Capital-Skill Complementarity and Cross-Country Skill Premia*

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Abstract

The Capital-Skill Complementarity (CSC) hypothesis links the dynamics of wage inequality to the capital accumulation process and provides an explanation for the post-war evolution of the skill premium in the U.S. But is the CSC framework consistent with the observed cross-country pattern of skill premia?

We use data on the skill premium, labor supply and the determinants of steady-state capital intensity (saving rates and barrier to capital accumulation), to test at a cross-country level the consistency of the CSC, hypothesis, to obtain a new estimate of the elasticity of substitution between inputs and, indirectly, to test the hypothesis of a common world technology.

We find weak evidence for the CSC hypothesis in the full sample and strong evidence in the non-OECD subsample, suggesting that developing countries are undergoing a transition similar to that documented by Goldin and Katz (1998) for the U.S. during the first part of the twentieth century, in which CSC seems to have had a role. The relatively low explanatory power of the steady-state regressions suggests the rejection of the common world technology assumption and indirectly supports models featuring cross-country skill-biased technology differences.

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1 Introduction

The Capital -Skill Complementarity hypothesis (CSC), originally formulated by Griliches (1969), can loosely be described as the statement that capital and skilled labor are relative complements or, the other way around, that capital and unskilled labor are relative substitutes: new machines substitute unskilled workers more easily than skilled ones. Properly formalized, the CSC assumption links the dynamics of wage inequality, as measured by the skill premium, i.e. the wage of skilled workers relative to the wage of the unskilled, to the capital accumulation process: accumulation of capital tends to increase the relative marginal product of skilled labor and, in a competitive setting, the skill premium. The CSC assumption provides a framework for a quantitative analysis of time series and cross country patterns of skill premia in terms of two observable variables, the relative supply of skilled labor and the capital stock. Krusell et al (2000) evaluate the potential of CSC in explaining the dynamics of the U.S. wage inequality in the last 30 years, a period over which the skill premium has continuously grown in spite of a large increase in the relative supply of skilled labor: it turns out that with CSC, the rapid growth in the stock of capital equipment is able to generate a behaviour of the U.S. skill premium quite close to the observed one. Moreover Krusell et al (2000) show that CSC is also consistent with other stylized facts which characterize U.S. growth experience, such as the relative constancy of the aggregate labor share of income and a trendless rate of return on physical capital.

The linkage imposed by the CSC hypothesis between wage inequality and the capital accumulation process can be exploited to test the consistency of CSC using cross-country data on skill premia, relative supplies of skilled labor and observables that determine national capital stocks. Intuitively, the skill premium should be relatively higher in developing countries because of a low supply of skilled labor, a pure quantity effect. On the other hand, it should also be relatively lower there because of low saving rates and because of the existence of barriers to capital accumulation, policy distortions and institutional settings that discourage investments.

We proceed by obtaining a steady-state approximation for aggregate capital intensity in a Solow-setting with an exogenous saving rate and we derive a linear relationship between the skill premium, the relative supply of skilled labor, the saving rates and barriers that can be used for a cross-country regression much in the spirit of Mankiw, Romer and Weil (1992). This approach allows us to test for the presence of CSC and at the same time to obtain an estimate for the elasticity of substitution between each couple of inputs: thus, our study also adds to the literature on the specification of the aggregate production function.

Is the CSC hypothesis also consistent with cross-country differences in the skill premium? Since CSC depends on the dynamics of capital accumulation the latter question can be reformulated as: is the cross-country pattern of skill premia consistent with existing differences in saving rates and with barriers to capital accumulation? Can these observables explain the existing variation of cross-country skill-premia or are technology differences between countries required?

These questions are very similar to those that characterize recent theoretical and empirical research in growth theory. This is in a sense obvious since in such a highly aggregate setting the skill premium is a pure macroeconomic phenomenon: the fundamental question is whether the cross-section of observables quantities (and in particular capital) are able to explain growth and inequality patterns, or if unobservable effects (technology) act in a systematic and quantitatively relevant way. This study can also be interpreted as an indirect test of the existence of a common world technology, using cross-country skill premia instead of cross-country income differences as a testing ground.

