

An Accounting Method for Economic Growth

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Abstract

As Chari et al. (2007) indicate, many growth theories explaining frictions in real economies are equivalent to a competitive economy with some exogenous taxes. Using this idea, I develop an accounting method for identifying fundamental causes of economic growth. A two-sector neoclassical growth model with taxes is used as a prototype economy, and its equilibrium conditions define wedges. These wedges endogenously determine the long run growth rate, which is exogenous and not correlated with any other variables in a one-sector growth model. Furthermore, the importance of wedges in explaining the long-run growth rate can be evaluated through the prototype economy. Applying this method to fifty countries reveals that, among seven wedges, two wedges are important in explaining economic growth.

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1. Introduction

Differences in economic growth across countries have been substantial in history. Since 1950 the industrial countries have either grown at a remarkably stable rate or converged to the stable trend, a few developing countries have experienced rapid growth, yet some other countries grow at only a stagnant rate. Over the last two hundred years the industrial leaders also witness accelerating economic growth: the United Kingdom grew around 1.2% per year from 1820 to 1890; and the United States has a 2% average annual growth rate throughout the twentieth century (use data from Maddison (2003)). What sustains growth over long periods of time? Which country will be the industrial leader in the twenty-first century, and what will its trend growth rate be? In this paper, I extend the “Business Cycle Accounting” framework of Chari et al. (2007) to provide a platform for addressing these questions.¹

The insight from Chari et al. (2007) is that a neoclassical growth (NCG) model with taxes is a good perspective with which underlying causes of the observed gaps in growth can be analyzed. Wedges associated with a prototype economy’s equilibrium conditions can be defined as exogenous variables, and interpreted as taxes, efficiency shifters, and government consumption. Furthermore, specific growth models that can theoretically explain the observed gaps correspond to these wedges too. Compared with the conventional growth accounting method, the whole set of equilibrium conditions, rather than only production functions, are used to decompose economic growth; and the decomposition results can be connected to the fundamental causes of growth more easily. I choose a two-sector NCG model, essentially Rebelo (1991) with different taxes, as the prototype economy, in which the long run economic growth is endogenously driven by the accumulation of the broadly defined human capital.

When the values of the endogenous variables and parameters in the prototype economy are observable, the wedges defined by equilibrium conditions of the prototype economy can be recovered. Substituting these variables and parame-

¹Kydland and Prescott (1982) unify business cycle and growth theory by arguing that business cycle models should be consistent with the empirical regularities of long-run growth. So growth theories can naturally take advantage of any methodology that proves to be useful in business cycle models.

ters into each equilibrium condition of the prototype economy gives the wedge value associated with that equation. Given the values of individual wedges, their relevance can be evaluated through the prototype economy too. This flexibility allows us to tackle the important question of identifying fundamental causes of the long-term economic growth.

I collect the relevant data for fifty countries, measure various wedges for each country and evaluate the contributions of individual wedges. By assuming that no frictions exist in the US, and using the detailed data for the US during the 1960-2000 period, I calibrate the parameters in the prototype economy. The US is a critical benchmark for this study and the interpretation of the experiment results should be based on the critical assumption, because there may be distortions even in a comparably undistorted country such as the US. The main findings reveal some interesting observations. In accounting for growth performance across countries, on average, the efficiency wedge with the production function for the broadly defined human capital, and the wedge associated with the Euler equation for human capital are of primary importance. The wedge with the labor-leisure trade-off condition and the wedge with the condition of the allocation of labor across sectors are also important, though their effects are smaller. Moreover, these patterns are robust across the sub-samples of countries in and out of the Organization for Economic Co-operation and Development (OECD). These results will help researchers develop quantitative models of economic growth.

This paper relates to a large literature that studies the determinants of the large gaps of economic performance. Some studies deal with proximate causes, such as physical and human capital, or technology changes and adoption (e.g., Lucas (1988), Romer (1990), and Klenow and Rodriguez-Clare (2005)). Others pay more attention to fundamental causes, such as differences in raw materials, geography, preferences, and economic policies (e.g., McGrattan and Schmitz (1999), Cole et al. (2005), Acemoglu et al. (2001) and Rodrik et al. (2004)).² Re-

²Solow (1957) is an early, but modern, attempt to account for different patterns of economic development, which becomes the cornerstone of the NCG model. Lucas (1988) emphasizes the effects of human capital accumulation; Romer (1990), among others, endogenizes technological change; Klenow and Rodriguez-Clare (2005) address the interaction between open economies. McGrattan and Schmitz (1999) focus on differences in economic policies and review estimates for a wide range of policy variables; Cole et al. (2005) argue that Latin America's failure to replicate Western economic success is primarily due to TFP differences, and that barriers to competition

cently, Hsieh and Klenow (2009) study the misallocation in manufacturing activities with firm-level precision. This is promising in explaining the cross-country efficiency variations, which underlie the exogenous efficiency shifters in my paper. My paper complements this literature by organizing promising stories under a unified framework. In this respect, my work provides a particular response to Lucas (1988), where the author recommended economists: (1) to develop quantitative theories that describe the observed differences across countries and over time, in both levels and growth rates of income per person; (2) to explore the implications of competing theories with respect to observable data; and (3) to test these implications against observation.

The rest of the paper is organized as follows. Section 2. describes the prototype economy, its steady-state equilibrium, and its relationship with a standard one-sector growth model with wedges. Section 3. briefly explains the accounting procedure, presents the raw data sources, the construction of variables, including the broadly defined human capital and its relative price in terms of final goods. Section 4. shows the experiment results. Section 5. concludes.

2. The Prototype Economy

In this section, I specify the prototype economy as a two-sector model of endogenous growth with taxes, and describe its steady-state equilibrium.

The prototype economy is a variant of Rebelo's two-sector model (see Rebelo (1991)). One sector produces final goods, which can be either consumed or invested in physical capital; the other sector produces human capital, which enhances labor productivity. Both sectors use Cobb-Douglas aggregate production functions,³

$$y(t) = A[v(t)k(t)] [u(t)h(t)l(t)]^1, \quad (1)$$

$$x_h(t) = B[(1 - v(t))k(t)] [(1 - u(t))h(t)l(t)]^1, \quad (2)$$

where y , l , x_h , k and h are per person output of final goods, labor input, invest-

are the cause of these differences.

³Sturgill (2009) suggests that the inclusion of energy as a further input has a substantial impact on the estimated contribution of TFP on long-run growth. So this widely-used specification of production function deserves a further consideration.

ment in human capital, physical capital stock and human capital stock respectively;⁴ v and u represent the fractions of physical capital stock and labor devoted to the final goods sector; α represents the common capital share in both sectors;⁵ A and B are two productivity shifters in these two sectors.⁶

Firms face competitive output and factor markets, and thus they take the relative price of human capital in terms of final goods q , factor prices of physical capital and labor in the final goods sector (r_k, w_k) and in the other sector (r_h, w_h) as given when they make their output decisions. The costs of physical capital and labor in the final goods sector are taxed with rates τ_1 and τ_2 . And firms find the capital-labor combinations to maximize their profits,

$$y(t) - (1 + \tau_1)r_k(t)v(t)k(t) - (1 + \tau_2)w_k(t)u(t)l(t),$$

$$q(t)x_h(t) - r_h(t)(1 - v(t))k(t) - w_h(t)(1 - u(t))l(t).$$

Let x_k denote per person physical capital investment, δ_k the depreciation rate of physical capital. Then the law of motion for physical capital is,

$$(1 + n)k(t + 1) = (1 - \delta_k)k(t) + x_k(t), \quad (3)$$

With a depreciation rate for human capital δ_h , the law of motion for human capital can be similarly defined,⁷

$$(1 + n)h(t + 1) = (1 - \delta_h)h(t) + x_h(t). \quad (4)$$

⁴When there is no risk of confusion, I drop time arguments, but whenever there is the slightest risk of confusion, I will err on the side of caution and include relevant arguments.

