# The Human Capital Stock: A Generalized Approach. Reply

Benjamin F. Jones*

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**Abstract**

Human capital differences across countries can appear large or small depending on measurement methods. This reply clarifies key assumptions and conceptual distinctions across accounting approaches. Accounting-based arguments for small human capital differences are difficult to sustain. By contrast, large human capital differences are theoretically and empirically coherent. Non-accounting arguments against large human capital variation are examined and their weaknesses pinpointed. This reply also suggests a fruitful way forward for this literature, providing a natural conception of human capital that integrates literatures on ideas and institutions with the accounting of Jones (2014).

*Kellogg School of Management, Northwestern University, and NBER. Contact: Strategy Department, Kellogg School of Management, 2211 Campus Drive, Evanston IL 60208 USA; bjones@kellogg.northwestern.edu. I thank Francesco Caselli, Antonio Ciccone, Hannes Malmberg, and Ben Olken for helpful comments. All errors are my own. The author declares that he has no relevant or material financial interests that relate to the research described in this paper.

# 1 Introduction

The measurement of human capital has long been a source of debate in the development accounting literature. The disagreements have sprung not from differences in data but from conceptual differences in the measurement methods. Caselli and Ciccone's comment on Jones (2014) provides a welcome opportunity to further address these important issues.

To advance this debate, this reply will do three things. First, it will provide an overarching framework that precisely defines the different methodological choices in human capital accounting. Second, it will evaluate specific arguments against human capital playing a substantial role in economic development. Third, it will suggest how this literature may fruitfully move forward.

Section 2 clarifies the key assumptions across accounting methods and elucidates their implications and intuitions. The analysis puts traditional macro-Mincer accounting, Jones (2014), and Caselli and Ciccone (2013, 2018) into a common frame, with the goal of clarifying exactly which assumptions drive which results. A primary theme is that both Jones and Caselli and Ciccone relax key assumptions in traditional accounting. The result is that human capital variation across countries can become much larger than the original accounting suggested.

Specifically, the change to human capital accounting in Jones (2014) is to allow for complementarities across workers (e.g., as with a division of labor) instead of assuming all workers are perfect substitutes. This single change to traditional accounting amplifies differences in human capital stocks across countries and "reject[s] the constraints on human capital variation that traditional accounting has imposed" (Jones 2014 abstract). Section 2 then pinpoints the further assumption in traditional accounting that Caselli and Ciccone's method relaxes – the idea that one can infer human capital from the observed productivity gains with schooling. I show that the main point of Jones (2014) – that human capital variation across countries can be substantially amplified – still obtains under these relaxed assumptions. But if one breaks the relationship between human capital and the productivity gains associated with schooling, as Ciccone and Caselli (2013, 2018) do, then in some sense 'anything goes' – the productivity gains via human capital can be arbitrarily large or small, and accounting no longer meaningfully proceeds. Section 2 makes these arguments precise.

A second conclusion from Jones (2014) is that, once one allows for complementarities across workers in a standard way and using standard data, the accounting "illustrates the possibility that capital variation may now account (even fully) for the large income variation between rich and poor countries." Given that accounting evidence is consistent with this possibility, Section 3 considers other arguments (i.e., not based in accounting) against the idea that human capital variation is large. Caselli and Ciccone (2018) [hereafter, CC] argue against this possibility according to its implications; namely, one should reject a central role for human capital because the implications are untenable. For example, CC argue that the Jones (2014) accounting would imply that a high-skill individual would migrate from rich to poor countries. I discuss why this implication does not follow; in particular, the migration argument can be naturally overturned when skilled workers have important complementarities with each other, among other potential reasons (a formal model that rules out migration along this line is Jones (2011)). A second argument is that other features, like ideas and institutions, are important for development; hence, human capital cannot play a central role. However, this logic assumes an unnecessary tradeoff between capital, ideas, and institutions and conflates "proximate causes" and "deep causes" in understanding economic development. An alternative logic, drawing on related literature, is presented in the final part of this reply.

While elucidating key differences in accounting methods, this reply also highlights important points of agreement. Three points of agreement are as follows. First, human capital accounting based on perfect substitutes reasoning appears problematic; it is inconsistent with empirically-grounded elasticities of substitution between skilled and unskilled workers. Second, using realistic substitution elasticities (i.e., allowing for complementarities) the productivity gains of skilled workers appear much higher in rich countries than poor countries. Third, embracing broader literatures, other features - including ideas and institutions – appear important in understanding the wealth and poverty of nations.

These points of agreement suggest a path forward. This reply therefore closes by synthesizing key points of agreement and suggesting where this literature might fruitfully move. Section 4 provides a neoclassical synthesis that positions human capital, ideas, and institutions in a conceptually coherent framework that is consistent with the main facts, CC's arguments, and the accounting in Jones (2014).

# 2 Assumptions and Implications

It is remarkable that many authors have used essentially the same data to undertake human capital accounting and come up with entirely different conclusions. This section clarifies how, first by stating differences in assumptions and then following these through into different implications and interpretations. Elucidating these foundations will further clarify key intuition and lead to a precise critique of Caselli and Ciccone's approach.

## 2.1 Assumptions

We consider (1) the literature's baseline "macro Mincer approach"; (2) the generalized approach of Jones (2014); and (3) Caselli and Ciccone (2013, 2018). The differences in assumptions are summarized in Table 1.

### 2.1.1 Macro-Mincer Accounting

The macro-Mincer approach (Klenow and Rodriguez-Clare 1997, Hall and Jones 1999, Caselli 2005), uses the wage gains with schooling to estimate human capital stocks. This traditional accounting approach proceeds on the basis of:

**Assumption 1.** *Different human capital types are perfect substitutes.*

This assumption is implemented with the human capital aggregator

$$H^c = h_1^c L_1^c + h_2^c L_2^c \tag{1}$$

where $c$ indexes countries and the subscripts indicate different type of labor.

The human capital associated with schooling (or experience, etc.) are then inferred from wages, assuming factors are paid their marginal products.[1] Namely, with the production function (1) given by Assumption 1, we have

$$\frac{h_2^c}{h_1^c} = \frac{w_2^c}{w_1^c} \tag{2}$$

so that relative wages estimate the relative human capital of different groups within a country.

Importantly, this approach was seen as an improvement on regression methods (Mankiw et al. 1992), which were thought to have identification problems, whereby average schooling

[1] All the methods discussed here assume that factors are paid their marginal products; the differences in human capital stock accounting thus come from other assumptions, as highlighted in the text.

in a country – which strongly predicts per-capita income – could be a spurious association. By contrast, the above accounting, based in microevidence on the returns to schooling via wage returns, was argued to be better because it captured the productivity of human capital directly. That is, there is an additional, implicit assumption in this approach, which is embedded in its supposed identification advantage.

