Back to the basics: Revisiting the development accounting methodology

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A R T I C L E   I N F O

A B S T R A C T

The standard baseline estimate in development accounting is imprecise because of a mismatch between the estimate of physical capital and the estimate of physical capital's share, the fraction of total income accruing to physical capital. I adjust for this mismatch, and in so doing, incorporate natural capital. I also treat factor shares as variables, not constant parameters. To accommodate these adjustments, I carry out a development accounting analysis using translog multilateral indices of outputs, inputs and productivity. Results reveal that the correction for the mismatch between physical capital and its share, which is the weight assigned to the physical capital input in development accounting, reduces the variation in output per worker explained by observables by as much as 15 percentage points relative to the standard baseline. Most of this reduction is due to a decline in the explanatory power of physical capital per worker. Natural capital per worker, which is usually ignored, is found to explain up to 7.2% of the variation in cross-country output per worker. Variation in factor shares, also omitted from most studies, explains up to 6.3% of the variation in cross-country output per worker, which is nearly half as much as all observables together explain.

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1. Introduction

Development accounting, which aims to allocate cross-country differences in output to observable and unobservable components, requires that the relationship between factors of production, productivity and output be quantified. Virtually all functional forms that serve as an avenue for this quantification incorporate factor shares in some manner. This paper reconsiders how factor shares are incorporated.

1.1. The mismatch

There is an empirical mismatch between the notions of physical capital and physical capital's share. *Total capital's share* combines the fractions of income accruing to both physical and natural capital.[1] Physical capital and natural capital are two distinct factors. Physical capital is reproducible, meaning it can be accumulated, whereas natural capital is non-reproducible and cannot be accumulated.[2] Physical capital encompasses tools, machinery and structures, and natural capital encompasses

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[1] The simplest estimate of *total capital's share* is computed as $\left(1 - \frac{employee\ compensation}{GDP}\right)$. Gollin (2002), Bernanke and Gurkaynak (2001) and Sturgill (2012) account for the income of the self-employed and compute *total capital's share* as $\left(1 - \frac{employee\ compensation}{GDP-indirect\ taxes-self\ employed\ income}\right)$.

[2] Non-reproducible factors are those factors with which an economy is endowed. Reproducible factors have to be produced.

all natural resources including land, minerals and oil. Incorporating total capital's share into a development accounting analysis is warranted if the capital input into production is some amalgamation of physical and natural capital. However, the majority of empirical studies involving aggregate production, including the development accounting analyses of Klenow and Rodriguez-Clare (1997), Hall and Jones (1999) and Caselli (2005), ignore natural capital and associate total capital's share with the physical capital input.

These studies often insert 1/3, the long-run average of total capital's share in the U.S. and the approximate average of total capital's share across countries, as the exponent on physical capital in a Cobb–Douglas production function or the multiplicative parameter in front of physical capital in a CES production function. This insertion is imprecise. The value of 1/3 is being treated as the elasticity of output with respect to physical capital, which, under the assumption of perfect competition, is equivalent to physical capital's share. But 1/3 is not the average of physical capital's share across countries; it is the average of the sum of physical capital's share and natural capital's share across countries.[3]

1.2. The constant share assumption

In addition to the mismatch between physical capital and its share, virtually all development accounting studies assume that factor shares are constant. The claim that factor shares are constant was first made by Phelps Brown and Weber (1953) and reiterated by Kaldor (1961) as one of his widely accepted "stylized facts" of macroeconomics. As a result, the standard assumption in studies involving aggregate production, including development accounting, is that total capital and total labor shares are constant over time and across countries.

Cross-country averages of total capital's share are close to 1/3, but the cross-country data exhibit quite a bit of variation. Gollin (2002) reports an average of 0.33 for his Adjustment 2 measure of total capital's share across a sample of 31 countries. However, the shares range from 0.17 to 0.53. Bernanke and Gurkaynak (2001) find an average total capital share of 0.35 for a sample of 53 countries, but shares range from 0.21 to 0.55. The average total capital share equals 0.42 in Sturgill's (2012) 46 country sample, but shares range from 0.14 to 0.69.

Caselli (2005) argues that the development accounting conclusions "would be unchanged if factor shares, while not constant, were not systematically related to income." Gollin (2002) and Bernanke and Gurkaynak (2001) conclude that total capital's share is not systematically related to income per worker across countries. However, Sturgill (2012) finds that total capital's share is negatively related to income per worker across countries at the 1% level.[4]

In light of this conflicting empirical evidence, it seems reasonable to at least consider variation in factor shares as a potential explanation for cross-country differences in per worker incomes. But there is a more compelling reason to allow for variable factor shares in development accounting. Since physical capital's share is the weight that should accompany physical capital, the variability of physical capital's share, not total capital's share, is what matters, and economic theory and empirical evidence both indicate systematic cross-country variation in physical capital's share.

Peretto and Seater (2013) and Zuleta (2008b) develop economic growth models that allow factor shares to change endogenously via spending on Research and Development. The changing factor shares serve as the catalyst for growth. As economies advance, reproducible and non-reproducible factors of production become more and less important, respectively. The empirical implication of this is that reproducible factor shares should increase with output per worker, and non-reproducible factor shares should decrease with output per worker. Though these theories pertain explicitly to intertemporal variation, cross-sectional variation is implied via the symmetry between time and space as long as countries follow different development paths, which they do. Thus, any cross-sectional evidence of factor share variation is supported by theory.

Caselli and Feyrer (2007), Zuleta (2008a), and Sturgill (2012) perform empirical analyses that acknowledge the entanglement of physical and natural capital shares in the standard total capital share computation. All three studies separate physical capital's share from natural capital's share. As would be expected, the average physical capital share across countries is found to be less than 1/3, but more importantly, the evidence reveals systematic variation. Physical and natural capital shares are positively and negatively related to output per worker, respectively, at statistically significant levels. Zuleta (2008a) and Sturgill (2012) also decompose total labor's share into its reproducible and non-reproducible components. Both studies find that cross-country estimates of human capital's share and raw labor's share are positively and negatively correlated with output per worker, respectively, at statistically significant levels.

1.3. A new framework

Correcting the mismatch and allowing for variable shares is non-trivial and involves more than just inserting country-specific values of physical capital's share in place of the standard constant share estimate of total capital's share. Developing this new baseline requires the incorporation of natural capital and a departure from the standard Cobb–Douglas or CES pro-

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[3] The approximate average of *total labor's share* across countries is 2/3 and this value is typically assigned as the weight on the labor input. *Total labor's share* combines the fractions of income accruing to human capital and raw labor. The labor input is generally some estimate of effective labor per worker, which combines raw labor and human capital, so there is usually no mismatch between labor and its share in the development accounting methodology.

[4] All three of these analyses make the adjustment for self-employed income initially proposed by Gollin (2002). However, Sturgill (2012) is a true cross-section analysis for the year 2000, whereas Gollin (2002) and Bernanke and Gurkaynak (2001) are based on pooled data with observations that range from 1977 to 1995. This distinction may help to explain the difference in the results.