Our empirical approach to the evaluation of the CSC hypothesis is new, but a number of other studies have tried to test the consistency of CSC using cross-country data: Duffy, Papageorgiou and Perez-Sebastian (2004) directly estimate the parameters that control the elasticity of substitution between inputs of several version of a production function allowing for CSC, using a panel dataset of 73 countries over the period 1965-90, while Papageorgiou and Chmelarova (2005) use data on cross-country skill premia in a partial equilibrium framework, obtaining a testable relationship between the skilled labor share of the wage bill, the capital-output ratio and the skill premium.

We find weak evidence in support for the CSC hypothesis for the full sample, but strong evidence in favour of CSC in the non-OECD subsample and no evidence in the OECD subsample. This results confirm and reinforce those obtained by Papageorgiou and Chmelarova (2005): there is increasing evidence that developing countries are undergoing a transition similar to that documented by Goldin and Katz (1998) for the U.S. during the first part of the twentieth century, when the shift from the classical factory to continuous production processes seems to have been characterized by CSC. Furthermore, we obtain estimates of the elasticities of substitution close to those reported in the literature only when the threshold separating unskilled and skilled labor is relatively high: defining as skilled those workers who have completed only a primary cycle of education seems to be too weak a requirement, leading to unrealistic degree of substitutability between couple of inputs. Finally we are able to get an estimate of the steady-state or long run impact on the skill-premium of a change in the effective saving rate, i.e. the saving rate corrected for the magnitude of policy barriers discouraging investments: for OECD countries where CSC is ineffective the impact is null, while in non-OECD countries in which CSC acts a 10% increase in the effective saving rate it generates a 3% increase of the skill premium. As a final remark, observables quantities are able to explain only up to 30% of observed cross-country dispersion of skill-premia, suggesting that unobservable forces have a role in shaping cross-country inequality. If the analysis of cross-country income differences suggest that large international productivity differences are needed, the dispersion of cross-country skill premia reinforces this perspective and calls for a theory of productivity differences able to simultaneously explain growth and inequality facts.

The rest of the paper is organized as follows. Section 2 reviews some key facts on CSC and the skill-premium. Section 3 presents our steady-state approximation of the skill premium and derives the estimating equation. Section 4 presents the data and the results of the estimations. Section 5 concludes.

2 Capital-Skill Complementarity and the Skill Premium

Suppose, as in Caselli and Coleman (2006), that per capita output is given by

$$y = F(k, L_u, L_s) = k^{\alpha} \left[(A_u l_u)^{\sigma} + (A_s l_s)^{\sigma} \right]^{\frac{1-\alpha}{\sigma}} \qquad \sigma < 1 \tag{1}$$

where k is per worker capital, l_u and l_s are respectively the unskilled and skilled share of total labor $L = L_u + L_s$, while A_u and A_s are efficiency indexes of the two types of labor. This production function generalizes the Cobb-Douglas technology by splitting the labor force of an economy into two types of labor and allowing a variable degree of substitutability between them, given by the elasticity of substitution $\varepsilon = \frac{1}{1-\sigma}$. On the other hand the elasticity of substitution between physical capital and the CES labor aggregate is fixed to one by the Cobb-Douglas assumption and the partial elasticities of substitution between capital and skilled and unskilled labor are the same.

If markets are competitive, factors are paid their marginal product and the skill premium is given by

$$\frac{\omega_s}{\omega_u} = \frac{\partial F / \partial L_s}{\partial F / \partial L_u} = \left(\frac{A_s}{A_u} \right)^{\sigma} \left(\frac{L_s}{L_u} \right)^{\sigma - 1} \tag{2}$$

Here the dynamics of the skill premium is controlled by a technology effect, given by the ratio $\frac{A_s}{A_u}$, which measures the degree of skill-bias of technology, and by a quantity effect, given by the relative supply of skilled labor $\frac{L_s}{L_u}$. An increase in the relative supply of skilled workers always lowers the skill premium, while an increase in the relative efficiency of skilled labor raises the skill premium only if $\sigma > 0$ and the elasticity of substitution ε is sufficiently high, which seems to be the empirically relevant case (Acemoglu (2003)). Note that the level of the skill premium is independent of the stock of per worker physical capital in the economy: the capital accumulation process plays no role in shaping the degree of wage inequality. This is a consequence of the assumption of a unique degree of substitutability between capital and both types of labor: intuitively, (1) represents machines as being skill-neutral, equally substituting (or complementing) unskilled and skilled labor.

