Why capital (physical and human) doesn't move from rich to poor countries

Philippe Darreau, François Pigalle

Economics Bulletin

Volume 32, Issue 2

Why capital (physical and human) doesn't flow from rich to poor countries ?

Philippe Darreau
LAPE, University of Limoges

François Pigalle
LAPE, University of Limoges

Abstract

Capital (physical and human) doesn't flow from rich to poor countries. We show that in order to solve these twin paradoxes, assumption of externality of physical capital is better than assumption of externality of human capital.

Corresponding authors : LAPE, 5 rue Felix Eboue, 87031 Limoges Cedex, France. Email: philippe.darreau@unilim.fr, francois.pigalle@unilim.fr
Citation: Philippe Darreau and François Pigalle, (2012) "Why capital (physical and human) doesn't flow from rich to poor countries ?", *Economics Bulletin*, Vol. 32 No. 2 pp. 1353-1360.
Contact: Philippe Darreau - philippe.darreau@unilim.fr, François Pigalle - francois.pigalle@unilim.fr.
Submitted: January 11, 2012. **Published:** May 07, 2012.

1. Introduction

Flows of capital (physical and human) are not moving from rich to poor countries. This is paradoxical for the neoclassical theory. On the one hand, if poor countries are poor because they lack physical capital, the productivity should be higher in poor countries than in rich countries and physical capital should migrate to poor countries. However, the physical capital does not migrate from rich to poor countries. The opposite occurs. It is the paradox of Lucas (1990). On the other hand if poor countries are poor because they lack human capital, the productivity should be higher in poor countries than in rich countries and human capital should migrate to poor countries. Yet human capital does not migrate from rich to poor countries. The opposite occurs. It is the paradox of Romer (1995).

This paper puts forward the idea that in order to solve this double paradox, the assumption of externality in physical capital is more relevant (although it has little support in the literature) that hypothesis of human capital externalities (which is more readily accepted by the literature). Rebelo (1991) popularized the hypothesis of externality in physical capital, in the famous AK model. Unfortunately this theory of endogenous growth requires a double knife-edge assumption. Not only the elasticity of physical capital in the production of knowledge must be equal to unity but the rate of population growth should be zero. This famous critique of Jones (1995) is responsible of the development of R & D models, and originally the disrepute of the hypothesis of externality in physical capital. We will show however that the assumption of physical capital externality is - all things being equal - the best way to solve the paradox of Lucas and Romer. This is the best hypothesis to explain that between rich and poor, both, the productivities of physical capital are approximately equal (ignoring risk premium) and the productivities of human capital are higher in rich countries. Externalities of capital in rich countries attract both, skilled labor and capital.

Our demonstration is based on a simple argument. We assume a Cobb-Douglas function of physical capital, human capital, unskilled labor and a term representing the total factor productivity (TFP). Under the assumption of equal marginal productivities of physical capital, we calibrate the ratio of productivity of human capital between rich and poor. We assume then three hypotheses to explain these values: A difference in TFP, an externality of human capital, an externality of physical capital. We show that the necessary value of the externality on human capital is unrealistic, while that on physical capital is empirically possible. Section 2 presents the model and stylized facts, section 3 provides three hypotheses, section 4 tests these assumptions, section 5 concludes.

2. Model and stylized facts

Assumption 1 : We assume for each country a Cobb-Douglas production function.

$$Y = A.K^{\alpha}(hL)^{1-\alpha} \text{ dividing by L , } y = A.k^{\alpha}h^{1-\alpha} \text{ with } \alpha = 0.33 \quad (1)$$

Productivity of factors (labor, physical capital, human capital) are :

$$MPL = A(1-\alpha)k^{\alpha}h^{1-\alpha},\ MPK = A\alpha k^{\alpha-1}h^{1-\alpha},\ MPH = A(1-\alpha)k^{\alpha}h^{-\alpha} \quad (2)$$

Denote ratios of technology, physical and human capital, between rich R and poor P:

$$\frac{A_R}{A_P} = a, \quad \frac{k_R}{k_P} = x, \quad \frac{h_R}{h_P} = z \tag{3}$$