⁵Capital shares need be sector-specific both conceptually and empirically. However, the lack of reliable data for certain components of human capital makes calibrating the human capital production function considerably more difficult.

⁶These production technologies are labor-augmented $Y = AK^\alpha(hL)^{1-\alpha}$, where uppercase variables denote total amounts. The reason why I choose the labor-augmented technology is that any technology consistent with balanced growth can be represented by this form.

⁷If the labor-augmented human capital includes a general technology level that can be “publicly” used, population growth would not dilute the human capital stock per person. Then the law of motion would be $h(t + 1) = (1 - \delta_h)h(t) + x_h(t)$. Both forms follow Ben-Porath (1967). A different approach is a log-linear law of motion. Chang et al. (2002) use the log-linear approach to analyze learning by doing, Hansen and Imrohoroglu (2009) extend it to study on-the-job training. Both approaches are approximately isomorphic to each other around steady state.

There is a representative household in the model. The physical capital and human capital investment made and the total labor income earned by the household are taxed with after-tax rates $(1 + \tau_{xk})(1 - \tau_1)$, $(1 + \tau_{xh})(1 - \tau_l)$ and $(1 - \tau_l)$ respectively. The household also receives a lump-sum transfer, whose per person value, T , equals all tax revenues minus the government consumption g . Assume that $\tau_{xk}\tau_1 = \tau_{xh}\tau_l = 0$. Then

$$T = \tau_1 r_k k_k + \tau_2 w_k l_k + (\tau_{xk} - \tau_1)x_k + (\tau_{xh} - \tau_l)qx_h + \tau_l[w_k ul + w_h(1 - u)l] - g.$$

The household has $N(t)$ members, which grows at a rate of n . It maximizes a discounted utility over flows of consumption $c(t)$ and leisure $1 - l(t)$. Let $\beta \in (0, 1)$ be its discount factor, and $\theta \in (0, 1)$ be the consumption share in the period utility function. The household's problem is,

$$\max_{t=0}^{\infty} \beta^t [\theta \ln c(t) + (1 - \theta) \ln(1 - l(t))] N(t),$$

subject to (a) a budget constraint,

$$\begin{aligned} c(t) + (1 + \tau_{xk})(1 - \tau_1)x_k(t) + (1 + \tau_{xh})(1 - \tau_l)q(t)x_h(t) &= r_k(t)v(t)k(t) \\ &+ r_h(t)(1 - v(t))k(t) + (1 - \tau_l)[w_k(t)u(t)l(t) + w_h(t)(1 - u(t))l(t)] + T(t), \end{aligned}$$

(b) factor prices derived from profit maximization problems,

$$(1 + \tau_1)r_k(t) = \alpha y(t)/[v(t)k(t)],$$

$$(1 + \tau_2)w_k(t) = (1 - \alpha)y(t)/[u(t)l(t)],$$

$$r_h(t) = q(t)\alpha x_h(t)/[(1 - v(t))k(t)],$$

$$w_h(t) = q(t)(1 - \alpha)x_h(t)/[(1 - u(t))l(t)],$$

(c) the law of motion for physical capital and human capital, and $x_k(t), x_h(t) \geq 0$.

The competitive equilibrium of the prototype economy is a set of prices and allocations such that they are solutions to firms' and consumers' problems, and

satisfy the resources balance,

$$c(t) + x_k(t) + g(t) = y(t). \quad (5)$$

The return to human capital investment is a higher labor income. Notice that the wage rate perceived by the household is $w = \frac{q(1-u)x_h}{(1-u)hl}h$, which equals the human capital stock multiplied by a term that the household takes as given in equilibrium. Then the equilibrium conditions can be derived as follows,

$$(1 - \tau_l) \frac{\theta}{c(t)} \frac{(1 - \alpha)q(t)x_h(t)}{(1 - u(t))l(t)} = \frac{1 - \theta}{1 - l(t)} \quad (6)$$

$$(1 + \tau_1)q(t)x_h(t)v(t) = y(t)[1 - v(t)], \quad (7)$$

$$(1 + \tau_2)q(t)x_h(t)u(t) = y(t)[1 - u(t)], \quad (8)$$

$$\frac{c(t+1)}{c(t)}(1 + \tau_{xk}) = \beta \left[\frac{\alpha y(t+1)}{v(t+1)k(t+1)} + (1 - \delta_k)(1 + \tau_{xk}) \right] \quad (9)$$

$$\frac{c(t+1)}{c(t)}(1 + \tau_{xh}) = \beta \frac{q(t+1)}{q(t)} \left[\frac{(1 - \alpha)x_h(t+1)}{(1 - u(t+1))h(t+1)} + (1 - \delta_h)(1 + \tau_{xh}) \right], \quad (10)$$

together with production functions, laws of motion, and the resources balance. Given the transversality condition, $\lim_{t \rightarrow \infty} \left(\frac{1+\tau}{1+\tau} \right)^t c(0) = 0$, and the initial stocks, $k(0)$, $h(0)$, these equations characterize competitive equilibrium paths of the prototype economy.⁸

⁸Solving the following Bellman equation yields equilibrium conditions,

$$V(k, h) = \max \{ U(c, l) + \beta(1 + n)V(k^0, h^0) \}$$

where $c = r_k vk + r_h(1 - v)k + (1 - \tau_l)[w_k ul + w_h(1 - u)l] + T - (1 + \tau_{xk})(1 - \tau_l)[(1 + n)k^0 - (1 - \delta_k)k] - (1 + \tau_{xh})(1 - \tau_l)q[(1 + n)h^0 - (1 - \delta_h)h]$. Notice that equations (6), (7) and (8) are from first order conditions with respect to l , v and u ,

$$U_c(1 - \tau_l)(w_k u + w_h(1 - u)) + U_l = 0$$

$$r_k k - r_h k = 0$$

$$(1 - \tau_l)(w_k l - w_h l) = 0.$$

Using canonical dynamic programming, we obtain,

$$c^0(1 + \tau_{xk})(1 - \tau_1) = c\beta[r_k^0 + (1 - \delta_k)(1 + \tau_{xk})(1 - \tau_1)]$$

$$c^0(1 + \tau_{xh})(1 - \tau_l)q = c\beta[(1 - \tau_l)\left(\frac{\partial w^0}{\partial h^0}\right)l^0 + q^0(1 - \delta_h)(1 + \tau_{xh})(1 - \tau_l)].$$

The prototype economy also has a steady-state equilibrium, whose local properties are now well understood: a unique steady-state equilibrium exists, and it is saddle-path stable (e.g., Mulligan and Sala-i Martin (1993)). In the steady-state equilibrium, the growth rate of every variable is constant.⁹ More specifically, v , u , l , and q are constants, and all other endogenous variables grow at the same rate, γ . As a result, solutions to the steady-state equilibrium are only ratios or rates. There are ten equations that can be used to solve for the ten endogenous variables, v , u , l , q , γ , h/k , y/k , c/k , x_k/k , and x_h/h .

