.22	1.49	1.32
Philippines	.09(92)	.35	.49	.19	8.9(.73)			.61		
Sri Lanka	.12(92)	.76	.83	.14	6.0(.50)					
Syria	.22(90)	.43	.57	.38	6.6(.55)					
Austria	.73(92)	.86	.91	.81	8.6(.71)	.68	.93	.76	1.15	
Belgium	.78(92)	.74	.81	.96	9.4(.77)		.96			
Germany	.87(92)	.72	.80	1.08	10.3(.85)	.85	.79	1.04	1.06	.67
Hungary	.25(92)	1.00	1.00	.25		1.59		.86	1.92	1.30
Italy	.72(92)	.84	.89	.81	9.1(.76)	1.06	1.11	1.41	1.27	1.45
Norway	.74(92)	.66	.76	.97	9.2(.76)		.83			1.04
Poland	.21(92)	.70	.79	.27		.65	.88	.64		1.19
Romania	.13(89)	.67	.76	.17		.53	.78	.54	1.45	.93
Sweden	.79(92)	.50	.63	1.26	9.6(.80)					.82
United Kingdom	.70(92)	.72	.80	.87	8.5(.70)	.63	.78		.69	
Australia	.80(92)	.52	.64	1.24	8.7(.72)	.87	.69	.80	.85	.85

Note: **Y**: per-capita output over US per-capita output (year); **H**: human capital input based on laborer earnings; $\mathbf{H^{2/3}}$: per-capita output accounted for by human capital input; **A**: per-capita output accounted for by factors other than human capital input; **Hs**: mean years of schooling in 1985; **Hac**: human capital input based on accountant earnings; **Ham**: human capital input based on automobile mechanic earnings; **Hcp**: human capital input based on computer programmer earnings; **Hgp**: human capital input based on general physician earnings; **Hmt**: human capital input based on second-level mathematics teacher earnings;



Plot1: human capital input based on labourer earnings
human capital input
log2 per-capita GDP
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0
1
2
3
4
5
6


Plot 2: mean years of schooling
years of schooling
log2 per-capita GDP
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0
1
2
3
4
5
6


Plot 3: output difference due to human capital input difference
per-capita GDP
log2 per-capita GDP
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0
1
2
3
4
5
6