We obtain the ratio of marginal productivity of, labor, physical and human capital :

$$\frac{MPL_R}{MPL_P} = \frac{y_R}{y_P} = a.x^{\alpha} z^{1-\alpha}, \quad \frac{MPK_R}{MPK_P} = a.x^{\alpha-1} z^{1-\alpha}, \quad \frac{MPH_R}{MPH_P} = a.x^{\alpha} z^{-\alpha} \tag{4}$$

To explain why capital (physical and human) doesn't flow from rich to poor countries we make the following hypothesis:

Assumption 2 : We assume the equality of marginal products of physical capital. Equal MPK implies $a.x^{\alpha-1} z^{1-\alpha} = 1$, and thus : $\frac{x}{z} = a^{\frac{1}{1-\alpha}}$. By wearing this condition in the expression of relative productivities of human capital yields :

$$\frac{MPK_R}{MPK_P} = 1 \Longleftrightarrow \frac{MPH_R}{MPH_P} = \frac{x}{z} = a^{\frac{1}{1-\alpha}} \tag{5}$$

Now we evaluate the relative productivities of human capital by measuring x and z. On the basis of actual data of physical and human capital, we calculate actual values of x and z. As rich country we take the United States, and we calculate for each country (i) the values of x_i and z_i. The data were built by Baier, Dwyer and Tamura (2005). The database[1] contains the logarithms of physical and human capital in 144 countries and for different years. We retain decadal data from 1880 to 2000, a total of 940 data. We removed six outliers. The following graphs show the values of x_i (Fig. 1) and z_i (Fig. 2) for 934 data. To present data more clearly, we have arranged in ascending order of GDP per worker.

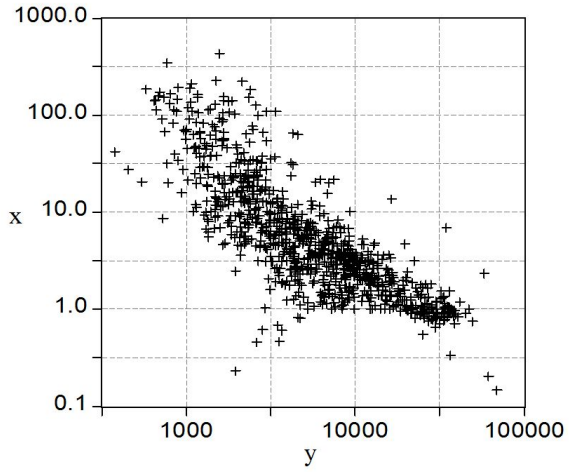

Figure 1: x_i capital per worker

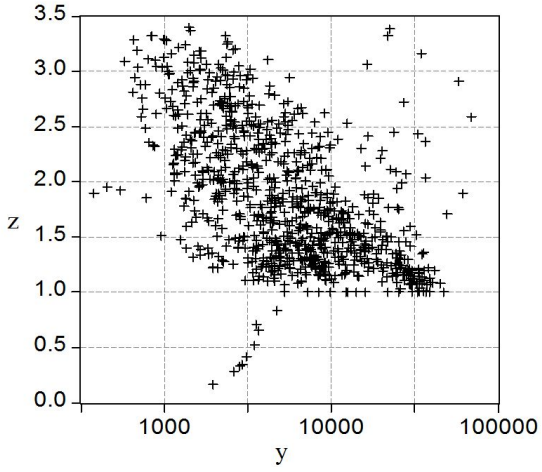

Figure 2: z_i human cap. per capita

We observe an important fact for our purposes: between rich and poor countries, the difference in physical capital is much greater than the difference in human capital (and that whatever the imperfections of the data). By choosing a mean value, $x = 30$ and $z = 2$, assuming equal MPK, according to equation (5), the ratio of productivity of human

[1] http://www.jerrydwyer.com/pdf/bdtinterp200404.xls and http://www.jerrydwyer.com/pdf/dataapp.pdf

capital between the United States and poor countries is 15. So we will retain as stylized facts, a report of MPK equal to 1 and a report of MPH equal to 15. This is consistent with the absence of capital flows (physical and human) from rich to poor countries. Now we just need to explain why $a^{\frac{1}{1-\alpha}} = 15$.