**Assumption 2** *The productivity gains associated with schooling represent human capital.*

The notation in (1) and (2), where authors use "$h$", evokes this assumption. More precisely, under Assumption 2 one interprets the ratio $h_2^c/h_1^c$ as identifying the productivity gains from increased human capital per se. One can then proceed to estimate the human capital stock.[2] The key data inputs are relative wages and labor allocations, which are readily available across countries.

### 2.1.2 A Generalized Approach (Jones 2014)

Jones (2014) departs from traditional accounting in one (and only one) way, by relaxing Assumption 1 above, so that different human capital types are not treated as perfect substitutes. Jones (2014) is broadly motivated by the idea that different types of labor do different things (i.e., there is a division of labor). Formally, Jones (2014) makes general theoretical statements using an aggregator $H = G(H_1, Z(H_2, ..., H_N))$ where $Z(.)$ aggregates a wide range of skilled-labor types and where different types of labor have some degree of complementarities.[3]

When it comes to estimation, Jones (2014) then specifically replaces the perfect substitutes aggregator with a CES generalization, drawing on micro-evidence that suggests skilled and unskilled workers are not perfect substitutes but rather have a finite elasticity

[2] In practice, we estimate the human capital stock as $H^c = h_1^c \left(L_1^c + \frac{h_2^c}{h_1^c} L_2^c\right) = h_1^c \left(L_1^c + \frac{w_2^c}{w_1^c} L_2^c\right)$. Since $h_1^c$ is not known, authors commonly make the additional assumption that $h_1^c$ does not vary across countries. That is, low-skill workers are assumed to have the same human capital everywhere. Jones (2014) considers human capital accounting with and without this assumption. See also Hendricks and Schoelman (2018). In this reply, as in the comment, we will maintain the assumption that $h_1^c$ does not vary across countries to highlight the core differences in the existing implementations, which lie elsewhere.

[3] The key conceptual results in Jones (2014) are Lemmas 1-3, which consider general classes of human capital aggregators. This reply will more narrowly focus on a CES approach, following the comment.

of substitution. Notationally, to be in concert with the CC comment, we write[4]

$$H^c = \left[ \left(h_1^c L_1^c\right)^{\frac{\varepsilon-1}{\varepsilon}} + \left(h_2^c L_2^c\right)^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{3}$$

in place of (1). Continuing to assume that factors are paid their marginal products, this CES aggregator implies that we replace (2) with[5]

$$\frac{h_2^c}{h_1^c} = \left(\frac{w_2^c}{w_1^c}\right)^{\frac{\varepsilon}{\varepsilon-1}} \left(\frac{L_2^c}{L_1^c}\right)^{\frac{1}{\varepsilon-1}} \tag{4}$$

As before, the key data inputs are relative wages and labor allocations.

### 2.1.3 Caselli and Ciccone

Caselli and Ciccone (2013, 2018) consider a further departure from the assumptions above. Like Jones (2014), they relax the perfect substitutes assumption and use (4). Consequently, using the same data, we estimate the same $h_2^c/h_1^c$. This is an important point of agreement.

However, the Caselli and Ciccone method now also departs from Assumption 2. They depart from the idea that these productivity gains ($h_2^c/h_1^c$) represent human capital itself. In relaxing Assumption 2, the productivity gains associated with schooling ($h_2/h_1$) are now written

$$\frac{h_2^c}{h_1^c} = \frac{\tilde{h}_2^c}{\tilde{h}_1^c} \frac{a_2^c}{a_1^c} \tag{5}$$

which mixes a human capital piece ($\tilde{h}_2/\tilde{h}_1$) and some residual productivity piece ($a_2/a_1$). The aggregator that produces (5) is

$$X^c = \left[ \left(\tilde{h}_1^c a_1^c L_1^c\right)^{\frac{\varepsilon-1}{\varepsilon}} + \left(\tilde{h}_2^c a_2^c L_2^c\right)^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}}. \tag{6}$$

I will denote this aggregate "$X$", emphasizing that it is no longer in general a human capital stock. Rather, it mixes human capital and residual productivity terms.

We thus have an identification problem in the micro data that formed the basis of macro-Mincer accounting. Once you relax Assumption 2, (i) the relationship between the productivity gains associated with schooling ($h_2/h_1$) and human capital gains associated

[4] In Jones (2014), the average productivity from skilled workers is called $h_z$ and is thought of as a collective output produced by differentiated skilled workers; we will call it $h_2$ here to relate it to the CC comment.

[5] In looking at two skill classes, the expression (4) reduces to the calculation of Caselli and Coleman (2006) but with Jones (2014) and Caselli and Ciccone (2018) offering different interpretations of the productivity terms that weight different types of labor. In this reply, as in the comment, we focus on this two-type approach. Both Jones (2014) and Caselli and Ciccone (2013) consider much wider classes of aggregators and labor types in making their conceptual arguments about bounds on human capital differences and in making specific estimates.

with schooling ($\tilde{h}_2/\tilde{h}_1$) is ambiguous (see (5)), and (ii) a "human capital stock" is no longer clearly defined (see (6)).

Nonetheless, Caselli and Ciccone (2013, 2018) still seek to address the role of human capital in development accounting. Specifically, they are interested in an exercise where one fixes the productivity returns to schooling and then changes the poor country's labor allocation to the rich country's labor allocation. In this framing, human capital differences appear, at least on the surface, to be greatly diminished.[6] To make a human capital interpretation, Caselli and Ciccone (2018) assume that

$$\frac{\tilde{h}_2^c}{\tilde{h}_1^c} = \frac{h_2^P}{h_1^P} \tag{7}$$

where $P$ represents a benchmark poor country. This assumption encapsulates two separate claims. First, human capital gains from schooling ($\tilde{h}_2/\tilde{h}_1$) are assumed to be the same in all countries. Second, these human capital gains ($\tilde{h}_2/\tilde{h}_1$) are assumed to be the same as the productivity gains in the poor country specifically (as opposed to some other country).

Below I will provide a critique of this approach. But first we will consider the implications that follow from the different assumptions in the above methods, clarify the key sources of agreement and disagreement, and discuss the key intuition.

## 2.2 Implications and Intuitions

Using the same datasets, the above approaches lead to sharply different conclusions. We can see why with simple calculations, as summarized in Table 1. We examine the ratio of human capital stocks, $H^R/H^P$, comparing a rich ($R$) and a poor ($P$) country. As a benchmark, and consistent with CC's comment, we will take the 85th percentile country (Israel) and 15th percentile country (Kenya) in the world income distribution.[7] Real output per worker is 16.9 times higher in Israel than Kenya. The question is how much of this output difference human capital can help explain.