In later sections, I only use the steady-state equilibrium conditions to derive country-specific wedges. For clarity, the steady-state equilibrium conditions are collected in one place as follows,

$$(1 - \tau_l) \frac{1 - l}{l} \frac{(1 - \alpha)qx_h}{(1 - u)h} \frac{h}{k} = \frac{1 - \theta}{\theta} \frac{c}{k}, \quad (11)$$

$$(1 + \tau_1)v \frac{qx_h}{h} \frac{h}{k} = (1 - v) \frac{y}{k}, \quad (12)$$

$$(1 + \tau_2)u \frac{qx_h}{h} \frac{h}{k} = (1 - u) \frac{y}{k}, \quad (13)$$

$$(1 + \gamma)(1 + \tau_{xk}) = \beta \left[\frac{\alpha y}{vk} + (1 - \delta_k)(1 + \tau_{xk}) \right], \quad (14)$$

$$(1 + \gamma)(1 + \tau_{xh}) = \beta \left[\frac{(1 - \alpha)x_h}{(1 - u)h} + (1 - \delta_h)(1 + \tau_{xh}) \right], \quad (15)$$

$$\frac{y}{k} = Av \left(ul \frac{h}{k} \right)^1, \quad (16)$$

$$\frac{x_h}{h} \frac{h}{k} = B(1 - v) \left((1 - u)l \frac{h}{k} \right)^1, \quad (17)$$

$$\frac{x_h}{h} = \gamma + n + \delta_h, \quad (18)$$

Notice that $r_k = \frac{\alpha y}{(1 + \tau_1)vk}$. And the Maclaurin approximation suggests that $(1 + \tau_1)^{-1} \approx 1 - \tau_1$. Then we have the Euler equations (9) and (10).

⁹To avoid repetition, let γ_a be the growth rate of an arbitrary variable a in steady state. Equations (7) and (8) imply that $\gamma_u = \gamma_v = 0$, equation (6) implies $\gamma_l = 0$, equation (8) implies $\gamma_y = \gamma_{xh} + \gamma_q$, equation (5) implies $\gamma_c = \gamma_{xk} = \gamma_g = \gamma_y$, the law of motion for h implies $\gamma_{xh} = \gamma_h$, the law of motion for k implies $\gamma_{xk} = \gamma_k$, production function (1) implies $\gamma_y = \alpha\gamma_k + (1 - \alpha)\gamma_h$, production function (2) implies $\gamma_{xh} = \alpha\gamma_k + (1 - \alpha)\gamma_h$. Combining all of these results implies that v , u , l , q are constant, and all the other variables grow at the same rate.

$$\frac{x_k}{k} = \gamma + n + \delta_k, \quad (19)$$

$$\frac{c}{k} + \frac{x_k}{k} + \frac{g}{k} = \frac{y}{k}. \quad (20)$$

I call τ_l the labor wedge, τ_1 the capital input wedge, τ_2 the labor input wedge, τ_{xk} the capital investment wedge, τ_{xh} the human capital investment wedge, A the final goods efficiency wedge, B the human capital efficiency wedge, and g/k the government consumption wedge.

2.1. The mapping between a one-sector optimal growth model and the prototype economy

Chari et al. (2007) first define a prototype economy and the associated wedges to address important business cycle questions. The prototype economy that they use is a one-sector stochastic growth model, which has four wedges: the efficiency wedge $A(t)$, the labor wedge $1 - \tau_l(t)$, the investment wedge $1/[1 + \tau_x(t)]$, and the government consumption wedge $g(t)$. Here I compare its deterministic version with the model that I use.

In the model, consumers maximize their utility over per capita consumption $c(t)$ and per capita labor $l(t)$,

$$\max_{t=0}^{\infty} \beta^t [\theta \ln c(t) + (1 - \theta) \ln(1 - l(t))] N(t),$$

subject to the budget constraint

$$c(t) + [1 + \tau_x(t)]x(t) = [1 - \tau_l(t)]w(t)l(t) + r(t)k(t) + T(t)$$

and the capital accumulation law

$$(1 + n)k(t + 1) = (1 - \delta)k(t) + x(t)$$

where $k(t)$ denotes per capita capital stock, $x(t)$ per capita investment, $w(t)$ the wage rate, $r(t)$ the rental rate on capital, β the discount factor, δ the depreciation rate of capital, $N(t)$ the population with growth rate equal to $1 + n$, and $T(t)$ per

capita lump-sum transfers.

The production function is $y = Ak((1 + \gamma)^t l)^{1-\theta}$, where y is per capita output, the labor-augmenting technology progress $(1 + \gamma)$ is assumed to be constant. Firms maximize profits given by $Ak((1 + \gamma)^t l)^{1-\theta} - rk - wl$.

The equilibrium of this model is summarized by the following,

$$c(t) + x(t) + g(t) = y(t),$$

$$\frac{1-\theta}{\theta} \frac{c(t)}{1-l(t)} = [1-\tau_l(t)](1-\alpha) \frac{y(t)}{l(t)},$$

$$\frac{c(t+1)}{c(t)} [1 + \tau_x(t)] = \beta [\alpha \frac{y(t+1)}{k(t+1)} + (1-\delta)[1 + \tau_x(t)]],$$

and the production function.

Notice that in the one-sector model, the labor-augmenting technology $1 + \gamma$ is exogenous and not correlated with the four wedges; while in the two-sector model, it is the long-run growth rate, and endogenously determined by exogenous wedges. Thus the underlying causes of growth can be analyzed in a two-sector model, though growth is typically assumed to be constant in business cycle theories.

Suppose that the total consumption in Chari et al. (2007) contains both the final goods consumption and the human capital investment in terms of final goods. Then the consumption in Chari et al. (2007) equals

$$c^{CKM} = c + qx_h,$$

and the output in Chari et al. (2007) equals

$$y^{CKM} = y + qx_h.$$

Substituting the above two equations into the equilibrium conditions of the one-sector model, and comparing them with the equilibrium conditions of the two-sector model in steady state yields the mapping between these two prototype economies. Table 1 summarizes this relationship.