3. Three alternative Assumptions

Consider the general form of the production function $Y = A^{\varphi}h^{\eta}k^{\mu}.K^{\alpha}(hL)^{1-\alpha}$. We put successively three assumptions: Difference in TPF ($\varphi = 1, \mu = 0, \eta = 0$), externality of human capital ($\varphi = 0, \mu = 0, \eta > 0$), externality of physical capital ($\varphi = 0, \mu > 0, \eta = 0$).

Assumption 3.1 (TPF) : Assuming a gap of Total Factor Productivity (TFP), we can solve the twin paradox simply by choosing a value of relative TFP (a) adequate. Between the United States and poor countries, if $x = 30$, $z = 2$, $\alpha = 0.33$, ratio of $MPK = 1$, and ratio of $MPH = 15$, then one can conclude from equation (5), $a^{\frac{1}{1-\alpha}} = 15$, that: $a = 6$. The explanation of productivity ratios (ratio of MPK equal to 1 and ratio of MPH equal to 15) is that the United States has a total factor productivity 6 times higher than poor countries. However, this explanation is *ad hoc* because it explains the ratios of factor productivity, by the ratio of *ad hoc* total factor productivity.

Assumption 3.2 (Externality of human capital) : To justify that human capital is scarcer in poor countries but more productive in the United States it is quite natural, as proposed by Lucas, to assume that the level of human capital per capita generates positive externalities. The higher the level of human capital is, the more productive it is. The production function becomes convex. We then have the model:

$$Y = h^{\eta}.K^{\alpha}(hL)^{1-\alpha} \text{and } y = h^{\eta}.k^{\alpha}h^{1-\alpha}$$

This hypothesis therefore leads to replace in equation (5) the variable a by z^{η}. We have: $z^{\frac{\eta}{1-\alpha}} = 15$. We can solve the double paradox by choosing the adequate value of the elasticity of the externality η. We get $\eta = 2.6$. Now, the explanation of productivity ratios is that since the United States has two times more human capital than poor countries and that the level of human capital carries a positive externality, the U.S. total factor productivity is, *for this reason*, six times higher ($2^{2.6} = 6$).

Assumption 3.3 (Externality of physical capital) : In order to justify that human capital is more productive in the United States than in poor countries, it is also possible to assume that the level of per capita physical capital generates positive externalities. We then have the model:

$$Y = k^{\mu}.K^{\alpha}(hL)^{1-\alpha} \text{ and } y = k^{\mu}k^{\alpha}h^{1-\alpha}$$

This hypothesis therefore leads to replace in equation (5) variable a by x^{μ}. We have: $z^{\frac{\mu}{1-\alpha}} = 15$. It is sufficient this time to choose the proper value of μ. We get $\mu = 0.53$. Now the explanation of the ratios of factor productivity is that since the United States has 30 times more physical capital than poor countries and that the level of physical capital carries a positive externality, the U.S. total factor productivity is, *for this reason*, six times higher ($30^{0.53} = 6$).

4. Evaluation of the three hypotheses

Without any constraint on productivity, we measure actual values of TFP (A), externality of human capital (η), and physical capital externality (μ). Assuming that respectively $y = A.k^{\alpha}h^{1-\alpha}$ then $y = h^{\eta}.k^{\alpha}h^{1-\alpha}$ and $y = k^{\mu}.k^{\alpha}h^{1-\alpha}$, for $\alpha = 0.33$ (value used by Baier, Dwyer, Tamura) we calculate the values of :

$$\ln(A_{it}) = \ln(y_{it}) - \alpha \ln(k_{it}) - (1-\alpha)\ln(h_{it})$$

$$\eta_{it} = (1/\ln(h_{it}))\left[\ln(y_{it}) - \alpha \ln(k_{it}) - (1-\alpha)\ln(h_{it})\right]$$

$$\mu_{it} = (1/\ln(k_{it}))\left[\ln(y_{it}) - \alpha \ln(k_{it}) - (1-\alpha)\ln(h_{it})\right]$$

The following graphs show the values calculated for all countries and all years of the sample. To present data more clearly, we have arranged in ascending order of GDP per worker in order to appreciate dispersion of the variables on the vertical axis and to justify the mean values adopted in the calibration.