To establish basic intuition, the key stylized facts are (i) wage gains with schooling ($w_2^c/w_1^c$) are very similar across countries, and modest, while (ii) labor allocations ($L_2^c/L_1^c$)

[6] Caselli and Ciccone (2018) argue that "human capital differences go from explaining all cross-country income differences (for plausible values of the elasticity of substitution between workers with different skills) to explaining none." Caselli and Ciccone (2013), while speaking to the role of schooling in development accounting (as in its title and abstract), is presented more as a kind of policy exercise than a development accounting exercise - an interpretation that will be considered below.

[7] Data is from the Penn World Tables v6.1, using the 1996 benchmark year.

are extremely different across countries. Specifically, local wages rise approximately 10% per year of schooling in rich and poor countries, but people with advanced education are in far greater relative supply in rich countries. For example, the fraction of the adult population with at least some college education is 34 times higher in Israel than Kenya.[8]

Consider traditional accounting. Using (1) and (2), we have[9]

$$\left.\frac{H^R}{H^P}\right|_{Traditional} = \frac{L_1^R + \frac{w_2^R}{w_1^R} L_2^R}{L_1^P + \frac{w_2^P}{w_1^P} L_2^P}$$

Intuitively, this approach translates skilled labor in each country into its unskilled labor equivalents, with the weight on skilled labor determined by the local wage gain with schooling. Now, since wages rise only about 10% per year of schooling in rich and poor countries, it is easy to see under traditional accounting that differences in human capital stocks will appear small. In particular, the weight on the skilled labor allocation is small.[10] Table 1 shows a benchmark result of $H^R/H^P = 2.0$ using this method, which adds little in explaining the large real output per worker ratio of 16.9.[11]

Now consider Jones (2014). In relaxing the perfect substitutes assumption, we arrive at (4). The productivity gains with schooling ($h_2^c/h_1^c$) are no longer determined solely by the (relatively modest) gain in relative wages ($w_2^c/w_1^c$). Rather, the estimated productivity gains must now also account for the relative supply of skilled labor ($L_2^c/L_1^c$), which is much greater in rich than poor countries. For a reasonable elasticity of substitution, the calculation (4) will imply that[12]

$$\frac{h_2^R}{h_1^R} >> \frac{h_2^P}{h_1^P} \tag{8}$$

Table 1 considers the case where $\varepsilon = 1.5$, which is thought to be a realistic estimate in the micro literature. The result is $H^R/H^P = 11.7$, or about six times the difference traditional

[8] Education data is for adults over age 25 in 1995 and comes from Barro and Lee (2001).

[9] Here, for simplicity, we are assuming that $h_1^R = h_1^P$. See also footnote 2.

[10] For example, if college completion requires about ten years of schooling beyond primary school education, and there is a 10% wage gain per year of schooling, then the wage gain of the college educated over the primary school education is $w_2/w_1 \approx 2.7$. Thus, even if everyone in the rich country were college educated and everyone in the poor country were primary school educated, the difference in human capital stocks would be only 2.7. Since the population in each country has a mix of both skilled and unskilled workers, the difference in human capital stocks will be smaller than this.

[11] Using the a Cobb-Douglas production function, a physical capital share of 1/3, and the perpetual inventory method to calculate physical capital stocks (all standard in this literature), physical and human capital variation collectively appear to account for only 25% of the variation in output per worker between Israel and Kenya. Most of this capital contribution comes from physical capital, not human capital, in this traditional calculation. See Table 1 of Jones (2014).

[12] This assumes an elasticity of substitution greater than 1, which is the relevant empirical case.

accounting presented. Such amplification allows capital stock differences to explain much larger shares of output differences and even become large enough for capital input differences to more-or-less fully account for the variation in output per worker across countries. Intuitively, from (8), we are weighting up the productivity advantage of skilled labor in rich countries, which naturally expands the human capital differences across countries.

Caselli and Ciccone (2018) call this a "relative-efficiency effect", which they distinguish from a "relative-supply effect" describing labor allocations. My prior work uses a "quality" and "quantity" nomenclature, describing (8) as differences in the quality of skilled workers or their services, and differences in labor allocations as differences in the quantity of skilled workers (Jones 2011, 2014). Notably, the amplification gets larger as the elasticity of substitution falls. In abandoning perfect substitutes, we have introduced downward sloping demand for workers' services. The relative price of skilled workers services will therefore decline as their relative output expands - and the more so the steeper demand. This intuition is emphasized by Caselli and Coleman (2006), Caselli and Ciccone (2013, 2018), and also by Jones (2014), which explains "To the extent that rich countries 'flood the market' with skilled labor compared to unskilled labor, downward sloping demand implies that the relative price of skilled services will decline. The more downward sloping the demand for skilled services...the greater the output return to schooling in rich countries needed to maintain the observed wage returns to schooling."

This intuition, based on how we weight the skilled labor allocation, is important but incomplete for seeing the whole picture. Figure 1 encapsulates the broader intuition, which incorporates two additional features. The first concerns the "slope" of wages. In particular, despite very large differences in productivity terms, the wage returns to schooling in different countries are broadly the same. This follows naturally from equilibrium reasoning about labor supply, where labor reallocates in accordance with the productivity advantages of skilled labor. Conceptually, simple models of individual human capital investment (e.g., Willis 1986, Jones 2014) will drive equilibrium wage returns toward the discount rate. Hence in Figure 1, we see similar relative wage schedules in all countries.

The second feature regards the wage "intercept". Namely, even if the productivity advantages concern skilled workers in the rich country (8), the effect is felt as a shift in the entire wage schedule - both unskilled and skilled workers benefit equally. Jones

(2014) emphasizes a general formulation, rewriting the human capital aggregator as $H^c = (\partial H^c/\partial H_1^c)\, H^c_{traditional}$, which suggests a more complete intuition. One can indeed think of relative wages as translating skilled labor into unskilled labor equivalents ($H^c_{traditional}$). The difference is that the intercept shifts. The wage schedule in the rich country ends up floating above the wage schedule in the poor country. See Figure 1. Note that this "intercept not slopes" intuition is fundamentally a story of human capital *interdependence*; effectively, large productivity gains limited to skilled workers drive up real incomes throughout the economy. Critically, this shift in the intercept need no longer be driven by physical capital or TFP; rather, it can be driven by human capital. This intuition is essential, among other reasons, for being careful about how we think about immigration experiments (see Section 3.1).