Note also that in this framework the only measurable quantity that can be used to study the time series and cross-country behaviour of the skill premium is the relative supply of skilled workers, since the technology ratio $\frac{A_s}{A_u}$ is unobservable.

Suppose instead that per capita output is given by the two level CES[1]:

[1] Originally introduced by Sato (1967), particular versions have been used by Krusell et al. (2000), Goldin and Katz (1998) and Duffy, Papageorgiou and Perez-Sebastian (2004), while its general properties in a Solow setting are discussed in Papageorgiu and Saam (2005).

$$Y = \left[(A_x X)^\sigma + (A_u L_u)^\sigma \right]^{\frac{1}{\sigma}} \qquad \sigma < 1 \tag{3}$$

$$X = \left[bK^\theta + (1-b)\, L_s^\theta \right]^{\frac{1}{\theta}} \qquad \theta < 1 \tag{4}$$

which is obtained by nesting into a first CES aggregate with unskilled/raw labor, a second CES composite that aggregates physical capital and skilled labor: this second aggregate, denoted as X, should be interpreted as a measure of total capital, physical and human.

Here A_x and A_u are indexes of the technological state of the capital-skill composite and of unskilled labor respectively, b is a share parameter which is supposed constant, σ and θ are curvature parameters that determine the elasticity of substitution between K, L_u and L_s.

In particular Duffy, Papageorgiou and Perez-Sebastian (2004) have shown that if $\sigma > \theta$ then Capital-Skill Complementarity holds, since both the partial and direct elasticities of substitution between L_u and K are bigger than the elasticity of substitution between L_s and K, and physical capital substitutes unskilled labor more easily than skilled labor.

In a competitive setting the skill premium is given by:

$$\frac{\omega_s}{\omega_u} = \frac{\partial F/\partial L_s}{\partial F/\partial L_u} = (1-b) \left(\frac{A_x}{A_u} \right)^\sigma \left(\frac{L_s}{L_u} \right)^{\sigma-1} x^{\sigma-\theta} \tag{5}$$

There are now three components which influence the degree of wage inequality: a technology effect given by the ratio $\frac{A_x}{A_u}$, a labor supply effect given by the relative supply of skilled labor $\frac{L_s}{L_u}$, and the CSC effect given by the $x^{\sigma-\theta} \equiv \left[\frac{X}{L_s} \right]^{\sigma-\theta} = \left[bk + (1-b) \right]^{\frac{\sigma-\theta}{\theta}}$ term, which now links the magnitude of the skill premium to the capital accumulation process.

In particular an increase in the stock of aggregate capital per skilled worker $x = \frac{X}{L_s}$ increases the skill premium if and only if CSC holds ($\sigma > \theta$), while the percentage variation in the skilled premium induced by a one per cent increase in capital per unit of skilled labor $k = K/L_s$ id given by

$$\frac{\partial \ln \left(\frac{\omega_s}{\omega_u} \right)}{\partial \ln k} = (\sigma - \theta) \frac{bk^\theta}{bk^\theta + (1-b)} = (\sigma - \theta)\, b \left(\frac{k}{x} \right)^\theta = (\sigma - \theta)\, b \left(\frac{K}{X} \right)^\theta \tag{6}$$

which is positive if and only if CSC holds.

Its magnitude varies with the relative share of physical capital over aggregate (physical and human) capital X and with the degree of substitutability between physical and human capital controlled by θ: if θ is positive, and physical and human capital are relative substitutes, the higher the physical share of aggregate capital the greater the effect on the skill-premium, while the reverse is true when physical and human capital are relative complements ($\theta < 0$).

