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A note on human capital externalities, factor substitution, and technology differences

Erich Gundlach
Hamburg University and GIGA German Institute of Global and Area Studies

Rasmus Thönnessen
Hamburg University

Abstract

Estimates of human capital externalities that are based on the Mincerian approach have been found to be biased in the presence of limited possibilities for factor substitution. Technology differences may be more important for the Mincerian bias than limited possibilities for factor substitution.

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Contact: Erich Gundlach - erich.gundlach@wiso.uni-hamburg.de, Rasmus Thönnessen - rasmus.thoennessen@wiso.uni-hamburg.de.
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1. Human capital externalities vs. factor substitution

Based on a specification introduced by Mincer (1974), empirical estimates of human capital externalities usually compare the estimated macroeconomic returns to schooling and experience with the well-known individual returns. A positive difference between macro and micro returns is interpreted as evidence in favor of a human capital externality (Pritchett 2006). However, returns to human capital may not only differ because of externalities but also because of different factor intensities (Acemoglu and Angrist 1999).

For instance in economies with high-skilled and low-skilled workers, a larger endowment with high-skilled workers generates a higher factor intensity in production. Unless there is perfect factor substitution, the relative wage of low-skilled workers will be higher in the economy with the higher factor intensity. What looks like the effect of a human capital externality – a relatively higher wage of low-skilled workers associated with higher average skill and income levels – may simply reflect the aggregate effects of imperfect factor substitution

Ciccone and Peri (2006) show analytically that the Mincerian approach correctly identifies a human capital externality if the elasticity of factor substitution is infinite but otherwise misreads substitution effects as externalities. Since all available evidence points to an imperfect elasticity of substitution between high-skilled and low-skilled workers, it follows that the Mincerian approach tends to find a human capital externality when in fact there is none. This is what Ciccone and Peri (2006) call the bias of the Mincerian approach.

The Mincerian bias can be illustrated with a one-good version of the Lerner diagram (Lerner 1952). But in the two-good version of the Lerner diagram, there can be no Mincerian bias within the cone of diversification according to the Rybczynski theorem (Rybczynski 1955). [1] However, if one allows for technology differences across cones of diversification, the Mincerian bias reappears. Technology differences rather than limited possibilities for factor substitution may be the main reason for biased Mincerian estimates of human capital externalities.

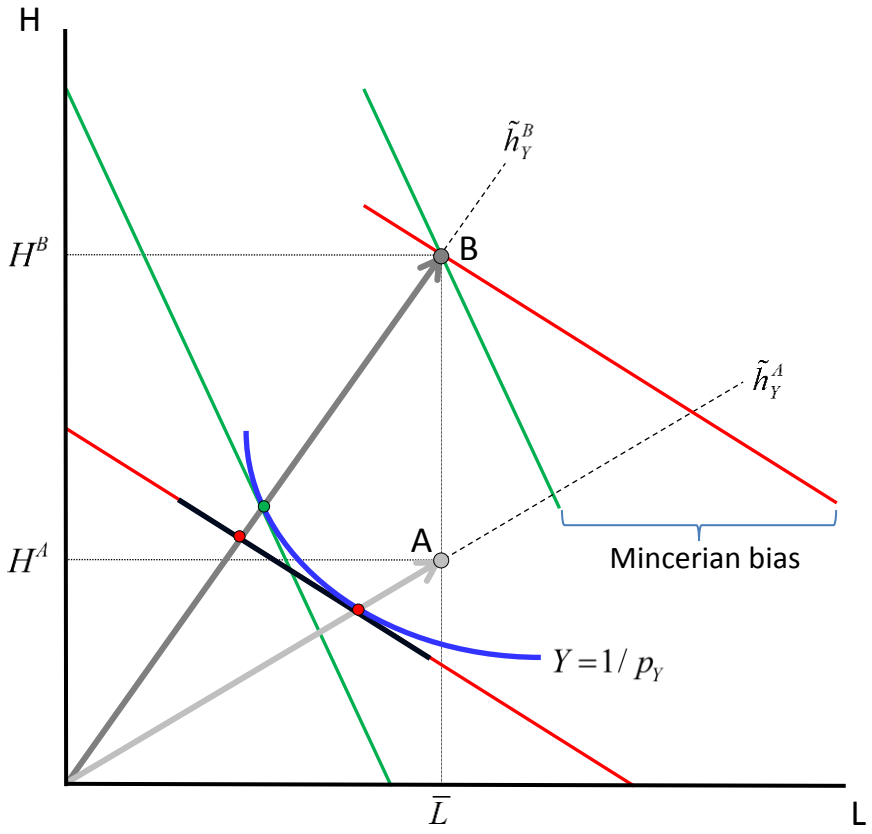
2. The Mincerian bias in a one-good model