Now consider Caselli and Ciccone's approach. Both Caselli and Ciccone (2013, 2018) and Jones (2014) share the production function (3) and estimate $h_2^c/h_1^c$ using (4). That is, both methods relax Assumption 1 (perfect substitutes) in the same way. Both methods thus arrive at (8) and therefore agree on a key point: the productivity advantages with schooling appear much greater in rich countries than in poor countries. The difference between CC and Jones (2014) is one of interpretation, which concerns Assumption 2. Caselli and Ciccone (2018) do not interpret these productivity advantages with schooling ($h_2^c/h_1^c$) to be informative of human capital in rich countries (though they do appear to interpret them as human capital in the poor country). I will discuss the issue of identification first, as it is a central to this entire literature, before critiquing Caselli and Ciccone's specific alternative approach.

## 2.3 Identification

Relaxing Assumption 2 concerns a core idea that motivated the human capital accounting literature. To see this, return to the initial perfect substitutes approach, which by relaxing Assumption 2 becomes

$$X^c = \tilde{h}_1^c a_1^c L_1^c + \tilde{h}_2^c a_2^c L_2^c$$

with the relative wages

$$\frac{w_2^c}{w_1^c} = \frac{\tilde{h}_2^c}{\tilde{h}_1^c}\frac{a_2^c}{a_1^c}$$

The wage gains ($w_2^c/w_1^c$) no longer pin down human capital variation ($\tilde{h}_2^c/\tilde{h}_1^c$), but rather

provide information regarding some mix of human capital and other productivity terms. Thus, once you drop the core identification idea (Assumption 2) that motivated macro-Mincer accounting in the first place, relative wages no longer tell us about the relative human capital of skilled and unskilled labor. Traditional accounting thus fails. There are no bounds on the actual skill returns to schooling ($\tilde{h}_2^c/\tilde{h}_1^c$) in any given country, which could now be anything (enormously positive, mild, zero, even skill-diminishing) so long as the productivity terms ($a_2^c/a_1^c$) balance out in the right way to be consistent with the wage returns. Things are, fundamentally, not pinned down.

As stated in Jones (2014), "the generalized accounting, like the traditional case, infers the productivity gains from human capital investment building from evidence on the wage returns to schooling. An additional interpretative question is to ask whether the wage gains associated with more schooling are in fact due to human capital investment as opposed to simply being associated with it. This identification challenge, if left unchecked, would undermine the basis for accounting (generalized or traditional)..." At this level, if you reject Assumption 2, the constraints imposed by traditional accounting (the claim that human capital differences across countries must be small) are again eliminated, as with Jones (2014), but now for a different methodological problem in the traditional accounting literature - namely, an identification problem.

This identification issue, given prior debates, may seem surprising. In particular, regressions of per-capita income on average schooling in cross-country data can suggest a large role for human capital in understanding the wealth and poverty of nations (Mankiw et al. 1992). The macro-Mincer approach was developed in part as a reaction to that regression evidence, arguing that such regressions are badly identified. Microevidence on wage gains with schooling was supposed to avoid regression's identification problem. If we relax Assumption 2, however, wage-based accounting would, ironically, appear to no longer have an identification advantage.

Things are not so bleak for accounting, however. Namely, the relationship between schooling levels and wages is not just a correlation. The large literature using IV methods argues that the wage returns from schooling are *causative*. IV-based microevidence in both rich and poor countries (see, e.g., the review by Card 2001) suggest that an extra year of schooling causes wages to rise by approximately 10 percent. As Jones (2014) states, "This

literature provides an empirical basis for going beyond the identification problem, so that the returns to schooling can be interpreted causatively as the treatment of schooling itself." Viewing the IV literature's wage gains through the lens of a human capital aggregator (e.g., (4)), it follows that the productivity gains ($h_2^c/h_1^c$) depend causatively on the schooling: Schooling leads the individual to achieve $h_2^c$ in the given country, while that individual would only achieve $h_1^c$ if s/he didn't receive the schooling. In this sense, macro-Mincer style accounting can proceed.

Of course, the further implication, following (4), is that the productivity gains from schooling are identified to be much greater in rich than poor countries. Namely, while the causal wage gain from schooling is modest (about 10 percent) the implied causal productivity gain (achieving $h_2^R$) is very large in rich countries. As Jones (2014) states, "Bringing the generalized accounting together with the IV literature thus suggest two points: (1) human capital investment appears causative but (2) its effects are highly heterogeneous." Thus the IV literature is guiding, but it is incomplete. It is guiding because it puts human capital causatively at the center of achieving these productivity gains (which in turn can substantially help explain the wealth and poverty of nations). But it is incomplete, because it does not tell us why there are heterogeneous treatment effects in rich and poor countries. Section 4 will further consider such heterogeneous outcomes and offer a candidate explanation.

## 2.4 Critique of Caselli and Ciccone Approach

The Caselli and Ciccone (2013, 2018) approach relaxes Assumptions 1 and 2. These papers also appear, at times, to offer statements about human capital in development accounting. I will discuss here why this is conceptually difficult to do. The following analysis will show that their comparison of human capital stocks is not between a rich and poor country; thus, it does not decompose sources of income differences across countries.

Caselli and Ciccone's thought experiment focuses on the amount of schooling, holding the productivity gains from schooling fixed. The difficulty for human capital assessment comes when one maintains this fixed-productivity approach yet moves away from perfect substitutes (relaxing Assumption 1). Now Assumption 2 (identification) and similar human capital gains from schooling across countries do not sit easily together. On the one hand,

if you abandon Assumption 2, then things are no longer pinned down. On the other hand, if you maintain Assumption 2 and yet insist that the human capital gains are the same in all countries, then you have a conflict with the empirical evidence.

To the extent that Caselli and Ciccone are offering a human capital analysis, they navigate this problem in a particular way. The analysis proceeds from the assumption (7), which can be thought of as a partial relaxation of Assumption 2. Specifically, the productivity gains with schooling represent human capital in the poor country per se. The human capital stock of the poor country is then

$$H_{CC}^{P} = \left[ \left( h_1^P L_1^P \right)^{\frac{\varepsilon-1}{\varepsilon}} + \left( h_2^P L_2^P \right)^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}}$$

They then construct a counterfactual human capital stock, denoted $H_{CC}^{R}$, as

$$H_{CC}^{R} = \left[ \left( h_1^P L_1^R \right)^{\frac{\varepsilon-1}{\varepsilon}} + \left( h_2^P L_2^R \right)^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}}$$

which is the rich country's labor allocation but the poor country's productivity terms.