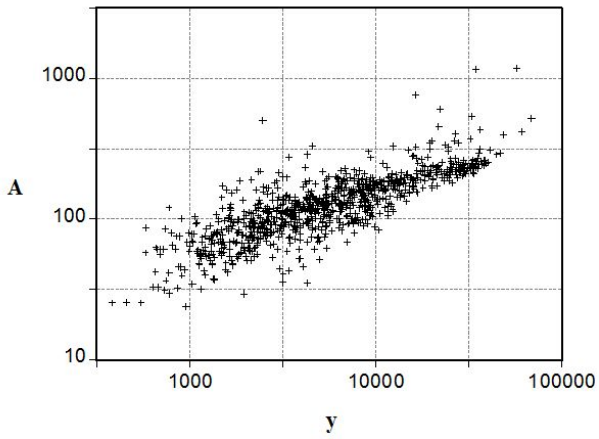

Figure 3: Values of A

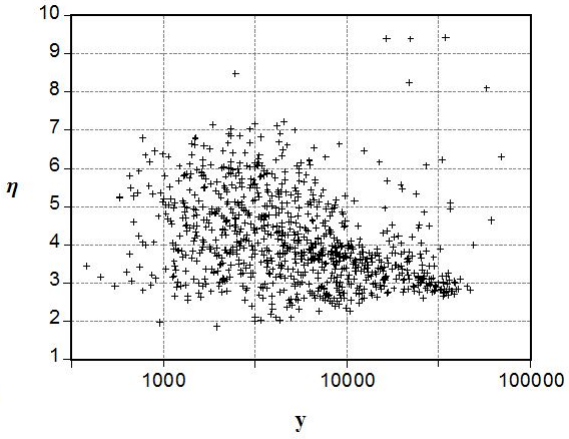

Figure 4: Values of η

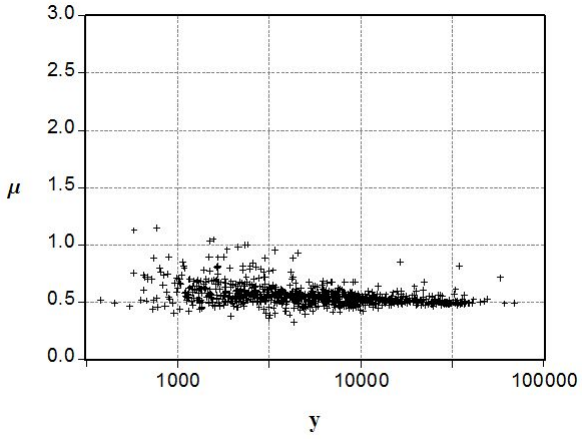

Figure 5: Values of μ

We find in these calculated values, the values used in our example. The value of A is from 50 to 500, then (a) is between 1 and 10 (Fig. 3). The elasticity of externality on

human capital (η) is between 2 and 7 (Fig. 4). The externality on physical capital (μ) is remarkably close to 0.5 for all countries and dates (Fig. 5). The average value is 0.558. For the actual values, what is the assumption which resolves the paradoxes of Lucas and Romer ?

If we assume TFP differences, the actual values of the differences in TFP (the a_i) do not lead to equality of MPK. The following graphs represent ratios of productivity (for physical and human capital) for the actual values of a_i. Under this assumption, poor countries have productivities of physical capital up to 10 times higher than in the United States. As has been said, to obtain equal MPK should be chosen *ad hoc* values of a_i. This hypothesis does not solve the paradoxes.