In the CSC framework capital accumulation does play a decisive role in shaping the degree of wage inequality of an economy and differences in the parameters which characterize this process (i.e. saving rates and barriers to capital accumulation) will translate in differences, over time and across economies, in skill premia: it is possible to use cross-country data on skill premia at a point in time to test the consistency of the CSC hypothesis. In particular the skill premium should be relatively high in the skill scarce-low income countries because of the quantity effect acting through the $\frac{L_s}{L_u}$ ratio, but it should also be relatively high in the skill-abundant-high income countries because of higher saving rates and lower barriers to capital accumulation acting on the stock of aggregate capital x.

3 The Skill Premium in the Steady State

The general idea is to calculate the steady state value of x for an economy with a production function given by (3) and (4) and a Solow-like assumption on the saving rate, in order to obtain a steady-state relationship between the skill premium and the saving rate that could be used to evaluate the explanatory power of the CSC hypothesis. Since our focus is on the ability of the capital accumulation process and its determinants to explain observed international variation in the skill premium, we abstract from skill-biased technology differences and impose a Hicks neutral common world technology on the production function (3) and (4)

$$\begin{aligned} Y_t &= A_t \left\{ \alpha X_t^{\sigma} + (1-\alpha) L_{u,t}^{\sigma} \right\}^{\frac{1}{\sigma}} \\ &= A_t \left\{ \alpha \left[b K_t^{\theta} + (1-b) L_{s,t}^{\theta} \right]^{\frac{\sigma}{\theta}} + (1-\alpha) L_{u,t}^{\sigma} \right\}^{\frac{1}{\sigma}} \end{aligned} \tag{7}$$

Suppose the law of motion of *aggregate* capital is given by

$$\overset{\bullet}{X}_t = \frac{I_t}{\pi} - \delta X_t \tag{8}$$

where I_t is investment in term of the consumption good and π is a parameter that determines the rate at which foregone consumption is transformed into capital goods: π should be interpreted as a measure of barrier to capital accumulation, i.e. taxes, corruption, institutional settings that raise the relative price of investment. We assume in (8) that the economy has to accumulate through direct investment not only physical capital, but the whole X composite: here investment should be thought of as involving the combination of machines and human capital, and I_t is a measure that includes both capital equipment and intangibles as organizational and knowledge capital.

Finally we simplify the steady-state analysis by imposing that both unskilled and skilled labor supplies are given ($L_{s,t} = L_s$ and $L_{u,t} = L_u$), and that world technology evolves exogenously at a rate g, i.e. $\dot{A}_t / A_t = g$.

With a Solow assumption $I_t = sY_t$, where s is the exogenously given saving rate, we have:

$$\dot{X}_t = \frac{s}{\pi} Y_t - \delta X_t \tag{9}$$

and $\frac{s}{\pi}$ is the effective saving rate of a country with barriers π: for a given saving rate s, the higher the level of the barriers to capital accumulation π, the lower the fraction of total foregone consumption sY that is transformed into new capital goods.

Considering aggregate capital per unit of effective skilled labor $\widetilde{x} = X/AL_s$, (8) becomes

$$\dot{\widetilde{x}}_t = \frac{s}{\pi} \frac{Y_t}{A_t L_s} - (\delta + g)\widetilde{x}_t \tag{10}$$

so that the steady-state level $\widetilde{x}^*$ of aggregate capital is obtained by setting $\dot{\widetilde{x}}_t = 0$

$$\frac{s}{\pi} \left[\alpha (\widetilde{x}^*)^\sigma + (1-\alpha) \frac{L_u}{L_s}^\sigma \right]^{\frac{1}{\sigma}} = (\delta + g)\widetilde{x}^* \Rightarrow \widetilde{x}^* = \left[\frac{(1-\alpha)\left(\frac{L_u}{L_s}\right)^\sigma}{[\frac{\pi(\delta+g)}{s}]^\sigma - \alpha} \right]^{\frac{1}{\sigma}} \tag{11}$$

For all possible values of σ, an increase of the saving rate s or of the relative supply of unskilled labor raise the steady-state level of aggregate capital, while an increase of the depreciation rate, the technology growth rate or of the barriers magnitude decreases it. The effects of cross-country differences in saving rates and barriers on the steady-state value of the skill premium are straightforward: a higher saving rate (or lower barriers to capital accumulation) raises $\widetilde{x}^*$ and, if CSC holds, the steady-state skill premium increases.