The log-linear specification of the macro-Mincerian income equation implies constant returns to increasing levels of schooling and experience. The functional form imposes the restriction that differences in the endowment with skilled workers do not affect the relative returns, which in turn implies an infinite elasticity of substitution between low-skilled and high-skilled workers. Therefore, the relative wage should be the same across economies, independent of the average level of schooling and experience (human capital). If the observed wage ratio actually differs across economies with different levels of human capital, the Mincerian approach ascribes such a difference to a human capital externality.

This reasoning can be summarized with a Lerner diagram like Figure 1, which compares average incomes and relative factor prices in two economies *A* and *B*. The two factor inputs human capital *H* and labor *L* are used to produce a single output good *Y*. Imperfect factor substitution enters through the curved blue unit value isoquant $Y = 1/p_Y$, which represents a value of output equal to one unit of exchange for a given level of technology, with p_Y as the price of the output good.

1. See Deardorff (2002) for an exposition of core theorems of neoclassical trade theory with the Lerner diagram.

Figure 1. Mincerian bias with factor substitution



For given factor endowments, cost minimization forces optimal production to take place with factor intensities $\tilde{h}_Y^A$ and $\tilde{h}_Y^B$, with $h = H/L$. Linear unit value isocost functions (in red and green) are tangential to the intersection points of the factor intensity lines with the unit value isoquant. The slopes of the unit value isocost lines represent the relative wage w_L / w_H, such that a steeper slope means a higher relative wage of low-skilled labor *L*.

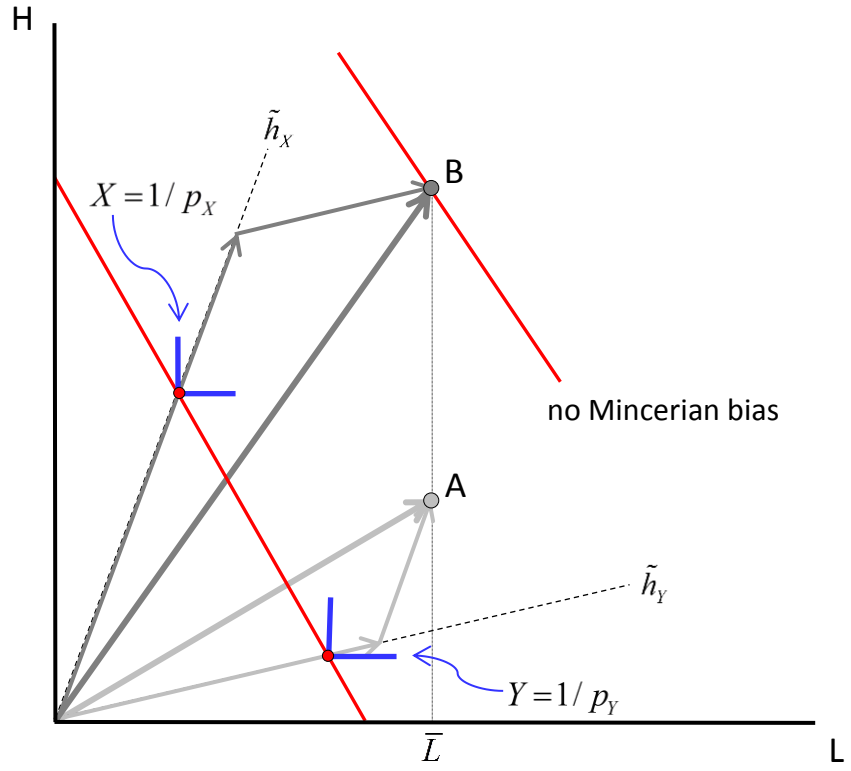
Economies *B* and *A* only differ by the level of *H*. The longer arrow in dark gray pointing to *B* represents a larger quantity of output than the arrow in light gray pointing to *A*. This means that average income is higher in *B* than in *A*. The slopes of the unit value isocost lines indicate that the relative wage of low-skilled workers is also higher in *B*.