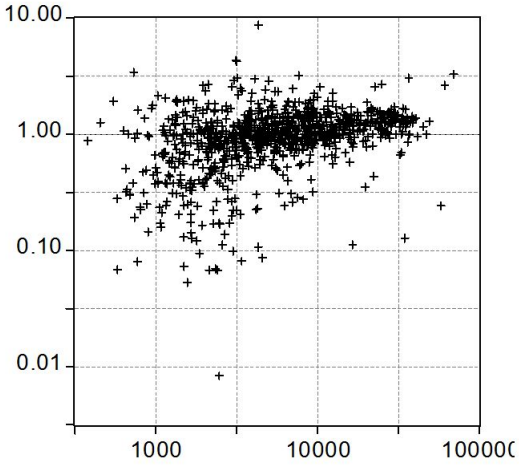

Figure 6: $\frac{MPK_{US}}{MPK_i} = \frac{A_{US}}{A_i}.\left(\frac{x_i}{z_i}\right)^{0.33-1}$

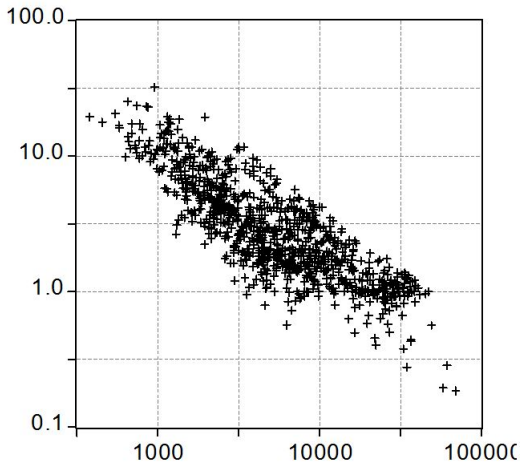

Figure 7: $\frac{MPH_{US}}{MPH_i} = \frac{A_{US}}{A_i}.\left(\frac{x_i}{z_i}\right)^{0.33}$

Assume that externality is on human capital is also unsatisfactory. The calculated values of the elasticity on the human capital are very different between countries. But the most unfortunate is that the calculated values of the elasticity on the human capital are clearly too high to be realistic (between 2 and 7). To paraphrase Lucas (1990), this would mean that '*a 10% increase in the average quality of those I work with, increases my productivity to 20% to 70%*'.

If we assume externality on physical capital, the elasticity values are remarkably similar for all countries. The most remarkable is that calculated value of elasticity is in all cases realistic and very close to average $\mu = 0.558$. We conclude that hypothesis of externality on physical capital is better to explain the paradoxes of Lucas and Romer. The following graphs represent ratios of capital productivity (physical (Fig. 8) and human (Fig. 9)) for the actual values of ${x_i}^{0.558}$. Graphs show that for these actual values, paradoxes are resolved. Even if poor countries have less physical and human capital, the ratios of MPK are close to unity and those of MPH are even higher than the country is poor. There is no incentive for physical capital migrates to poor countries and a strong incentive that human capital migrates to rich countries.

Empirically, the fundamental reason for our result is that between rich and poor countries, the difference in physical capital is much greater than the difference in human capital. So there is no need to invoke an excessive externality of physical capital to solve the paradoxes of Lucas and Romer. Even if rich countries have 3 or 4 times more human

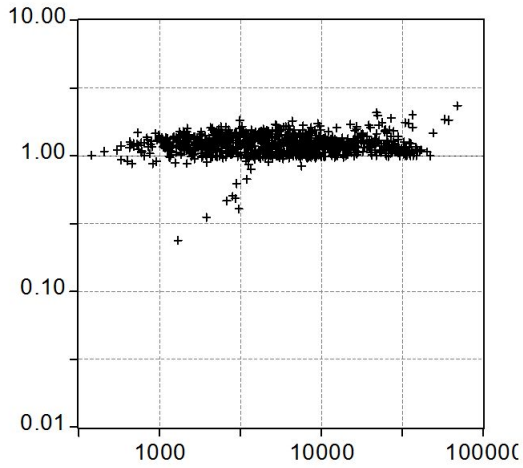

Figure 8: $\frac{MPK_{US}}{MPK_i} = {x_i}^{0.558}.\left(\frac{x_i}{z_i}\right)^{0.33-1}$