It is now possible to express the steady-state level of the skill premium in terms of technology, the relative supply of skilled labor and the variables that control capital accumulation.

Since $x^* = A_t \widetilde{x}^*$, from (5) we obtain an expression for the steady-state value of the skill premium

$$\begin{aligned} \ln\left(\frac{\omega_s}{\omega_u}\right) &= \ln(1-b) + \sigma \ln\left(\frac{\alpha}{1-\alpha}\right) + (1-\sigma)\ln\left(\frac{L_u}{L_s}\right) + (\sigma - \theta)\ln(A_t) + \\ &+ (\sigma - \theta)\ln(\widetilde{x}^*) \end{aligned} \tag{12}$$

Notice that if CSC holds ($\sigma > \theta$) then in a steady state with a constant relative supply of unskilled labor $\frac{L_u}{L_s}$, the skill premium grows at the exogenous rate of neutral technological progress g, while if capital and skilled labor are relative substitutes ($\sigma < \theta$) the skill premium decreases with technological change[2].

It is possible to approximate $\ln(\widetilde{x}^*)$ by a first-order Taylor approximation in the neighborhood of $\sigma = 0$ to obtain[3] (see Appendix A):

$$\ln(\widetilde{x}^*) \simeq \ln(\frac{L_u}{L_s}) + \frac{1}{1-\alpha}\ln(\delta+g) + \frac{1}{1-\alpha}\ln(\frac{s}{\pi}) \tag{13}$$

and inserting this approximation in (12)

$$\begin{aligned} \ln\left(\frac{\omega_s}{\omega_u}\right) &= \ln(1-b) + \sigma\ln\left(\frac{\alpha}{1-\alpha}\right) + (\sigma-\theta)\ln(A_t) + (1-\theta)\ln\left(\frac{L_u}{L_s}\right) + \\ &\quad + \frac{(\sigma-\theta)}{(1-\alpha)}\ln(\delta+g) + \frac{(\sigma-\theta)}{(1-\alpha)}\ln(\frac{s}{\pi}) \end{aligned} \tag{14}$$

Equation (14) is a steady-state *linear* approximation of the skill-premium that predicts the magnitude of the coefficients on the observables $\frac{L_u}{L_s}$ and $\frac{s}{\pi}$ and that can be estimated using cross-country data in order to obtain an estimate of the curvature parameters of the production function and at the same time to perform a new test on the consistency of the CSC hypothesis. Krusell et al (2000) use US time-series data to obtain an estimate of the curvature parameters of a two-level CES, using a simulation based estimation technique in a partial equilibrium framework, Duffy, Papageorgiu and Perez-Sebastian (2004) estimate directly a two-level CES production function using nonlinear least squares while Papageorgiu and Chmelarova (2005) use cross-country data on the skill-premium in a partial equilibrium framework known as the quasi-fixed cost function approach.

None of those studies focuses on steady-state or on parameters which influence capital accumulation: here household preferences over consumption are included in their simplest form, an exogenous and constant saving rate, and barriers to capital accumulation are taken into account, in order to assess the contribution of the capital accumulation process on wage inequality as measured by the skill premium.

4 Data, Estimation and Results

We use data taken from a variety of sources:

[2]The observed oscillations of the skill premium along the growth path of some economies, documented by Krusell et al. (2000) for the U.S. and by Lindquist (2005) for Sweden are not consistent with this prediction, but they can be expression of out of steady-state behaviour of the economies. Moreover, here we neglect movements in relative supply of skilled labor, which directly influence the skill premium in and out of the steady-state.