Through this simple illustration, we can see the correspondence between the

Wedges and Growth		Variables	
One-sector	Two-sector	One-sector	Two-sector
A^{CKM}	$[Av - u^1 + qB(1 - v) - (1 - u)^1]$	y^{CKM}	$y + qx_h$
$1 - \tau_l^{CKM}$	$\frac{1 - l - c + qx_h}{1 + u - \frac{c}{c}}$	c^{CKM}	$c + qx_h$
$1 + \tau_x^{CKM}$	$\frac{(1 + v - 1)(1 + x_k)}{1 + 1}$	x^{CKM}	x
g^{CKM}	g	k^{CKM}	k
$(1 + \gamma^{CKM})^t$	h	l^{CKM}	l

Table 1: Equivalence Result for Chari, Kehoe, and McGrattan (2007)

wedges in Chari et al. (2007) and the wedges embedded in Rebelo (1991). The efficiency wedge largely contains efficiency shifters, the labor wedge is largely two labor related wedges, the investment wedge is quite close to the physical capital investment wedge, and the government consumption wedges in these two prototype economies are identical. In the one-sector growth model, wedges are not correlated with the growth γ , while in the two-sector model, wedges determine the growth. The relative importance of each wedge in explaining growth is the question addressed by the following sectors.

3. Method and Data

The accounting method consists of computing wedge values and evaluating the fit of individual wedges. Envisage a world consisting of $j = 1, \dots, J$ countries. For any country j , the economy experiences one event s_j , which indexes the state for that country. This state determines country j 's economic performance. Assume that endogenous variables in the prototype economy include aggregate variables that characterize a country's economic performance, and that the wedges and population growth in the prototype economy uniquely uncover the event s_j . Substituting the country-specific values of endogenous variables into the steady state equilibrium conditions of the prototype economy gives the

wedge values across countries.

Notice that despite resembling tax rates, efficiency levels or government consumption in the prototype economy, wedges are clearly not formal tax rates, measures of technological efficiency, or observed government consumption. Rather wedges are the results of policies and institutions that make economic activities more costly or reduce their associated returns. In particular, every wedge in the prototype economy is a measure of overall frictions in the particular market with which it is associated.

To evaluate the importance of wedges in explaining growth, I change each wedge in the favorable direction by 0.1% of its observed values while keeping the rest wedges fixed; and decompose the marginal change of growth and efficiency into the effects of individual wedges.

For example, country j 's long-run growth rate γ_j , a differentiable function of all wedges, can be decomposed as follows,

$$\begin{aligned}\hat{\gamma}_j - \gamma_j &\approx \frac{\partial \gamma}{\partial A}(\hat{A}_j - A_j) + \frac{\partial \gamma}{\partial B}(\hat{B}_j - B_j) \\ &\quad + \frac{\partial \gamma}{\partial \tau_l}(\hat{\tau}_{lj} - \tau_{lj}) + \frac{\partial \gamma}{\partial \tau_1}(\hat{\tau}_{1j} - \tau_{1j}) + \frac{\partial \gamma}{\partial \tau_2}(\hat{\tau}_{2j} - \tau_{2j}) \\ &\quad + \frac{\partial \gamma}{\partial \tau_{xk}}(\hat{\tau}_{xkj} - \tau_{xkj}) + \frac{\partial \gamma}{\partial \tau_{xh}}(\hat{\tau}_{xhj} - \tau_{xhj}) + \frac{\partial \gamma}{\partial (g/k)}[(\frac{\hat{g}}{k})_j - (\frac{g}{k})_j].\end{aligned}$$

Here each variable with a hat is the computed value of growth rate when all wedges are slightly different from their observed values; γ_j is the growth rate observed from the data; and $\frac{\partial}{\partial x}(\hat{x} - x)$ is the difference between the observed value and the computed value of the growth rate when only one wedge x is slightly different from its observed value, but all other wedges are kept at their observed values. It imitates the marginal effect of wedge x on growth rate γ . Thus the left-hand side of this expression is the comprehensive marginal effect on growth rate γ ; the right-hand side is the sum of individual marginal effects. Dividing the marginal effect of a wedge by the comprehensive effect displays how important this wedge is in explaining the observed value of γ .

As shown in table 1, efficiency consists of endogenous variables and wedges,

$$\text{Efficiency} = \frac{y + qx_h}{k(hl)^1} = Av u^1 + qB(1-v)(1-u)^1.$$

It depends on the resource allocation (v and u), the relative price of human capital (q), and two efficiency wedges (A and B). Wedges A and B can affect it both directly and indirectly, while the effects of other wedges are only indirect through v , u , and q . Similarly, the the marginal change of efficiency can also be decomposed

human capital stock is available.¹⁰ Notice that the wage rate, by definition, is equal to $(1 - \alpha)\text{GDP}/l$. Thus,

$$\ln w(t) = \ln(1 - \alpha)\text{TFP} + \alpha \ln \frac{k}{hl} + \ln h(s) + \gamma(t - s) + \phi(\text{sch}(t))$$

The average wage rate depends on a constant term, a trend term, and schooling years. Labor economists estimate the following Mincerian regression (see Mincer (1974)), which is informative to construct $\phi(\cdot)$,

$$\ln w = \text{constant} + \phi \cdot \text{sch}.$$

Hall and Jones (1999) assume that $\phi(\cdot)$ is a continuous, piecewise linear function constructed to match the rates of return on education reported in Psacharopoulos (1993). For schooling years between 0 and 4, the return to schooling $\phi'(\cdot)$ is assumed to be 13.4 percent which is an average for sub-Saharan Africa. For schooling years between 4 and 8, the return to schooling is assumed to be 10.1 percent, which is the world average. With 8 or more years, the return is assumed to be 6.8 percent, which is the average for the OECD countries.¹¹ Then they construct human capital stocks using $h_{HJj} = e^{(\phi' \cdot \text{sch}_j)}$. I use the Hall and Jones (1999) specification

Total GDP includes two parts: final goods output and the human capital investment in terms of final goods. The latter is the value added only in the education sector (ISIC:M),¹² and corresponds to qx_h in the prototype economy. The rest is the final goods output y in the prototype. The partition between final goods and human capital investment may be arbitrary. However, they are consistent with the concepts used in the prototype economy.¹³

When the human capital investment qx_h is known, with the law of motion of human capital in steady state, I construct the human capital stock in terms of final goods as,

$$(qh)_j = \frac{(qx_h)_j}{\gamma_j + n_j + \delta_h}.$$

Dividing this value by $e^{(s-t)}e^{(sch(t))}$, we have

$$\frac{(qh)(t)_j}{e^{j(t-s)}e^{(sch_j(t))}} = \frac{q_j h_j(s) e^{j(t-s)} \cdot e^{(sch_j(t))}}{e^{j(t-s)}e^{(sch_j(t))}} = q_j h_j(s)$$

Notice that the human capital is broadly defined and equal to the labor augmented technology in the literature. Parente and Prescott (2006) argue that “most of the stock of productive knowledge is public information, and even proprietary information can be accessed by a country through licensing agreements or foreign direct investment”.

This statement is, in particular, true by the end of the 20th century. Technological innovations have improved the speed of transportation and communications and lowered their costs. These included jet airplanes and their universal use in transporting people and goods, the containers used in international shipping, the improved road infrastructure that enabled a large share of trade to be carried by

¹²Kendrick (1976) discussed a broad class of capital stocks, including tangible and intangible, human and non-human capital. He categorized physical capital as “tangible non-human capital”, child rearing costs as investments in “tangible human capital”, research and development (R&D) expenditures as investments in “intangible non-human capital”, and outlays of education, training, health, safety, and mobility as investments in “intangible human capital”. Ideally human capital should contain all tangible and intangible human capital.