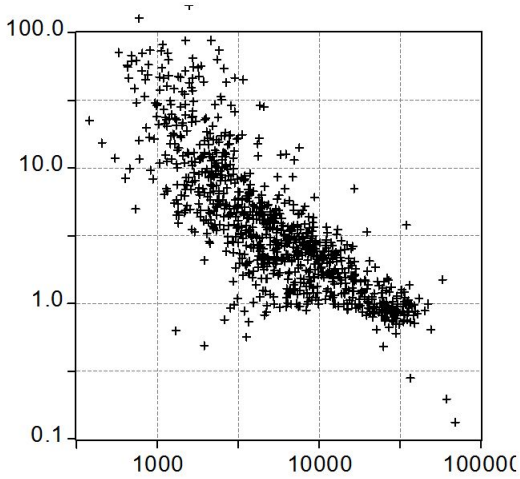

Figure 9: $\frac{MPH_{US}}{MPH_i} = {x_i}^{0.558}.\left(\frac{x_i}{z_i}\right)^{0.33}$

capital than poor countries, the externality of human capital should always be excessive to solve the paradoxes of productivity.

Technically the reason is simple : the production function represented in three dimensions (y, k, h) becomes convex when we introduce an externality. There are two solutions : $y = k^{\alpha}h^{(1-\alpha+\eta)}$ either $y = k^{\alpha+\mu}h^{1-\alpha}$. If we introduce externality on human capital, production function remains "very concave" in space (y, k). Achieve equal MPK in space (y, k, h) then requests a very strong externality. If we introduce the externality "on the side where the function is more concave", on physical capital, it immediately becomes less concave in the (y, k). In our calibration it becomes nearly linear (as in the AK model) as $\alpha = 0.33$ and $\mu = 0,55$. Achieve equal MPK demand low externality (less than 0.67 by construction) and therefore a more realistic externality.

5. Conclusion

There are no large differences in productivity of capital, neither historically nor geographically. There are however today, large differences in productivity of skilled labor for the benefit of rich countries. To explain this, we must of course take into account the differences in human capital endowment as suggested by Lucas. But this is insufficient because to achieve equality of MPK, it must be assumed than human capital in poor countries is extremely rare, and then it becomes extremely more productive than human capital in rich countries. To avoid this paradox of Romer, one must obviously assume an externality. But contrary to immediate intuition it is best to assume an externality in physical capital.

The literature on this issue rather favored the hypothesis of human capital externality. For example Easterly (2001) in his book, after setting out paradoxes of Lucas and Romer, devotes an important chapter 8 to explain that origin of increasing returns is in the human capital externalities. Unfortunately, it is impossible to solve the paradoxes of international differences in factor productivity, assuming this type of externality on human capital. Since MPK are approximately equal, the AK model is undoubtedly the most efficient. When developing countries have the physical capital, the productivity of skilled worker is very high, as observed for eye care in Turkey, for cosmetic surgery in Tunisia, and

dentistry in Hungary. If the Indian skilled workers go to work in the United States is not to take advantage of the externalities of their American colleagues, but to take advantage of machines and American technology. This is the physical capital that increases their productivity, not attendance American brains.

References

Baier S. L, Dwyer G. P., Tamura Jr. R., (2006), "How Important Are Capital and Total Factor Productivity for Economic Growth ? " *Economic Inquiry* 44. n 1, 23-49.

Baier S. L., Dwyer G. P., Tamura Jr. R., (2004), "Factor returns, institutions, and geography : a view from trade," Working Paper 2004-17, Federal Reserve Bank of Atlanta. http://www.frbatlanta.org/filelegacydocs/wp0417.pdf

Easterly, W. (2001), *The Elusive Quest for Growth*, Cambridge MA, MIT Press.

Jones, C.I. (1995), "R&D-Based Models of Economic growth", *Journal of Political Economy*, 103 : 759-784.

Lucas, R. (1990), "Why Doesn't Capital Flow from Rich to Poor Contries ? " *American Economic Rewiew*, 80 (2) may, 92-96.

Mankiw, N. Romer, D. Weil, D.N. (1992), "A Contribution to the Empirics of Economic Growth", *Quarterly Journal of Economics*, 107(2) : 407-437.

Rebelo, S. (1991), "Long Run Policy Analysis and Long Run Growth", *Journal of Political Economy*, 99 : 500-521.

Romer, P.M. (1995), "Comment on N. Mankiw ; The Growth of Nations", *Brookings Papers on Economic Activity*, 1, 313-320.