The bias of the Mincerian approach shows up in Figure 1 as the difference of the slopes of the two tangential isocost functions. The lower the elasticity of factor substitution, the larger the relative wage of low-skilled workers in an economy where they are surrounded by relatively more human capital. But the Mincerian approach predicts the same relative wage in *A* and *B* because it assumes an infinite elasticity of factor substitution, which is indicated by the linear segment of the unit value isocost function in dark blue. Finding that the relative wage of low-skilled workers is higher in *B* than in *A* is falsely interpreted as evidence in favor of a human capital externality. But before one concludes that the Mincerian approach will overestimate the empirical relevance of human capital externalities it should be considered that different factor endowments may not affect relative factor prices in a model with two goods.

3. The missing Mincerian bias in a two-good model

The Rybczynski theorem (Rybczynski 1955) states that in the two-good model of a small open economy with exogenous goods prices, different factor endowments do not affect relative factor prices as long as the different endowment points remain within the same cone of diversification. Given the Rybczynski theorem, there can be no Mincerian bias just because the elasticity of factor substitution does not matter for the equilibrium relative wage in the two-good model of a small open economy. This is shown in Figure 2.

Figure 2. No Mincerian bias with output substitution



As before, the two factor endowment points *A* and *B* are drawn in order to represent a constant amount of low-skilled labor $\bar{L}$. Now there are two goods, *X* and *Y*. Different from Figure 1, it is explicitly assumed that the elasticity of factor substitution equals zero in the production of both goods, as represented by the rectangular unit value isoquants (in blue). A zero elasticity of substitution would generate a maximum Mincerian bias in the one-good model. But in the two-good model there is no Mincerian bias at all because different factor intensities result in different output structures, independent of the elasticity of substitution.

The different factor intensities used to produce *X* and *Y*, $\tilde{h}_X$ and $\tilde{h}_Y$, span the cone of diversification. With factor endowments *A*, the economy would produce more of good *Y* than of good *X*. The output of *Y* produced in *A* is given by the thin arrow in light gray along $\tilde{h}_Y$ and the output of *X* is given by the connecting arrow to *A*, which is found by a parallel shift of $\tilde{h}_X$ through *A*. Along the same lines, the output of *X* and *Y* produced in *B* can be derived as the two thin arrows in dark gray, which imply that economy *B* specializes in the production of good *X*. Also as before, *A* and *B* differ with respect to average output and average factor

intensities, both denoted by the thicker arrows in light and dark gray, respectively. But now both economies have the same relative wages because they have the same two unit value isoquants, which are (only) determined by the exogenous goods prices p_X and p_Y.

According to the Rybczynski theorem, different factor endowments within the same cone of diversification lead to different relative specializations in production, but not to different relative wages, independent of the average factor intensity that is used in production. This result seems to demonstrate that the Mincerian approach would correctly identify human capital externalities when applied to a multiproduct setting of small open economies since observed differences in relative factor prices would not be due to imperfect factor substitution. But this argument leads to the question why factor endowments should differ across small open economies in the first place.

4. The Mincerian bias with technology differences

In neoclassical growth models, steady state factor endowments may differ because of differences in technology. The two most common definitions of technology differences refer to Hicks neutrality and Harrod neutrality. The former concept has been the standard in the trade literature since Findlay and Grubert (1959) and the latter has been the standard in the growth literature since Solow (1956). In the previous sections, technology has been held constant, i.e., the two factor endowment points *A* and *B* have been implicitly assumed to represent a single aggregate production function. Differences in technology imply that there are two different aggregate production functions, so there will be two pairs of unit value isoquants rather than one as before. With two pairs of unit value isoquants, there can be more than one cone of diversification, which opens the door for a new Mincerian bias. This is shown in Figure 3.