¹³One concern about the definition of human capital investment is that GDP do not include the value of students’ time, an important component of education investment. This slippage between model and data affects estimates for x_h and h . However, it will not change x_h/h in steady-state. Kendrick (1976) found about half of schooling investment consists of education expenditures which are included in GDP.

freight trucks in Western Europe and North America, and importantly, the personal computer, the cellular phone, the internet, and the World Wide Web that have contributed to profound socio-political and economic transformations.

In addition, changes in production methods, the political developments in 1990s, economic policies towards deregulation, multilateral efforts to liberalize international trade, and to stabilize macroeconomic environment have helped all countries in the world access the most advanced available knowledge. So around 2000, the accessible broadly defined human capital is roughly constant across countries.

I assume that $h_j(2000)$ is constant across countries and rescale the relative price of the broadly defined human capital across countries by assuming that relative price is one in the US. So for any country j ,

$$q_j = \frac{q_j h_j(2000)}{q_{US} h_{US}(2000)}$$

Consequently, the human capital stock for country j is

$$h_j(t) = (qh)_{US}(t) \cdot e^{(j - US)(t - 2000)} e^{(sch_j(t) - (sch_{US}(t)))}$$

3.2. Data and calibration

Data sources used in this analysis include the Groningen Growth and Development Center (GGDC), the United Nations Statistics Division (UNSD), the International Labor Organization (ILO), the World Bank, the Penn World Table 6.3 and the Barro and Lee (2001) educational attainment dataset.¹⁴

Some variables are directly observable from data sources, such as the average growth rate for per capita GDP and population, employment-population ratio, the share of workers in the education sector, physical capital investment-GDP ratio, consumption-GDP ratio, and schooling years. Other variables are de-

¹⁴The sample includes Argentina, Australia, Austria, Belgium, Bangladesh, Bulgaria, Bahrain, Brazil, Canada, Switzerland, Chile, China, Costa Rica, Germany, Denmark, Dominican Republic, Ecuador, Egypt, Spain, Ethiopia, Finland, France, United Kingdom, Greece, Guatemala, Hungary, Ireland, Iran, Iraq, Israel, Italy, Japan, Republic of Korea, Mexico, Malaysia, the Netherlands, Norway, New Zealand, Peru, the Philippines, Poland, Portugal, Romania, Sweden, Thailand, Turkey, Uganda, Uruguay, United States, and Vietnam.

capital share	α	0.3333
depreciation rate of physical capital	δ_k	0.0665
depreciation rate of human capital	δ_h	0.0518
consumption share	θ	0.3908
discount factor	β	0.9457

Table 2: Calibrated Values of Parameters

rived from these observable variables under certain assumptions. Appendix A presents the data sources and data construction in detail.

Since no much information of capital used in education across countries is available, I assume that the share of education expenditure in GDP is equal to the share of capital used in the education. Notice that this assumption is equivalent to that the capital input wedge τ_1 is always equal to zero in the prototype economy (see equation (7)).

There are five parameters in the prototype economy: the capital share, α , the depreciation rates, δ_k and δ_h , the discount factor, β , and the consumption share, θ . Each is assumed to be constant across countries. Online appendix presents the data used in calibration. Table 2 reports their calibrated values. One concern is the heterogeneity of parameters across countries. Gollin (2002) convincingly show that the capital share α is a number between 0.20 to 0.35 for most countries. Appendix B checks the robustness of the findings by changing parameter values in reasonable ranges for the full sample.

Following the literature, I assume that the capital share is 0.3333. For other parameters, I use the national accounts data for the US to calibrate them, by assuming that wedges are zero in the US economy during the 1960-2000 period.

The depreciation rate δ_k is estimated from the perpetual inventory method (see, for example, Kehoe and Prescott (2007), for a detailed description),

$$K(t+1) = I(t) + (1 - \delta)K(t),$$

together with a few restrictions on the initial capital stock and the depreciation

rate. The value of δ_k is chosen to be consistent with the average ratio of depreciation to GDP observed in the data from 1980 to 2004. The initial stock of capital is chosen so that the initial capital-output ratio in 1959 should match the average capital-output ratio over the 1960-1970 period. Using this rule gives the estimate for the depreciation rate δ_k .

The depreciation rate of human capital δ_h comes from the same procedure, except its value is chosen to be consistent with $\frac{x_h}{h} = \gamma + n + \delta_h$. By comparison, Kendrick (1976)'s estimates imply the depreciation rates of capital, $\delta_k = 0.0616$, of education, $\delta_e = 0.0343$, of health care, $\delta_{hc} = 0.0718$ and of R&D, $\delta_{RD} = 0.0876$.

For the remaining two parameters, standard calibration formulae are available (e.g., an online note for Kehoe and Prescott (2007)). The discount factor β stems from the following equation,

$$1 + \text{average growth rate} = \beta \left[\frac{\alpha \times \text{output-capital ratio}}{1 - \text{share of education in GDP}} + 1 - \delta_k \right].$$

The consumption share θ is from,

$$\theta = \frac{\text{share of consumption in GDP} \times \text{empl. rate}}{\text{share of consumption in GDP} \times \text{empl. rate} + (1 - \alpha) \times (1 - \text{empl. rate})}.$$

4. Decomposition Results

A large number of papers study the cross-country economic performance using either growth accounting or level accounting that connects economic performance to inputs and the efficiency with which inputs are used.¹⁵ Despite the large volume of work, results from many studies on a given issue frequently reach opposite conclusions. Moreover, a serious criticism by Acemoglu (2007) says that “at some level to say that a country is poor because it lacks physical capital, human capital and technology is like saying that a person is poor because he does not have money”. To satisfactorily understand economic growth requires, not only the contribution of inputs and efficiency to the cross-country income variance, but also an analysis of the reasons making some countries more abundant

¹⁵Bosworth et al. (2003) is a comprehensive study on growth empirics, including growth accounting. Caselli (2005) is a state-of-the-art study using level accounting.

Sub-sample	Total	OECD	non-OECD	above median	below median
Obs	50	26	24	25	25
τ_l	15.65%	14.20%	17.22%	12.91%	18.38%
τ_2	16.52%	16.37%	16.68%	15.06%	17.98%
τ_{xk}	5.98%	6.44%	5.48%	6.81%	5.15%
τ_{xh}	21.93%	22.27%	21.56%	23.33%	20.52%
A	11.91%	12.22%	11.59%	12.66%	11.17%
B	23.83%	24.44%	23.17%	25.32%	22.35%
g/k	4.18%	4.06%	4.31%	3.92%	4.44%

Table 3: Average Importance of Wedges on Growth Rate

in physical capital, human capital, and technology than others. In this section, I decompose the long-run growth rate and efficiency into effects of individual wedges, which can be linked to fundamental causes of economic growth.

Some interesting findings of the artificial experiments are: (1) when explaining the long-run growth rate, the human capital efficiency and human capital investment wedges play primary roles, while the labor and labor input wedges play secondary roles; (2) in explaining the efficiency, the effect of the final goods efficiency wedge is dominant; and (3) these patterns are robust across the OECD / non-OECD sub-samples.

