TALENT UTILIZATION, A SOURCE OF BIAS IN MEASURING TFP

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Abstract

This paper analyzes a model of economic growth that explains differences in economic structure across countries. It highlights the interplay between productivity, talents utilization and entrepreneurship incentives. The paper has two main results. First, it argues that when measuring human capital we ignore one dimension, which is "talents utilization". It is suggested then that, in development accounting, human capital is inaccurately measured. Second, it shows that the magnitude of talents utilization increases with the level of development. Thus, the paper suggests that talents utilization amplifies differences in productivity and contributes to the explanation of large observed international differences in per capita income.

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1 Introduction

"The Measure of Our Ignorance" this is how Abramovitz (1956) labeled the Solow residual, also known as "Total Factor Productivity" (TFP). According to development accounting, when considering income differences TFP is a component of income variation that is left over when factors of production have been accounted for. Accordingly, if the variety of inputs is accurately identified and accurately measured, then the level of TFP converges to the true underlying technological level. Although measurement is an empirical issue, the current paper suggests a theory concerning the explanation of the variation of TFP across countries.[1]

The contribution of this paper is twofold. First, it argues that when measuring human capital we ignore one dimension, which is "talents utilization". It is suggested then that, in development accounting, human capital is inaccurately measured. Second, it shows that the magnitude of talents utilization increases with the level of development. Although the level of development is endogenous, the focus of this paper is on the exogenous variables that affect economic performance. These exogenous variables are henceforth called "basic productivity". In this respect, I follow the seminal work of Hall and Jones (1999), which addresses the importance of these exogenous variables in explaining cross-country differences in per capita income.[2] In their paper they state that:

> We conclude that our results indicate that differences in social infrastructure account for much of the difference in long run economic performance throughout the world, as measured by output per worker, ... this evidence means that infrastructure is a powerful causal factor promoting higher output per worker (p. 107).

The main result of the current paper shows that differences in basic productivity are amplified at the macro level. Specifically, economies with higher basic productivity better utilize the heterogenous entrepreneurship talents embodied in its populations

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[1]Jorgenson and Griliches (1967) addresses the importance of theories in understanding the bias in TFP measurement.

[2]To capture the exogenous part, Hall and Jones use, as an instrument for social infrastructure, geographical characteristics and the languages that are spoken as first languages today.

by promoting the matching of these talents with the technologies implemented in these economies. The extent to which these talents are utilized is henceforth called the "matching capacity".

The main idea of the paper is presented by a model of economic growth where the final output is produced by many intermediate goods. Each country produces a different variety of intermediate goods. The size of the variety depends on basic productivity, which is country specific. Each intermediate good is produced in a different sector by many firms that use the same technology, which is sector specific. To implement a particular technology a specific entrepreneurship talent is required. The extent to which entrepreneur's talent matches the technology requirements determines the efficiency units of labor that this entrepreneur supplies.

A fix cost of importing each technology determines the number of sectors and the size of each sector, which reflects the number of firms in that sector. The main result of the model shows that countries with higher basic productivity have larger varieties of sectors, while the size of each sector is smaller such that the product of the two is, certainly, higher. This product reflects the number of entrepreneurs in the economy. Thus, on the one hand, a larger number of entrepreneurs implies that a higher share of population talents is utilized; and on the other hand, a smaller size of each sector implies a higher average matching. As a result, differences in basic productivity induce higher matching capacity and contribute to the explanation of large observed international differences in per capita output.

The paper belongs to a strand in the literature that tries to deal with the repeated question: why are some countries so much richer than others? The answer that this literature provides lies between factors accumulation and the efficiency with which these factors are used.[3] On the one hand, Mankiw, Romer and Weil (1992), Parente, Rogerson and Wright (2000), Weil (2005) and Manuelli and Seshadri (2005) find that most of the cross-country differences in per capita output are induced by factors accumulation.[4] On the other hand, Chari, Kehoe and McGrattan (1996), Prescott (1998), Parente and Prescott (2000), Klenow and Rodriguez-Clare (1997),

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[3]For an updated survey of such development accounting literature see Caselli (2005).