[3]Notice that approximating for σ close to 0 means that the production function (7) gets closer and closer to a Cobb-Douglas aggregate of total capital and unskilled labor, $Y_t \simeq A_t X_t^a L_u^{1-a}$ as in Barro and Sala-i-Martin (1995, pag.56).

- Data for the two main variables, the skill premium $\frac{\omega_s}{\omega_u}$ and the labor aggregates L_u and L_s, are obtained from Caselli and Coleman (2006). They build from the Barro and Lee (2001) dataset on the share of the labor force into seven different categories of educational attainment, three different measures of skilled and unskilled labor based on alternative thresholds: the primary completed threshold, by which is considered skilled everyone who has completed a primary cycle of education and unskilled who has not, the secondary completed threshold and the college completed one. These thresholds determine increasing requirements for a worker to be considered skilled and produce an increasing magnification of cross-country differences in the relative supply of skills. Once the threshold has been defined, each of the seven subgroup is then aggregated to form L_u and L_s using its wage relative (obtained as described below) to a base group as a weight: it follows that L_u and L_s are measured in efficiency units of the chosen base group. Data on educational attainment are from 1985.

  For each country Caselli and Coleman also estimate the difference in years of schooling between different subgroups, which, together with the cross-country estimates on Mincerian coefficients taken from Psacharopoulos (1994) and Bils and Klenow (2000), determines the skill-premium for each alternative skill threshold: in fact the estimated Mincerian coefficient β_i, which is obtained by regressing in each country i the log wage on years of schooling, is simply the percentage gain associated with an extra year spent in school and if n is the difference in schooling years between skilled and unskilled labor the skill-premium is $\exp(\beta_i n)$ .Mincerian coefficients collected in Psacharopoulos (1994) and Bils and Klenow (2000) come from country-level studies using micro-data: this studies were executed in different years, that we report in Appendix B. Since they reflect institutional features of a country schooling system, the estimated Mincerian coefficients should also show a high degree of persistence over time and the fact that the estimates come from different years should not affect the analysis.

- Data for the saving rate s are taken from Mankiw, Romer and Weil (1992) that draw them from Penn World Tables 4.0 as the average share of real investment on real GDP, including government investment, over the period 1960-1985. Since we take s to be the rate of investment of the capital-skill composite X, this variable could well be underestimated since the average share of real investment does not include intangibles like knowledge and or organizational capital.

- The parameter π which measures barriers to capital accumulation is empirically identified, as in Restuccia and Urrutia (2001), with the relative price of aggregated investment over consumption: cross-country differences in this relative price level should be interpreted as a measure of policy distortions which discourage capital accumulation. We construct π as the average over the period 1960-1985 of the relative price of investment, measured as the ratio P_I/P_C where P_I and P_C are respectively the price level of consumption and investment given in the Penn World Tables 6.1 (Heston, Summers and Aten (2002)). We normalize this average, as in Restuccia and Urrutia (2001), by the average relative price of investment in the U.S to facilitate cross-country comparisons.

There are 52 countries for which data on all relevant variables are available. Appendix B lists the countries in the sample, the variables and presents some descriptive statistics for the full sample and the OECD and non-OECD subsamples.

In order to estimate the steady-state equation (14) we make four identifying assumptions :

- A common world technology assumption: the Hicks-neutral efficiency index grows exogenously at a constant rate shared by all countries of the world economy, so that $A_{i,t} = A_{i,0}\exp(gt)$.
- While every country shares the same technology growth rate g, the $A_{i,0}$ term reflects the initial technology conditions of each country and includes elements such as resource endowments, climate and institutions that may differ across countries: we assume, exactly as Mankiw, Romer and Weil (1992) in their cross-country growth regression specification, that