Tables 3 and 4 summarize the average importance of each wedge in explaining the long-run growth rate and efficiency for the full sample and across different sub-samples. Note that the median in table 3 refers to the median growth rate of the total sample, while the median in table 4 is the median efficiency. Clearly the effects of wedges on the long-run growth rate scatter more evenly than those on efficiency across wedges. The human capital efficiency wedge and the human capital investment wedge explain 23.83% and 21.93% of the long-run growth rate on average. However, the final goods efficiency wedge alone accounts for 88.86% of efficiency.

Sub-sample	Total	OECD	non-OECD	above median	below median
Obs	50	26	24	25	25
τ_l	0.62%	0.76%	0.49%	0.74%	0.52%
τ_2	6.29%	6.12%	6.47%	5.72%	6.85%
τ_{xk}	0.22%	0.31%	0.13%	0.22%	0.22%
τ_{xh}	3.07%	3.44%	2.66%	3.35%	2.78%
A	88.86%	88.10%	89.68%	88.80%	88.92%
B	0.79%	1.08%	0.48%	0.98%	0.60%
g/k	0.14%	0.19%	0.09%	0.18%	0.11%

Table 4: Average Importance of Wedges on Efficiency

The above result does not contradict previous studies that TFP growth is as important as capital accumulation in explaining growth across countries. In an optimal growth model, the sole driving force of growth is the labor-augmented technology progress, which is not related to cross-country efficiency differences. The TFP growth in a growth accounting exercise includes both stable technology progress and the efficiency's movements. For a large number of countries, the TFP growth is largely the stable technology progress, and drives the accumulation of capital too. This is also consistent with the observation that initial income levels are not systematically correlated with growth performance thereafter, though income levels are largely determined by TFP levels.

Another interesting observation is that the labor and labor input wedges also play a role in accounting for long-run growth rate. So far, there have been many endogenous growth theories addressing the role of education or R&D, which actually exploit the human capital investment wedge. The role of the labor and labor input wedge, and their associated labor market policy implications, on growth are not fully explored and worthy of more attention.¹⁶

¹⁶By comparing France and the United States, Prescott (2002) gives an example showing that the labor wedge is responsible for the gap in terms of relative income level between these two countries.

Normalized values	τ_l	τ_2	τ_{xk}	τ_{xh}	A	B	g/k
Total	1	1	1	1	1	1	1
OECD	1.07	1.21	-0.53	0.69	1.15	0.50	0.63
Non-OECD	0.95	0.79	2.67	1.33	0.85	1.54	1.38
Fast	0.79	0.79	0.20	0.91	0.90	0.93	0.75
Slow	1.24	1.24	1.80	1.09	1.12	1.56	1.25

Table 5: Wedges' Values

The aforementioned patterns for the full sample do not change much across sub-samples of countries in and out of the OECD; below and above the median values of respective endogenous variables. This may be due to that most countries in the sample are rich or middle-income countries, whereas extremely poor countries may have different patterns. Another possibility is that these patterns depend more on the NCG structure than the magnitude of the country-specific wedges.

Table 5 presents the values of individual wedges for the total sample and sub-samples, and sheds some light on the above robustness. These values are normalized relative to the sample average. Although wedges differ across sub-samples, they have the same magnitude. Differences of τ_{xk} , τ_{xh} , and B between OECD and non-OECD countries are larger than those between fast and slow growers. But, except for τ_{xk} , all cross-sample normalized values are not far away from one.

What can be learned from these results? First, even if the human capital sector is small in the economy, a biased allocation of the broadly defined human capital over time would change the long run growth very much. Second, frictions that distort the final goods efficiency wedge are less important in changing the long-run growth than those affecting the human capital efficiency wedge. Third, compared with the other wedges, the two efficiency wedges can hardly be microfounded. These wedges seem to reflect everything except for the mechanism suggested by a detailed model. If this is true, then, even after decomposing the efficiency into the effects of seven wedges, it is still mostly a black box, because

the final goods efficiency wedge alone takes up nearly 90% of it. As Prescott (1998) points out, a theory of TFP differences is still needed.

5. Conclusion

This paper presents a method to account for long-run economic growth across countries. It also sheds light on underlying mechanisms of economic growth. The main findings suggest that endogenous growth theories that are equivalent to the prototype economy with a human capital investment wedge and/or a labor wedge are more consistent with the observed patterns of developing countries.

As Klenow and Rodriguez-Clare (1997a) said, more work should be done to empirically distinguish between theories of endogenous growth; to accomplish this, a quantitative approach avoids misspecification in empirical work and fully exploits the quantitative implications of candidate models. Banerjee and Duflo (2005), moreover, show that even a series of convincing micro-empirical studies is not enough to give an overall explanation for aggregate growth, and that a promising alternative is to build macroeconomic models.

Numerous studies show that the neoclassical growth model with wedges is a useful workhorse in accounting for various macroeconomic events (Cole and Ohanian (2004), McGrattan and Ohanian (2006) and Chen et al. (2007)). These findings suggest that the “Business Cycle Accounting” idea, together with neoclassical models, is a good way to organize the increasingly available data on various dimensions and aspects of economic growth.

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Endogenous Variable	Raw Data Used	Data Source
long-run growth rate	per capital GDP series	Maddison-GGDC
employment-pop ratio	employment, population	TED-GGDC
capital allocation	value added by industry,	UNSD
	public spending on education	WDI
labor allocation	employment by industry	ILO
investment-capital ratios	population growth	TED-GGDC
output-capital ratio	investment share in GDP	PWT 6.3
consumption-capital ratio	consumption share in GDP	PWT 6.3
relative price	education expenditure	UNSD
capital-human capital ratio	educational attainments	Barro-Lee 2001

Table 6: Data Sources for Endogenous Variables

A Appendix: variables in the cross-country dataset

This appendix explains how to create relevant variables for the cross-country dataset used in the paper.

The long-run growth rates come from the per capita GDP estimates by Maddison (2003). I compute the annual growth rates for each country year by year from 1951 to 2008, and assume the long-run growth rate equals the average of those annual growth rates. Fifty-eight years are long enough for a country to converge. The long-run population growth rates are from the midyear population estimates of the Total Economy Database. Similarly, I compute the annual growth rates from 1951 to 2008 and take the average. The Total Economy Database also has estimates for employment in the same period. I divide employment by midyear population and take their average as the average employment-population ratios.

As for the shares of employment in the education sector, I divide employment in education by total employment obtained from the ILO, and then take the average. The length of these employment series varies across countries, yet the

longest one comes from 1985 to 2008. To compute the shares of education output, I use value added of education and value added of the total economy in constant prices obtained from the National Accounts Official Country Data (Table 2.2) by the United Nations Statistics Division, and the public spending on education as a percentage of GDP is obtained from the World Development Indicators (WDI). I divide value added of education by value added of the total economy, take the average of them, and add it to the average percentage of public spending on education. The longest value added series comes from 1966 to 2008, and the longest public spending share series is from 1970 to 2008.