Applied to our two-good two-factor model, Harrod-neutral technology differences can be represented by two pairs of unit value isoquants that maintain a constant return to human capital and a constant ratio of human capital to output.[2] The return to human capital, w_H, can be read off at the intersection of the unit value isocost function with the *H*-axis. A constant human capital output ratio requires that the unit value isoquants for goods *X* and *Y* remain on horizontal lines for different levels of Harrod-neutral technology. Hence the intersection points of the two horizontal lines with two unit value isocost functions give the tangency points (in green and red) of two pairs of unit value isoquants for Harrod-neutral technology differences in the production of *X* and *Y*.

As Figure 3 is drawn, the assumed Harrod-neutral technology differences motivate two different cones of diversification.[3] The two green dots represent a pair of tangential unit value isoquants for *X* and *Y* that span the cone of diversification shaded in dark gray; the two red dots represent a pair of tangential unit value isoquants that span the cone of diversification shaded in light gray. By construction, the return to human capital and the human capital output ratio are the same for both pairs of unit value isoquants, so Harrod neutral technology differences prevail.

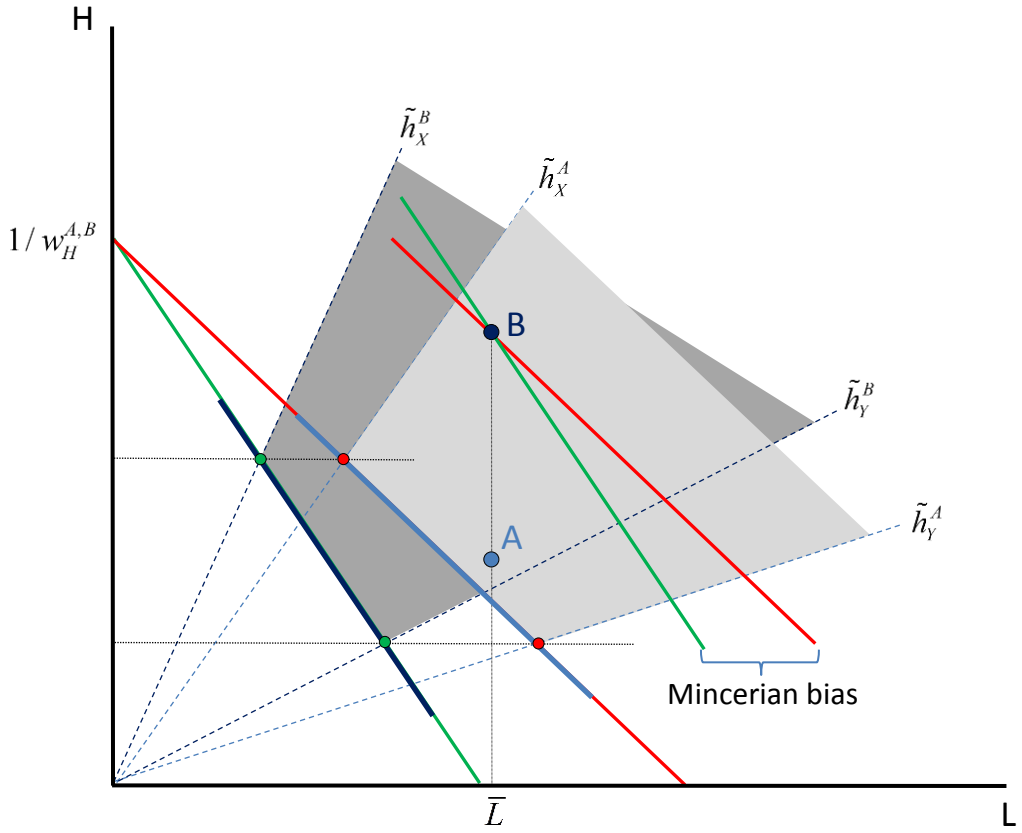
In order to isolate the effect of Harrod-neutral technology differences on the Mincerian bias, we assume an infinite elasticity of factor substitution. The two pairs of perfectly elastic unit value isoquants are represented as segments of the unit value isocost functions that are shaded in dark and light blue. The assumed degree of the elasticity of substitution does not

2. Hicks-neutral technology differences can be represented by two pairs of unit value isoquants that maintain a constant factor price ratio and a constant factor intensity.