[4]Mankiw et al. (1992) addresses the role of human capital, Parente et al. (2000) emphasize the role of home production, Weil (2005) examines the role of health and Manuelli and Seshadri (2005) stresses the importance of controlling for the quality of education when examining this question.

Bils and Klenow (2000) and Hendricks (2002) find that most of the cross-country differences in per capita output are induced by TFP.[5]

Closest to my argument comes Jeong and Townsend (2006), which focuses on occupational shift and financial deepening for explaining TFP growth.[6] However, Jeong and Townsend (2006) differs from the current paper in two respects. First, Jeong and Townsend (2006) shuts down all sources of exogenous technological change, while the current paper assumes that it is the key for understanding differences in economic performance across countries. Second, they model profits from talents in an additive way while in the current paper talent, a part of human capital, is an input of the production function, which seems a more reasonable assumption.

The current paper, therefore, addresses a new dimension of quality of human capital that helps to better understand the source of international differences in per capita output. It suggests that the level of human capital has not been accurately measured even after controlling for quantity and quality of education since part of the human capital, a country has, depends on an unobserved part, which is the extent to which talents are utilized. Moreover, the magnitude of this unobserved part is positively affected by the magnitude of basic productivity. To avoid these measurement problems, one empirical strategy, for estimating the extent to which entrepreneurs' human capital are utilized, is by observing entrepreneurs earnings in the same sector.[7] It turns out that differences in earnings across entrepreneurs with identical measured skill can be used to infer the unmeasured part, namely, the extent to which talents are utilized.

Basic productivity has an important role in explaining differences in per capita output across countries. This is another way to put the bottom line of the current paper. Zeira (1998), Basu and Weil (1998) and Acemoglu and Zilibotti (2001) are theoretical contributions that are strongly related to this argument. While Zeira

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[5]Chari et al. (1996), Prescott (1998) and Parente and Prescott (2000) allow for differences in physical and intangible capital and Klenow and Rodriguez-Clare (1997), Bils and Klenow (2000) and Hendricks (2002) allow for differences in the quality of education across countries.

[6]By calibrating their model using Thailand data for the period 1976 and 1996, Jeong and Townsend find that occupational shifts and financial deepening explain 73% of aggregate TFP growth.

[7]In general, this empirical exercise can be done at the labor market level. However, in order to avoid sectorial differences, which the current paper abstract from, it can be done at the sectorial level.

(1998) addresses the importance of basic productivity for determining the range of technologies that are adopted, Basu and Weil (1998) and Acemoglu and Zilibotti (2001) emphasize the importance of skill abundance for utilizing technologies that are adopted.

The rest of the paper is organized as follows. Section 2 formalizes the arguments, section 3 describes the solution, section 4 provides a comparative statics exercise and section 5 presents some concluding remarks.

2 The Model

Consider a small open economy in a world with one final good, which is used for consumption only. This final good is produced by a continuum of intermediate goods. For simplicity the model assumes no physical capital and, therefore, intermediate goods are produced by labor only. All markets are assumed to be perfectly competitive. The final good as well as each intermediate good is assumed to be perfectly tradable, but labor is not tradable, and its market is domestic. For simplicity there is no population growth and population size is normalized to one.

2.1 Production of the final good

The final good is produced by the following continuous log-linear production function

$$\log Y = \int_0^1 \log x_j \, dj \tag{1}$$

where Y is the total output produced in an economy, x_j is the input of intermediate good j.

2.2 Production of intermediate goods

Each country produces a discrete variety of intermediate goods out of a potential continuum, which is the interval $[0, 1]$. Each point on this unit segment represents

a different type of intermediate good which requires a specific talent to operate the technology by which it is produced. This specific talent will be henceforth called the "job requirements".