To construct investment-capital ratios for physical capital, I use the approach in Caselli (2005) $\frac{x_k}{k} = n + \gamma + \delta_k$, together with estimates of growth rates and population growth rates, and calibrated values of depreciation rates. Similarly, $\frac{x_h}{h} = n + \gamma + \delta_h$ can be constructed.

The final F.5/F53 7.9701 Tf 5.185 -1.793 Td [(h)]TJ/F4229an DitpuTf 12.643 0 Td [()]TJ/F53 7.9

mula,

$$\frac{k}{h} = \frac{x_k}{(1-v)GDP} \frac{x_h}{h} \frac{k}{x_k} \cdot q$$

B Appendix: robustness checks

This section is about the robustness of the findings reported in the text. I change the value of each parameter, holding the remaining parameters fixed to their calibrated values, and see whether the pseudo goodness-of-fit of various wedges changes very much.

B1. Capital share

The capital share in the US has been rather stable. When it comes to cross-country comparisons, a traditional measure of the capital income is the residual after employee compensation has been taken out from national income. These estimates are generally higher in poor countries than in rich countries. After adjusting the labor income in self-employed and small firms, and some other differences, Gollin (2002

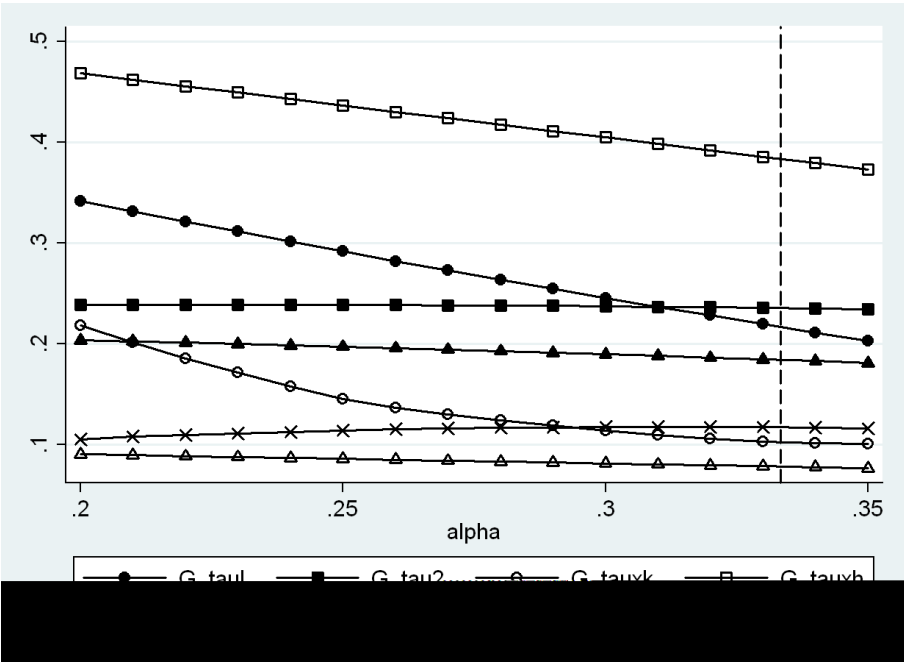


Figure 1: Robustness check with α on growth

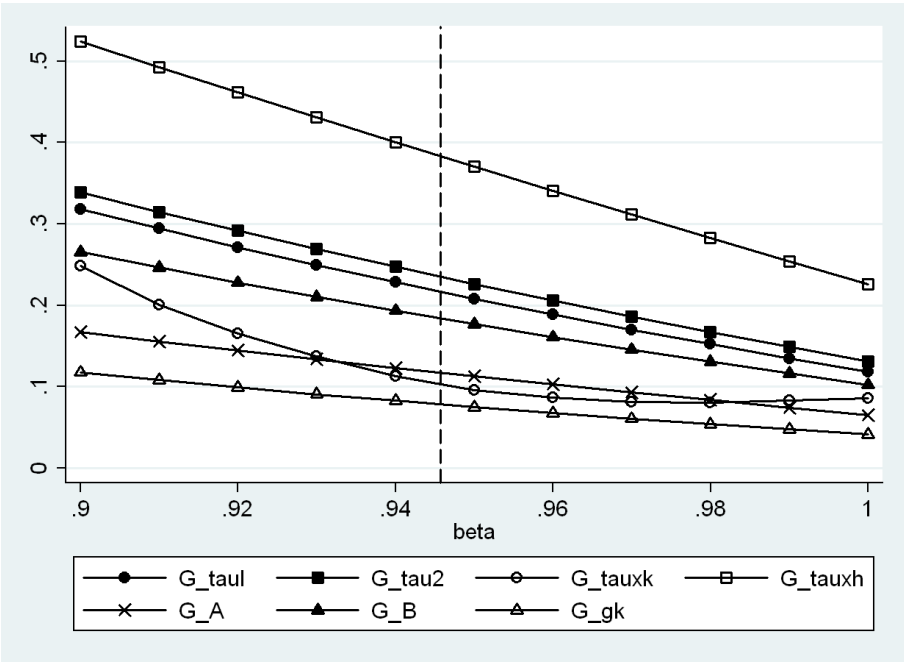


Figure 2: Robustness check with β on growth

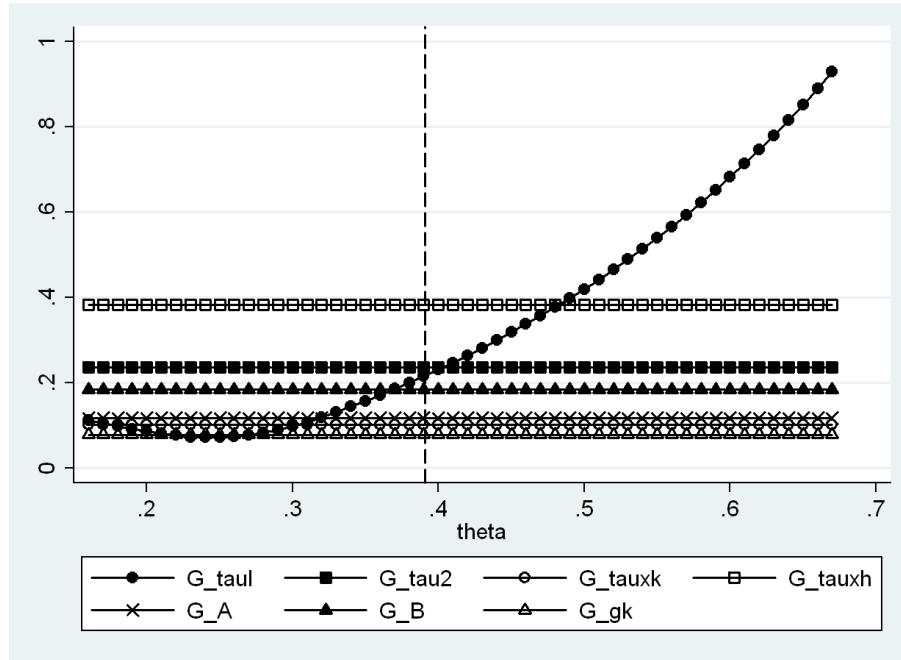


Figure 3: Robustness check with θ on growth

bound could be 0.67, and the lower bound could be 0.16. Figure 3 plots the contributions of various wedges in explaining growth in this range. Since θ only affects the labor wedge τ_l , except for the labor wedge, the contributions of all other wedges does not change. The labor wedge, however, is quite sensitive to changes in θ . When θ is around 0.23, the labor wedge reaches its bottom, and could be the least important factor in accounting for growth. But its explanatory power increases sharply, and it becomes the most important factor when θ is equal or higher than 0.47. The high sensitivity of τ_l around the benchmark value of θ implies that our results about the labor wedge may change non-trivially with more precise measures of the consumption share.