3. Assuming Hicks-neutral technology differences would not generate two different cones of diversification. For a more detailed discussion of technology differences in the Lerner diagram, see Gundlach (2007).

make a difference for ending up with two different cones of diversification. For a given level of Harrod-neutral technology differences, the same tangential points with the unit value isocost functions would also result with perfectly inelastic unit value isoquants.

Figure 3. Mincerian bias with technology differences



If it is assumed that the two factor endowment points *A* and *B* represent aggregate production functions with Harrod-neutral technology differences, it follows that they are located in different cones of diversification. With different cones of diversification, there are different relative factor prices even if there is an infinite elasticity of substitution and output substitution. This is indicated by the different slopes of the green and red unit value isocost lines. With different relative factor prices in *A* and *B*, a Mincerian bias shows up like in Figure 1, though for a different reason.

The main problem for empirical research on the new Mincerian bias would be a proper identification of technology differences. For instance, Figure 3 also allows for an interpretation where the two factor endowment points *A* and *B* represent a single production function because as drawn, both factor endowment points could be located in the dark-shaded or the light-shaded cone of diversification. And even if it is acknowledged that the factor endowment points *A* and *B* do represent different production functions, Hicks-neutral technology differences would not be enough to motivate different cones of diversification. Moreover, for claiming a Mincerian bias due to technology differences it has to be assumed that the two different cones of diversification do not reflect differences in goods prices. These caveats notwithstanding, it appears that Harrod-neutral technology differences can motivate the possibility of a new Mincerian bias.

5. Conclusion

The Mincerian approach is a standard tool of applied research on human capital externalities, but it will confuse human capital externalities with neoclassical substitution effects in a one-good model if the elasticity of substitution in production is not infinite (Ciccone and Peri 2006). This note makes two additional points. First, there is no Mincerian bias in a two-good model of a small open economy because of output substitution, even if the elasticity of substitution is zero. Second, different cones of diversification due to Harrod-neutral technology differences can generate a Mincerian bias even if there is output substitution and an infinite elasticity of substitution. Beyond one-good models, our results suggest that technology differences may be more important for the Mincerian bias in the estimation of human capital externalities than limited possibilities for factor substitution.

References

Acemoglu, D., Angrist, J. (1999) "How large are the social returns to education? Evidence from compulsory schooling laws" NBER working paper number 7444

Ciccone, A., Peri, G. (2006) "Identifying human-capital externalities: theory with applications" *Review of Economic Studies* **73**(2), 381-412

Deardorff, A.V. (2002) "Introduction to the Lerner diagram" University of Michigan, mimeo, http://www-personal.umich.gdu/~alandear/courses/441/handouts/Lerner.pdf
Accessed November 27, 2013

Findlay, R., Grubert, H. (1959) "Factor intensities, technological progress, and the terms of trade" *Oxford Economic Papers* **11**(1), 111-121

Gundlach, E. (2007) "The Solow model in the empirics of trade and growth" *Oxford Review of Economic Policy* **23**(1), 25-44

Lerner, A.P. (1952) "Factor prices and international trade" *Economica* **19**(73), 1-18

Mincer, J. (1974) *Schooling, Experience, and Earnings*, Columbia UP: New York

Rybczynski, T.M. (1955) "Factor endowments and relative commodity prices" *Economica* **22**(88), 336-341

Pritchett, L. (2006) "Does learning to add up add up? The returns to schooling in aggregate data" in *Handbook of the Economics of Education Vol. 1* by E.A. Hanushek and F. Welch, Eds., Elsevier: Amsterdam, 635-695

Solow, R. M. (1956) "A contribution to the theory of economic growth" *Quarterly Journal of Economics* **70**(1), 65-94