If we are meant to interpret this exercise as telling us about human capital differences in development accounting, then there are two problems. The first issue with this approach is that is arbitrary. It asserts that there is no identification problem in the poor country: $h_2^P/h_1^P$ is human capital. At the same time, it asserts that $h_2^R/h_1^R$ in the rich country is not human capital; rather, the human capital gains from schooling in the rich country are also taken as $h_2^P/h_1^P$. However, once you open the door to saying $h_2^c/h_1^c$ and human capital are not the same thing, on what basis can we assert that the human capital gains from schooling are indeed known via the poor country (but nowhere else)? Once you abandon Assumption 2, neither wages nor labor allocations tell us how to assign the productivity gains from schooling into human capital and residual productivity parts. And if even if we want to think of human capital as the productivity gains with schooling in some particular country, nothing guides which country to pick. Moreover, choosing the poor country, where $h_2^P/h_1^P$ is low, asserts especially low productivity gains with schooling.[13]

The second issue is that $H_{CC}^{R}$ does not correspond to any aggregate in the rich country. To the extent that human capital accounting should be comparing actual countries, for which we are decomposing observed income differences, we have a conceptual problem that

[13] If instead, you did the reverse experiment, defining $h_2^R/h_1^R$ to be human capital and giving the rich country the poor country's labor allocation, then the variation in capital stocks would grow considerably. But this alternative thought experiment would be equally arbitrary.

is difficult to resolve. The appropriate aggregate in the rich country, from (6), can be written

$$X^R = \left[ \left( h_1^P a_1^R L_1^R \right)^{\frac{\varepsilon-1}{\varepsilon}} + \left( h_2^P a_2^R L_2^R \right)^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}}.$$

But $X^R$ is not a human capital stock, and conceptually it is no longer clear how to define a human capital stock. The human capital is mixed up with residual productivity terms.

By studying $H_{CC}^R$, Caselli and Ciccone are not decomposing the sources of income differences between the rich and poor countries. Rather, by studying the object $H_{CC}^R$, CC are asking a different question: What happens if we took the poor country and gave it the rich countries labor allocation? This is CC's "relative supply effect" thought experiment. Viewed this way, CC tell us something potentially important, but it is not a cross-country accounting.

The calculation they make should be interpreted accordingly. We can look at their featured example and then clarify the deeper intuition behind their findings. From their notation, it might seem that Caselli and Ciccone (2018) are saying that the rich and poor country have the same human capital (see Table 1, where $H_{CC}^R/H_{CC}^P = 1.0$). This finding may seem surprising, given the huge disparities in education between these two countries. In Kenya, over half the population (56.4%) has no formal education, which is five times the proportion of such workers in Israel. In Kenya, a tiny fraction of the population (0.7%) has at least some college education, while the supply of such workers is 34 times greater in Israel. How could one conclude that these two countries have the same human capital stock? In Caselli and Ciccone's thought experiment, increasing the supply of skilled workers reduces the price of their services. This price decline fully offsets the higher quantity of skilled workers, resulting in no human capital gain.

This counterfactual exercise, however, based on $H_{CC}^R$, is not describing an aggregate in the rich country but rather describing an alternate version of the poor country itself - a counterfactual Kenya. CC's thought experiment may best be construed as examining a policy question, where a poor country decides to alter its allocation of skilled labor to a rich country's levels. CC's thought experiment tells us that this investment would be a bad policy. This policy orientation is emphasized in Caselli and Ciccone (2013).

Stepping back, you can also see a deeper intuition behind this conclusion. Namely,

CC are primarily considering an exercise in "factor reallocation", as opposed to "factor accumulation".[14] And reallocation in a market economy will be a bad idea. In particular, development accounting operates on neoclassical assumptions. There are no spillovers and factors are paid their marginal products. One can think of development accounting as determining the set of productivity terms, wages, and factor allocations that are consistent with each other in a given, neoclassical economy. Allocations will thus look efficient, conditional on the productivity terms. The immediate implication is that, having fixed the productivity terms, any deviation in the observed labor allocation should reduce real output. In practice, CC can find some gains in real income from reallocating to more skilled labor, but this is because their counterfactual exercise isn't quite complete from a policy perspective: their exercise imagines one can make more skilled labor for free.[15] In this sense, what CC are largely doing is, in contrast to saying something about a rich country, asking what happens when a poor country, given its labor productivities, adjusts its labor allocations. According to neoclassical theory, this is going to make the poor country worse off.

The caution that emerges from CC's analysis is then much more general. Adjusting factor allocations alone is a bad policy in a neoclassical framework. Jones (2014) also observes this issue, which suggests that research and policy must attend to the source of heterogeneous treatment effects in the returns to human capital investment across countries.[16] We will return to this subject in Section 4.

[14] With physical capital, the resources to provide more physical capital come from outside the production function itself (i.e., from savings). Hence output will be increasing with more physical capital and the costs of having more capital (i.e., foregone consumption) do not appear in production per se. With human capital, the exercise involves reducing one productive input (e.g., low skilled labor) to get more of the other (e.g., high skilled labor). Here the cost of having more human capital is substantially embedded in the production function itself. In this sense, Caselli and Ciccone's approach is primarily about "factor reallocation", rather than "factor accumulation".

[15] If we instead complete the economy, bringing in the cost of making skilled labor, then, regardless of the elasticity of substitution, a country will necessarily be worse off in altering its equilibrium labor allocation. In particular, if we allow a cost of education (specifically, where individuals forgo work while they are in school), then this reduction in labor supply will guarantee $H^P$ can only decline when increasing (or decreasing) the amount of skilled labor.

[16] Referencing the poorest country in the world, Jones (2014) writes "fixing the current quality of skilled workers in the Congo, producing more such workers might be counterproductive. Thus, even as the generalized accounting may bring human capital toward the center of the development picture, simply increasing the quantity of education in poor countries may not be a well motivated implication. Heterogeneous treatment effects suggest that education policy choices require more subtle understanding, where the quality of investment may be key and where the success of educational investments may interact with other economic and institutional features."

## 2.5 Summary of Accounting

The above analysis sought to (i) clarify the different assumptions among the accounting approaches and (ii) draw out resulting implications, intuitions, and interpretations. Importantly, both Jones (2014) and Caselli and Ciccone (2013, 2018) agree upon relaxing Assumption 1 (perfect substitutes). Their common approach doesn't seem controversial given extant evidence. Jones and CC thus also reach an essential point of agreement. The productivity gains associated with schooling appears vastly higher in rich than poor countries.

The key interpretive issue surrounds Assumption 2. In Jones (2014), like traditional accounting, the productivity gains with schooling are treated as human capital. Thus Jones (2014) shows how (a) the constraints on human capital variation imposed by perfect substitutes accounting no longer hold; and (b) human capital variation can be large enough to play a central role in explaining the wealth and poverty of nations.