Individuals are indexed on the unit segment with uniform density. The index of each individual represents her talent.[8] As job requirements represent the location of an entrepreneur whose talent accurately matches these requirements, individuals and intermediate goods are both indexed on the same unit segment without any ambiguity.

Each intermediate good is produced in a specific sector by a continuum of firms. Each firm is operated by a different entrepreneur whose talent, to some extent, matches the job requirements of the technology used in that sector. The extent to which an entrepreneur's talent matches the job requirements determines the number of efficiency units of labor, that this entrepreneur supplies, according to the following function.

$$h_{ij} = h_0 - bd_{ij} \tag{2}$$

where h_{ij} is the ex-post efficiency units of labor that entrepreneur i supplies for producing intermediate good j, h_0 is the maximum efficiency units of labor that an entrepreneur can have and d_{ij} is the distance between the location of intermediate good j, which reflects its job requirements, and that of entrepreneur i, which reflects her entrepreneurship talent. This distance expresses the level of mismatching between the two. The larger the distance is, the greater the mismatching and, thus, the smaller the number of efficiency units of labor that entrepreneur i supplies for producing intermediate good j.

This cost of mismatching is relevant to an entrepreneur who is considering joining an extant sector. However, it is irrelevant to an entrepreneur who is considering setting up a new sector for producing a new intermediate good since she chooses a

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[8]A different location on the unit segment reflects a different type of talent. More specifically, the location of a specific individual: $(s_i = 1)$ does not indicate a maximum level of talent; rather, it represents a different talent from any $(s_i \neq 1)$.

sector whose requirements match her talent precisely.[9] Such an entrepreneur will be henceforth called an "initiator".

In order to set up a new sector a fixed cost, C, is required. This cost, which is measured in terms of the final good, can be interpreted as the cost of importing a new technology for producing a new intermediate good. While this is a cost that an initiator bears, she earns the monopolistic price from each entrepreneur who wish to buy the knowledge by which this intermediate good is being produced.

Therefore, profit generated by initiator j is

$$\pi_j = [P_j x_j - w l_j] ds + R_j - C \tag{3}$$

where P_j is the price of intermediate good j, w is the equilibrium wage, x_j is the output of intermediate good j produced by initiator j, l_j is the number of workers employed by her j and R_j is the rents that she earns.[10]

Another entrepreneur i with skill, close to j finds it profitable to set up a new firm to produce the same intermediate good j. She does have the talent, but she lacks the knowledge for producing intermediate good j. This knowledge can be bought from initiator j at the cost r_j.

By the above described market for knowledge, each individual is a potential entrepreneur, who can set up a new firm in order to produce an intermediate good j according to the following production function

$$x_{ij} = A l_{ij}^{\alpha} h_{ij}^{(1-\alpha)} \tag{4}$$

where $\alpha \in (0, 1)$, x_{ij} is the output of intermediate good j produced by entrepreneur i, l_{ij} is the number of workers employed by her and A is a productivity parameter,

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[9]As will be shown later, this is the optimal behavior at equilibrium. Otherwise a sector does not cover the cost of importing technology.

[10]As will be apparent later, initiator j has his own firm that produces intermediate good j and sells the knowledge that she owns to a continuum of other entrepreneurs. Thus, the profit function described in 3 is a sum of two different measures: one is infinitesimal and the other is discrete.

which is country specific. This coefficient may reflect geography: land quality, climate and access to sea, resource endowments: land abundance and natural resources or even infrastructure, and should therefore differ across countries.

Since each intermediate good is produced by a continuum of firms, the market for each intermediate good is competitive. Namely, each entrepreneur takes the rent for using the sector specific technology, r_j, the equilibrium wage, w, and the price of each intermediate good, P_j, as given.