C Do previous studies contradict this analysis?

Previous quantitative studies on cross-country income variance find that efficiency is at least as important as inputs in explaining both growth and relative income differences. Does the data I collect or the alternative accounting method I

Hall and Jones (1999)	Income	Capital	Education	Residual	
Average (45)	0.481	0.957	0.695	0.678	
Standard Deviation	0.283	0.194	0.165	0.278	
Correlation w/ Y/L (logs)	1.000	0.658	0.700	0.812	
Correlation w/ A (logs)	0.812	0.156	0.225	1.000	
This Work	Income	Capital	Human Capital	Labor	Residual
Average (45)	0.437	1.001	0.665	0.895	0.683
Standard Deviation	0.284	0.205	0.179	0.179	0.262
Correlation w/ Y/L (logs)	1.000	0.788	0.771	0.394	0.785
Correlation w/ A (logs)	0.785	0.433	0.388	-0.162	1.000

Table 8: Level Accounting Comparison

into three multiplicative terms: capital intensity K/Y , education stock $e^{(sch)}$, and productivity, a residual term. All terms are expressed as ratios to US values. Forty-five countries in their sample overlap the sample I collect. As Hall and Jones (1999) do, table 8 reports each term's comparable averages, standard deviations, and correlations with other terms for the overlapped forty-five countries, from their work and this analysis. Bear in mind that the human capital in my level accounting includes a growth trend imposed by the steady state equilibrium, plus the education stock which is the same as the "human capital" in the baseline study. As a result, the residual in their exercise is different from mine. I also exclude the effect of relative labor participation from the residual term, since this information is available in my dataset.

The comparable characteristics for relative income and capital intensity are quite close to each other, as shown in the second and third column. The capital intensity in my accounting is more correlated with both per capita output and the residual than the baseline study. This is because, in the baseline study, capital

Bosworth et al. (2003)	Income	Capital	Education	Residual	
Industrial Countries (22)	2.2%	0.9%	0.3%	1.0%	
China (1)	4.8%	1.7%	0.4%	2.6%	
East Asia less China (7)	3.9%	2.3%	0.5%	1.0%	
Latin America (22)	1.1%	0.6%	0.4%	0.2%	
This Work	Income	Capital	Education	Labor	Residual
Industrial Countries (20)	2.1%	0.9%	0.4%	0.2%	0.6%
China (1)	4.3%	2.4%	0.7%	0.4%	0.9%
East Asia less China (4)	3.5%	1.9%	0.8%	0.4%	0.4%
Latin America (9)	1.8%	1.1%	0.5%	0.3%	-0.1%

Table 9: Growth Accounting Comparison

is smoothed using the perpetual inventory method. However, in my study it is not smoothed, but comes from the investment-output ratio with a linear transformation.

The education stock in the baseline study and the human capital stock in this work are related, but not identical concepts. Remember that I choose 2000 as the base year, and use the average growth rate to infer human capital stock. If all countries would share the same average growth rates, then the relative human capital would be identical to the education stock in the baseline study. And if a country grows faster than the US, its derived relative human capital would be smaller than its relative education stock. The observation that the average human capital stock is slightly smaller than the education stock confirms that countries in the sample grow slightly faster than the US, on average. It seems that the steady-state equilibrium is not too restrictive to examine cross-country differences in economic performance, at least for countries in this sample.

The labor participation says that, on average, other countries in this sample work less than the US. The residual in the alternative study, not surprisingly, looks similar to the baseline study; given that the human capital stock differs

little from the education stock.

In the case of growth accounting, Klenow and Rodriguez-Clare (1997b) use the following formula to decompose growth

$$\Delta \ln \frac{Y}{L} = \Delta \ln A + \frac{\alpha_1}{1 - \alpha_1 - \alpha_2} \Delta \ln \frac{K}{Y} + \frac{\alpha_2}{1 - \alpha_1 - \alpha_2} \Delta \ln \frac{H}{Y}$$

where the sum of inputs' contribution can be expressed as $\Delta \ln X$. They also use covariances to measure the contribution of each term to growth,

$$\frac{\text{Cov}(\Delta \ln \frac{Y}{L}, \Delta \ln A)}{\text{Var}(\Delta \ln \frac{Y}{L})} + \frac{\text{Cov}(\Delta \ln \frac{Y}{L}, \Delta \ln X)}{\text{Var}(\Delta \ln \frac{Y}{L})} = 1.$$

Bosworth et al. (2003) use a production function and a definition of human capital that is similar to Hall and Jones (1999), and a more conventional decomposition,

$$\Delta \ln \frac{Y}{L} = \Delta \ln A + \alpha \Delta \ln \frac{K}{L} + (1 - \alpha) \Delta \ln h_{HJ}$$

with averages to measure the contribution of each term,¹⁷

$$\text{Ave}\left(\frac{\Delta \ln A}{\Delta \ln \frac{Y}{L}}\right) + \alpha \text{Ave}\left(\frac{\Delta \ln(K/L)}{\Delta \ln \frac{Y}{L}}\right) + (1 - \alpha) \text{Ave}\left(\frac{\Delta \ln h_{HJ}}{\Delta \ln \frac{Y}{L}}\right) = 1.$$

Note that if the steady-state equilibrium were imposed, Klenow and Rodriguez-Clare (1997b) would wholly attribute growth to technology progress and not at all to capital accumulation; and Bosworth et al. (2003) would attribute α of growth to capital accumulation. Growth accounting would not be interesting. So I use Bosworth et al. (2003) as the baseline to account for growth without imposing further restrictions.¹⁸

Table 9 presents the results from the baseline study in the upper panel and from my calculations in the lower panel. Decompositions are made for four regions: industrial countries, China, East Asia less China, and Latin America.

¹⁷Covariances are actually weighted averages, with higher weights for larger deviations from the average.

¹⁸Actually, Klenow and Rodriguez-Clare (1997b) find that at least 85% of economic growth is due to technology growth under different specifications, which verifies that most countries in their sample are close to their steady states.

Notice that mostly, there are fewer countries in my sample. For example, twenty-two Latin American countries are in the baseline, but only nine are in my sample. Another point worth noticing is that the effect of labor participation is excluded from the residual in my calculation, while not in the baseline study.

Bosworth et al. (2003) confirms widely accepted observations across regions: in general, TFP contributes as much as physical capital accumulation and the increase of education explains a relatively small part; East Asia less China accumulates physical capital more rapidly during its miraculous growth in the past than others; and TFP grows slowly in Latin America. My calculations also confirm the baseline. It verifies that the data I have collected is as good (or bad) as the data used by previous studies.

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