If we instead relax Assumption 2, things are less clear. Generally, human capital accounting cannot meaningfully proceed using current methods. Our standard evidence from wages and labor allocations no longer pins human capital down. Macro-Mincer accounting no longer would have any apparent advantage over cross-country regression evidence about human capital. Thus, the constraints imposed by traditional accounting are not resuscitated; rather, the constraints disappear for another reason (relaxing Assumption 2) rather than the reason emphasized in Jones (2014) (relaxing Assumption 1).

CC's exercise does not change this state of affairs. CC pick one way of relaxing Assumption 2, which is both consequential and prevents them from comparing human capital aggregates across countries. The above analysis discusses why CC's method isn't a cross-country accounting exercise but more of a policy exercise about factor reallocations within a poor country, and clarifies the neoclassical intuition underneath the findings.

There is good news on two fronts, however. First, there is an important point of agreement: the productivity gains associated with schooling appear far higher in rich than poor countries. Understanding this difference (whether you want to call it human capital or not) is clearly a first-order question for economic development. Second, these productivity gains are not a happenstance association with schooling. Rather, the IV literature on schooling suggests that schooling has a causative role in unleashing these

productivity gains. These points together indicate that we should not brush aside human capital. Rather, human capital acquisition appears central to understanding the wealth and poverty of nations. The more nuanced point - and target for future research - is to understand the heterogeneity of treatment effects in schooling. Why are the productivity gains achieved through schooling vastly higher in rich than poor countries? Section IV will suggest a path forward on this question, but first we will tackle CC's other arguments against human capital, which are additionally instructive.

# 3 Other Arguments against Human Capital

The balance of CC's comment argues against substantial human capital variation across countries. CC make two kinds of arguments. One argument is that skilled productivity in rich countries cannot be human capital because then skilled workers in rich countries would migrate to poor countries. A second argument is that human capital cannot play a primary role because it would eliminate other explanations for the wealth and poverty of nations (e.g., institutions, ideas) that we have confidence in through other evidence. I will discuss these arguments in turn. While I will reject the logic of their arguments, engaging them will also help constrain the set of potential theories, pointing to the synthesis suggested in Section 4.

## 3.1 The Immigration Argument

If we move a person from one economic environment to another, the individual takes their personal human capital with them but leaves the other features of their environment behind. Migration may thus provide avenues for separating individual human capital from other features (e.g., Hendricks 2002, Hendricks and Schoellman 2018). CC's conceptual argument against human capital works on this margin. Namely, if skilled human capital were much higher in rich countries, then a skilled worker in the rich country would experience a large real wage increase by moving to the poor country (because skilled output is relatively scarce in the poor country and hence priced highly). Then there would seem to be, from a real wage perspective, an incentive for skilled workers in rich countries to move to poor countries.

A central issue with this reasoning is another kind of perfect substitutes assumption. CC's featured analysis treats skilled workers as independent production entities – i.e., the

marginal productivity of a skilled worker is assumed independent of the other skilled workers, and thus a skilled worker could move and take all the human capital that individual needs with him or her. But why should that be so? Complementarities between skilled workers - for example, a division of labor – can overturn the reasoning (both for an individual worker or a subset of the workers with specialized skills). For example, a turbine-blade engineer at General Electric can't make a jet engine by him/herself; rather, there are thirty different specialties that go into making jet engines (Jones 2011). Such complementarities are one reason why Jones (2014) calls the skilled aggregator the "Generalized Division of Labor Aggregator", examining the object $Z(H_2, ..., H_N)$, which aggregate many types of skilled labor. Jones (2014) develops an explicit model of the division of labor, where skilled productivities come from the collective output of skilled workers. Jones (2011) develops a division of labor model that explicitly rules out rich-to-poor migration.[17]

Once we move beyond perfect substitutes, we have to be careful with immigration arguments. For example, when going from poor to rich countries, an unskilled worker may experience a gain in real wages. In a perfect substitutes world, this gain would be (and has been) taken as evidence that the real income gain is not due to human capital. But with complementarities, the rise in real wage can be due to human capital – only it's other people's human capital (not the migrant's per se), which is exactly what is happening in Figure 1. Complementarities also impact migration incentives from rich to poor countries, as discussed above. When skilled laborers have a division of labor, they depend on each other to achieve high productivity. They don't bring their productivity with them alone. In short, migration thought experiments should avoid perfect substitutes reasoning (Assumption 1), just like calculations of aggregate human capital stocks.

## 3.2 The "What About Ideas and Institutions?" Argument

The other argument against human capital in CC's comment also pursues rejection by implication. The argument is that other features, like ideas and institutions, play prominent features in explaining economic development; hence, human capital cannot play a central

[17] The CC appendix acknowledges that you may have to move a group of skilled workers, rather than a single individual. But saying you have to move groups of workers makes the absence of such reverse migration less puzzling. A related thought experiment would be why skilled workers don't leave urban areas in rich countries for rural areas, where these skills are scarce. This also doesn't seem puzzling in the context of local complementarities.

role. While CC are focused on skill bias in rich countries (as Section 4 will focus on below), this type of reasoning reflects a broader tendency in the literature to interpret productivity residuals (including TFP) in an aggregate production function as representing ideas and/or institutions. Framed that way, it appears that expanding the role of capital inputs necessarily takes away from these explanations. This leads to key tensions in the literature. But this framing is problematic, and the tensions unnecessary, as follows.

First, it is clear that things like institutions, ideas, and skill-biased technical change appear important for understanding economic development. The rigorous evidence doesn't come from Solow residuals ("the measure of our ignorance"). Rather, the evidence lies elsewhere. For institutions, we have well-identified empirical studies (e.g., Acemoglu et al. 2001; Banerjee and Iyer 2005, Dell 2010) that are long run and reduced form. We also have core theories and evidence about the importance of property rights, contracts, public good provision, monetary policy and other institutional features for understanding economic outcomes. For ideas, we have impressive histories (e.g., Mokyr 1992) and the direct observation of changing production methods – it seems self-evident that advances in farming, manufacturing, transportation, computing, or health have depended on the creation and diffusion of ideas.[18]

Second, evidence about the importance of ideas and institutions does not rule out central roles for capital, nor vice versa. The literature's tendency to interpret residual productivity as ideas or institutions has set up an apparent horse race to be settled in the aggregate production function. I would argue that this interpretative paradigm is highly misleading because it conflates "proximate causes" and "deep causes" for economic development. Fruitful avenues for the literature may come in avoiding these horse-race style debates and engaging richer frameworks where capital and ideas/institutions are seen as integrated rather than substitute explanations.