Profit generated by entrepreneur i, who produces intermediate good j, is

$$\pi_{ij} = P_j A l_{ij}^{\alpha} h_{ij}^{(1-\alpha)} - w l_{ij} - r_j \tag{5}$$

3 Equilibrium

Let the final good serves as a numeraire. Profit maximization by firms, which produce the final good, leads to the following first-order condition

$$P_j = \frac{\partial Y}{\partial x_j} = \frac{Y}{x_j} \tag{6}$$

Substituting equation 6 into equation 1 we get that the condition $\left(\int_0^1 \log P_j \, d_j = 0 \right)$ must hold at the optimum. Due to symmetry and to the world competition in markets for intermediate goods all prices must be equal. Hence $P_j = P = 1$.

Profit maximization by entrepreneur i who produces intermediate good j leads to the following demand for labor

$$l_{ij} = \left(\frac{\alpha A}{w} \right)^{\frac{1}{1-\alpha}} (h_0 - b d_{ij}) \tag{7}$$

The process of establishing new firms by new entrepreneurs takes place until it becomes unprofitable to set up a new firm for producing the same intermediate good j. At equilibrium the marginal entrepreneur in sector j is indifferent between

being an entrepreneur in sector j or working as an employee in any firm. Formally:

$$\pi_{j \pm \bar{d}_j} = (1 - \alpha) A \bar{l}_j^{\alpha} \bar{h}_j^{(1-\alpha)} - r_j = w \tag{8}$$

where $\bar{h}_j$ is the number of efficiency units of labor that the marginal entrepreneur has and $\bar{l}_j$ is the number of workers employed by her. Recall from equation 2 that $\bar{h}_j = h_0 - b\bar{d}_j$, where $\bar{d}_j$ is the maximal distance between the requirements of sector j and the talent of the marginal entrepreneur. Notice that, since entrepreneurs join sector j from both sides, the size of sector j is represented by the width of that sector which is the interval $[j - \bar{d}_j, j + \bar{d}_j]$. Thus, the size of each sector, which is $2\bar{d}_j$, represents the continuum of firms that produces the same intermediate good j.

Inspection of equation 3 reveals that the first term: $[P_j x_j - wl_j]ds$ is infinitesimal while the last two terms: R_j and C are discrete. Thus, initiator j determines the price r_j as to maximize

$$\pi_j = 2\bar{d}_j r_j - C \tag{9}$$

From equation 8 it follows that the price that initiator j charges for selling her technology to other entrepreneurs, r_j, affects entrepreneurs' surpluses and therefore affects the size of sector j. Thus, first order condition with respect to the monopolistic price for knowledge yields:

$$\frac{\partial \bar{d}_j}{\partial r_j} r_j + \bar{d}_j = 0 \tag{10}$$

Applying the implicit function theorem on equation 8 implies that:

$$\frac{\partial \bar{d}_j}{\partial r_j} = \frac{-w^{\frac{\alpha}{1-\alpha}}}{\alpha^{\frac{\alpha}{1-\alpha}}(1-\alpha)bA^{\frac{1}{1-\alpha}}} \tag{11}$$

substituting equation 11 into equation 10, isolating w, substituting it into equation

8 and isolating r_j yields:

$$r_j = \gamma \frac{b\bar{d}_j}{(h_0 - 2b\bar{d}_j)^\alpha} A \qquad (12)$$

where $\gamma = \alpha^\alpha (1-\alpha)^{(1-\alpha)}$.

Another potential entrepreneur, k far from j finds it profitable to initiate a new sector that produces a different intermediate good. She incurs the set up cost, C, and through the above described market for knowledge she sells the technology to other entrepreneurs close to her. Ultimately, many sectors are being established, where each sector produces a unique intermediate good by a continuum of firms. The larger the variety of intermediate goods, the smaller the surplus for each initiator. This conclusion can be directly driven by the assumption of substitution of the intermediates in producing the final good. As a result, at equilibrium, the variety of intermediate goods in an economy is determined by applying the zero profit condition for all initiators, which yields:

$$2\gamma \frac{b\bar{d}_j^2}{(h_0 - 2b\bar{d}_j)^\alpha} A = C \qquad (13)$$

Since all initiators face the same cost of setting up a sector, C, all sectors have the same size, $\bar{d}_j = \bar{d}$, and therefore charge the same price for selling the technology, $\bar{r}_j = \bar{r}$.

let J denotes the equilibrium number of sectors. Labor market clearing implies that

$$2J \int_0^{\bar{d}} l_i \, ddi = 1 - 2\bar{d}J \qquad (14)$$

The term $2\bar{d}J$ represents the size of entrepreneurs out of the normalized population. Therefore, the left hand side of 14 represents the demand for labor and the right hand side of 14 represents the supply for labor.