$$\ln A_{i,0} = a + \epsilon_i \tag{15}$$

  where a is a constant and ϵ_i is a country-specific shock *independent* from the saving rate s and the level of barriers π: initial conditions on a country technology level are supposed not to affect, at least in the long run, the parameters that shape the future path of capital accumulation. This assumption makes it possible to estimate consistently equation (14) by ordinary least squares, but it should be noted that if saving rates, barriers to capital accumulation and initial technology conditions are correlated, then steady-state skill premia and the ratio $\frac{s}{\pi}$ are endogenous and the OLS coefficient on $\frac{s}{\pi}$ would be biased.
- As noted in Appendix A, approximating the skill premium for σ close to 0 means evaluating the steady-state in the limit in which the production function (7) approaches the Cobb-Douglas form $Y_t = A_t X_t^a L_u^{1-a}$, so that $(1-\alpha)$ is simply the share of output that goes to unskilled labor: we assume that this share is a *constant* across countries. Gollin (2002) shows that labor income share oscillates for most countries in the range 0.65-0.80, but he does not separately calculate unskilled and skilled labor share. Since we need an explicit value for $(1-\alpha)$ in order to identify σ and θ, we will make a rough guess and set $(1-\alpha) = \frac{1}{3}$ for all countries[4].
- Finally, we assume that also the depreciation rate δ is a constant that does not vary across countries.

[4]Incidentally, a value of α around $\frac{2}{3}$, which is plausible for a broad notion of capital including physical structures and intangibles like human capital, is also found by Restuccia and Urrutia (2001) to be the value needed in order to replicate observed income disparities using a simple one sector growth model with barriers to capital accumulation.

Substituting for A_t into equation (14) and adding up the constant terms we get a cross-country steady-state approximation of the skill-premium at a point in time (here for simplicity $t = 0$) in terms of the observables $\frac{L_u}{L_s}$ and $\frac{s}{\pi}$

$$\ln\left(\frac{\omega_s}{\omega_u}\right)_i \simeq C + (1-\theta)\ln\left(\frac{L_u}{L_s}\right)_i + \frac{(\sigma-\theta)}{(1-\alpha)}\ln\left(\frac{s}{\pi}\right)_i + \nu_i \tag{16}$$

where $\nu_i = (\sigma - \theta)\,\epsilon_i$.

The specification that will be tested using cross-country data on $\frac{\omega_s}{\omega_u}$, L_u and L_s, s and π will be the linear relationship

$$\ln\left(\frac{\omega_s}{\omega_u}\right)_i = \beta_0 + \beta_1\ln\left(\frac{L_u}{L_s}\right)_i + \beta_2\ln\left(\frac{s}{\pi}\right)_i + \nu_i \tag{17}$$

where the interpretation of the coefficients β_0, β_1 and β_2 is given by equation (16). Note that σ can be obtained using the OLS estimates of β_1 and β_2 through the linear transformation $\sigma = 1 + (1-\alpha)\,\beta_2 - \beta_1$. It is clear that if $\beta_2 > 0$, then $\sigma > \theta$ and CSC holds.

To assess the relevance of barriers to capital accumulation in explaining skill-premia dispersion, we ran the OLS regression of (17) with and without barriers: that is, we use alternatively $\ln(s)$, imposing $\pi = 1$ for each country in the sample as if there were no institutional distortion over the capital accumulation process, and $\ln\left(\frac{s}{\pi}\right)$ as regressors. To address the issue of parameter heterogeneity, that questions the usage of a common production function for countries that are at different stages of their development path[5], we split the sample in an OECD and a non-OECD subsamples and run separate regressions for each of them.

There are several interesting features of the regression results, presented in Tables 1-6:

- There is very weak evidence in favour of the CSC hypothesis in the full sample, either if barriers to capital accumulation are included or excluded: the coefficient on $\ln(s)$ or $\ln\left(\frac{s}{\pi}\right)$ is always positive but never significantly different from zero, for all of the possible choices of the skill threshold (Tables 1 and 2). Considering separately the OECD and the non-OECD samples reveals a consistent pattern: CSC appears not to hold in the OECD subsample, since the relevant coefficient becomes negative, even if imprecisely estimated, for each skill threshold and with or without barriers (Tables 3 and 5). On the other hand, CSC appears to hold consistently in the non-OECD subsample: the relevant coefficient is always significantly different from zero (Tables 4 and 6)