The point of Jones (2014) is that human capital may once again play a substantial role in understanding cross-country income differences. The point of Jones (2014) is *not* to say that ideas and institutions don't matter.[19] Even if human and physical capital can

[18] Mokyr's *The Lever of Riches* (1992) provides many historical examples as do overviews of 20th century U.S. economic growth (e.g. Augustine et al. 2007, Chapter 2, and *The Economic Report of the President* 2011, Chapter 3). Nordhaus (1997) provides a powerful example by studying the price of light through time. Conley and Udry (2010) is one of many studies demonstrating that ideas can fail to diffuse in poor countries.

[19] Rather, the interpretation of human capital differences involves "linking human capital investment,

fully account for output per worker differences across countries, that doesn't imply that capital is all one needs to consider. Rather, we must necessarily ask where human and physical capital come from. And here institutions and ideas naturally play central roles. The right conceptual framing may simply be more structural. This reply will close with a candidate explanation: a structural synthesis that can integrate the accounting findings, the heterogenous returns to schooling investments, and the broader extant literatures about ideas, institutions, and skill-biased technical change in a conceptually coherent framework.

# 4 Capital, Ideas, and Institutions: A Synthesis

We can encapsulate key empirical findings, which a successful conceptual framework must ultimately explain, as follows. First, using realistic elasticities of substitution, the productivity gains with schooling appear vastly higher in rich than poor countries. Even if one doesn't call this human capital per se, an implication is that large differences in productivity seem to adhere to skilled workers. Second, drawing on the IV literature on the returns to schooling, schooling appears causative in accessing these productivity gains. Third, widespread evidence underscores the importance of institutions in driving economic development. Fourth, advances in ideas appear central to improved productivity within specific production methods. Finally, other phenomena – such as skill-biased technical change and the direction of migration – should be explainable within the same conceptual frame.

The candidate synthesis below embraces these dimensions and has three essential pieces. The first concerns the nature of capital and its relationship to ideas. The second concerns specialization and the division of labor. The third concerns the role of institutions. I will discuss how these viewpoints can, together, provide a potentially fruitful way forward.[20]

## 4.1 Capital and Ideas

Human capital is often described based on how it is acquired. Because individuals around the world acquire human capital by similar broad means – namely, through schooling and experience – one might then be tempted to say that the productive value of these investments should be similar as well. This perspective may animate the CC approach, which imagines

ideas, and institutions" (Jones 2014), a perspective that drives the models in Jones (2014) and Jones (2011).

[20] Formal models, as specific examples of this synthesis, are provided in Jones (2011) and Jones (2014).

that human capital investments produce "constant quality" - a belief that the quality of high-skill workers is the same across countries.[21]

A different perspective on human capital emphasizes quality differences. This perspective arises when one conceives of human capital less by how it is acquired (schooling, experience) but instead on what is produced (specific skills). From this latter perspective, it become straightforward to see human capital as a vessel for specific ideas and, consequently, for large productivity gains. This perspective can also lead naturally to skill bias across the stages of development, as developed further below.

In particular, consider a capital input in the production process for a specific good or service. At this level, specific capital inputs look like intermediate goods that bring specific ideas into production. This perspective is reflected in many endogenous growth models, which often characterize new ideas as expanding the types of capital inputs, which may thought of as forms of human capital (e.g., Romer 1990) or physical capital, including models where capital inputs automate certain tasks (e.g., Acemoglu and Restrepo 2018). In these models, idea production is essential for growth, but its impact is not felt unless the ideas are implemented in specific capital goods, which are also essential for growth. Specific capital inputs become the embodiment of specific ideas. For example, consider that a building implements specific ideas (the plans of architects and engineers); that an internal combustion engine embodies specific ideas about thermodynamics, mechanics, and material science; that a thoracic surgeon embodies detailed knowledge of anatomy, surgical techniques, and the use of specialized tools, and that computer programmers embody specific knowledge of algorithms, software, and programming languages.

From this perspective, one can write a basic definition of capital investment that explicitly engages its relationship to ideas.

**Definition** *Capital investment is the process of embodying ideas.*

This definition says that human capital investment is, literally, the process of embodying ideas in people (i.e., a process of learning). Similarly, physical capital investment is the

[21] Of course, while "constant quality" had fit comfortably with traditional accounting (under Assumptions 1 and 2, where constant quality will appear consistent with similar wage returns in different countries), it no longer fits comfortably when we move away from perfect substitutes. See Section 2. The finding that the productivity gains with schooling are vastly higher in rich than poor countries seems, at the very least, to put strain on the constant quality viewpoint.

process of embodying ideas in things.

This is fundamentally a structural perspective: idea production happens upstream, ideas are then implemented through the creation of specific capital goods, and these capital goods combine to produce final output. In endogenous growth theory, this perspective is formalized through three separate equations.[22] More generally, it seems straightforward to say that capital equipment and infrastructure (e.g., buildings, airplanes, microprocessors, DNA sequencers, MRI machines, etc.) are the embodiment of ideas into objects and that human capital (e.g., the skills of architects, pilots, computer programmers, laboratory technicians, etc.) is the embodiment of specific ideas into people. It also seems natural that for ideas (e.g. techniques, designs, protocols, facts, methods, etc.) to enter production they must be known and implemented; that is, they must be actuated through tangible inputs. But regardless of whether we take a stand that all ideas must be embodied to be productive, it should be clear under this definition of capital that there is no tradeoff between capital investment playing a central role and ideas playing a central role. Rather, capital inputs can naturally be seen as the expression of ideas.

## 4.2 The Division of Labor

The next step concerns skill bias and involves the division of labor. Economists have long emphasized the division of labor as a critical source of productivity. Pre-dating even Adam Smith's (1776) emphasis on the division of labor, Francis Bacon's Novum Organum (1620) noted that "...men begin to know their strength when instead of great numbers doing all the same things, one shall take charge of one thing and another of another." This view doesn't seem controversial when examining modern economies, where workers (especially, skilled workers) bring highly differentiated training and experience to specialized tasks. All told, the U.S. Census recognizes over 31,000 different occupational titles.

Beyond the self-evident division of labor in labor markets and its pedigree in economics, the division of labor can make a potentially stronger and more basic claim upon the development process. The argument follows from the definition of capital above. Namely, if the set of productive ideas is too large for one person to know, then the division of labor becomes

[22] Specifically, there are three strucutural equations: a knowledge production function, where ideas are created; a capital accumulation function, where ideas are embodied into capital inputs; and a final goods production function, where these capital inputs combine to produce final output.

necessary to access and deploy these ideas, and thereby achieve high productivity.[23] This logic follows to the extent that one individual can only know so many things. Following the definition of capital above, we can encapsulate this viewpoint regarding human capital as follows.