Substituting equations 10, 11 and 12 into 14, isolating J yields:

$$J = \frac{1}{\left(\frac{\alpha}{1-\alpha} \frac{2h_0 - b\bar{d}}{h_0 - 2b\bar{d}} + 2 \right) \bar{d}} \tag{15}$$

4 Comparative Statics

This section examines how economies vary in their structure. More specifically, it analyzes how differences in productivity across countries explain differences in the number and size of sectors.

How the size of sectors varies across countries? This can be learned by differentiating $\bar{d}$ with respect to productivity, which is country specific. Applying the implicit function theorem on 13 yields:

$$\frac{\partial \bar{d}}{\partial A} = -\frac{\bar{d}}{2A \left(1 + \frac{\alpha b \bar{d}}{h_0 - 2b\bar{d}} \right)} < 0 \tag{16}$$

and differentiating the equilibrium number of sectors with respect to the equilibrium size of each sector yields:

$$\frac{\partial J}{\partial \bar{d}} = -\frac{\left(\frac{\alpha}{1-\alpha} \frac{2h_0 - b\bar{d}}{h_0 - 2b\bar{d}} \right) + \left(\frac{\alpha}{1-\alpha} \frac{3bh_0 \bar{d}}{(h_0 - 2b\bar{d})^2} \right)}{\left(\frac{\alpha}{1-\alpha} \frac{2h_0 - b\bar{d}}{h_0 - 2b\bar{d}} \right)^2 \bar{d}^2} < 0 \tag{17}$$

Thus, equations 16 and 17 show that the more developed the country is, the higher the variety of sectors and the smaller the size of each sector.

Let $E = 2\bar{d}J$. This reflects the equilibrium continuum of entrepreneurs in the economy. Differentiating this continuum with respect to $\bar{d}$ yields:

$$\frac{\partial E}{\partial \bar{d}} = -2 \frac{\alpha}{1 - \alpha} \frac{\frac{3bh_0}{(h_0 - 2b\bar{d})^2}}{\left(\frac{\alpha}{1-\alpha} \frac{2h_0 - b\bar{d}}{h_0 - 2b\bar{d}} + 2 \right)^2} < 0 \tag{18}$$

Thus, higher basic productivity increases the share of entrepreneurs out of the population. Since in this model talents play a role only through entrepreneurship activities, it turns out that in more developed countries population talents are better utilized, albeit the same ex-ante distribution of talents in all countries. Notice that although the continuum of entrepreneurs is larger in more developed countries, the size of each sector is smaller. As a result, the average matching between entrepreneurs' talents and job requirements is higher. put it differently, differences in basic productivity across countries are amplified through talents utilization. This talents utilization takes two forms: first, more people use their talents, and second, talents are being used more efficiently.

5   Concluding Remarks

This paper addresses that "talents utilization", a new dimension of quality of human capital, helps to better understand the source of international differences in per capita output. It argues then that the level of human capital is not accurately measured even after controlling for quantity and quality of education since part of the human capital, a country has, depends on an unobserved part, which is the extent to which talents are utilized. Then it is shown that the magnitude of this unobserved part is positively related to basic productivity.

To avoid these measurement problems the paper proposes one empirical strategy for estimating the extent to which entrepreneurs' human capital are utilized. This strategy is summarized by examining differences in earnings across entrepreneurs with identical measured skill. these differences can be attributed to the extent to which talents are utilized.

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