**Claim** *High productivity requires a division of labor.*

Note that this argument occurs at a more fundamental level than particular functional forms. If ideas are mapped into tangible inputs, and the set of ideas is too large to be embodied in one person, then the deployment of advanced ideas becomes equated with such specialization.

This perspective is also useful for conceptualizing skill-biased technical change. A closely related implication of the above reasoning is that, as ideas accumulate, the division of labor will increase. This point was made by Albert Einstein[24] and has been demonstrated in studies showing that increasing specialization and collaboration are generic features across wide areas of technical knowledge (e.g., Jones 2009, Wuchty et al. 2007, Agrawal et al. 2016). Notably, in this view development becomes innately skill-biased, as increasingly differentiated skilled workers embody an expanding set of productivity-enhancing ideas. This perspective is consistent not only with development accounting but also with skill-biased technical change. It is fundamentally not a perfect substitutes perspective. Rather this perspective emphasizes complements based in specialized capital inputs that collectively aggregate and embody advanced ideas.[25]

[23] Strictly speaking, the claim that specialized labor is necessary is also the claim that we can't just embody all the productive ideas in physical capital. At this point in history, automation is insufficient for a pure machine-oriented view. That said, it is of course natural to think that there is a close connection in production between specialized human capital and specialized physical capital, which may help explain the productivity gains of high-skilled individuals. A closely related trajectory for explaining skilled-labor productivity may be in the interaction between specialized skilled labor and specialized capital inputs. See, e.g., Krusell et al. (2000).

[24] Einstein observed that "...knowledge has become vastly more profound in every department of science. But the assimilative power of the human intellect is and remains strictly limited. Hence it was inevitable that the activity of the individual investigator should be confined to a smaller and smaller section..." (Einstein 1932).

[25] An additional advantage of this framework is its potential to explain cross-country migration patterns, including CC's observations, while also informing, for example, urban agglomeration, the "brain drain", and other related phenomena. See Jones (2011) for formal arguments about immigration behavior and additional applications.

### 4.3 Institutions

The last step emphasizes institutions. From the accounting evidence (either via CC or Jones), the key question that emerges is why some countries fail to achieve high productivity among their skilled workers. Following the synthesis above, the suggested answer lies in the failure to embody advanced ideas. This naturally leads to an institutional perspective. Putting ideas into production through capital inputs might actually be especially fruitful for institutional theories. Institutions of central interest to economists – e.g., property rights, contracts, public good provision, monetary policy, etc. – are all naturally central to investment. Failures in capital accumulation thus provide straightforward processes in which institutions matter. Weaknesses in institutions, which appear to describe lower income countries, can then naturally underpin failures to invest and provide direct and tangible explanations for why institutions matter. For the human capital piece, individuals may collectively fail to embody advanced ideas when faced with high borrowing costs, high coordination costs, and poor educational institutions (Jones 2011 and Jones (2014) Online Appendix). Institutional features like weak property rights, weak contracting environments, and poor public good provision can then naturally underpin investment failures.

Together, this perspective can allow one to move beyond some common debates about human capital, ideas, and institutions by seeing them not in contest with each other but as pieces of an integrated structural process. There need be no horse race between these features. Rather, output can be mapped into capital inputs, perhaps even fully. Capital inputs can be mapped onto ideas. Institutions affect these mappings. In this interpretation, the contribution of Jones (2014) is not in reducing the roles of ideas or institutions. It is in elevating the potential role of human capital. The accounting results are fully consistent with a framework in which investment, ideas, and institutions play essential roles – but where human capital can be drawn to the heart of economic development.

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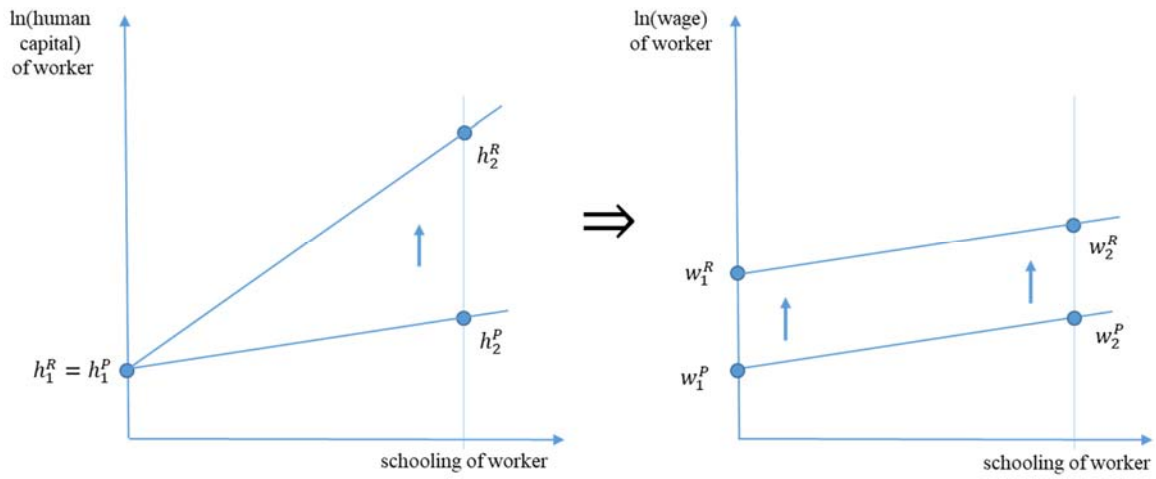
**Table 1: Assumptions and Conclusions**

| | Assumption 1 | Assumption 2 | $H^R/H^P$ |
|---|---|---|---|
| Traditional | Yes | Yes | 2.0 |
| Jones | No | Yes | 11.7 |
| Caselli & Ciccone | No | No | 1.0* |

Notes: Under Assumption 1, different types of labor are perfect substitutes (eq. 1). Under Assumption 2, the productivity gains associated with schooling are treated as human capital. When relaxing Assumption 1, both Jones and CC use the CES aggregator (eq. 3). The above estimates show the case where $\epsilon = 1.5$. The * indicates that the Caselli & Ciccone calculation is considering a counterfactual experiment about the poor country rather than a comparison between the rich and poor country (see Section 2.4).

**Figure 1: Skilled Productivity and Wages**




Notes: Productivity advantages of high-skill workers are shown to elevate the whole wage schedule, emphasizing the "intercepts, not slopes" intuition in assessing human capital when there are complementarities. The shift in the underlying labor allocations (the quantity of each labor type, not pictured) links the left and right diagrams. See Section 2.2 for further discussion, and Section 3.1 for implications in interpreting migration outcomes.