  This finding replicates that of Papageorgiou and Chmelarova (2005), but is obtained using a completely different approach: while they use a partial equilibrium framework that generates a linear relationship between the skilled-labor share of the wage bill and the capital-output ratio, here we obtain a steady-state linear approximation relating skill premia to the

[5] See for example Durlauf, Kourtellos and Minkin (2001) and Masanjala and Papageorgiou (2004) for an evaluation of cross-country parameter heterogeneity for the Solow growth model, using respectively a Cobb-Douglas and CES specification for the production function.

determinants of capital accumulation. The evidence in favour of a *dynamic degree of substitutability/complementarity* between capital, skilled and unskilled labor along the growth path of an economy is reinforced. It seems that countries that are at lower stages of the development path experience a strong degree of complementarity between capital and skills, which is reflected in the behaviour of skill-premia among them as a subset of the world economy: skilled labor receives a premium which may be interpreted as a sign of its crucial role in complementing relatively advanced technologies in a relatively backward technology environment. This is also consistent with Goldin and Katz (1998) finding of a high degree of capital-technology-skill complementarity in the transition from the classical factory to continuous process in the U.S. manufacturing sector in the period 1909-1940: it is conceivable that developing countries are experiencing a similar kind of transition, in which a relatively scarce skilled labor force commands an higher skill premium because of its essentiality in activating new technologies.

On the other hand, the fact that there is no evidence for CSC in the OECD subsample does not necessarily contradict the empirical findings of Krusell et al. (2000) and Lindquist (2005) about the relevance of CSC in explaining the *dynamic behaviour* of the skill premium in the U.S. and in Sweden: it simply indicates that, in this subsample as a whole, the observed dispersion at a point in time of the skill premium is not related to capital intensities as predicted by CSC, and points out that alternative mechanisms for generating the observed dispersion in wage inequality within the subgroup of developed countries are needed.

- The steady-state relationship (16) not only does offer an explicit test over the existence of CSC, but it also allows for a separate identification of the substitution parameters σ and θ: the predicted elasticities of substitution between each couple of inputs can be compared with those obtained in the literature, in general through microeconomic studies as summarized in Hamermesh (1993), to verify the ability of this pure cross-country macroeconomic setting to generate plausible values of these elasticities.

  We use the Allen partial elasticity of substitution, that for each couple of inputs measures the percentage change in the ratio of the two inputs generated by one per cent increase in the ratio of their prices, holding the price of the other input and output quantity constant, while the quantity of the other input is free to vary. Intuitively, in a partial equilibrium framework the inverse of the elasticity of substitution ε_{L_s,L_u} between skilled and unskilled labor measures the percentage increase of the skill premium following a one percent increase in the ratio $\frac{L_u}{L_s}$.

  Proceeding as in Sato (1967) one obtains the partial elasticities of substitution:

$$\begin{aligned} \varepsilon_{K,L_u} &= \varepsilon_{L_s,L_u} = \frac{1}{1-\sigma} \\ \varepsilon_{K,L_s} &= \frac{1}{1-\sigma} + \frac{1}{\zeta_X}\left[\frac{1}{1-\theta} - \frac{1}{1-\sigma}\right] \end{aligned} \tag{18}$$

where ζ_X is the relative share of K and L_s in total expenditure.

In a closed economy setting with competitive markets, ζ_X coincides with the share of GDP which goes to K and L_s: since we set the share of GDP which goes to unskilled labor to $\frac{1}{3}$, we impose $\zeta_X = \frac{2}{3}$ and we calculate the two elasticities using (18) and the estimates of σ and θ.

The values of the implied elasticities vary with the skill-threshold, with the inclusion or exclusion of barriers and with the samples: in general the full sample and the non-OECD subsample generate reasonable values, while the OECD subsample (which is composed of only 17 observations) does not. Using the primary school threshold the implied elasticities are in general way too high to be consistent with those reported by the literature, ranging from 15 to 50 for ε_{K,L_u} and ε_{L_s,L_u}, and from 10 to an astonishing and completely unrealistic 738 for ε_{K,L_s} (OECD subsample with barriers). Using the secondary school threshold the values become more realistic, especially for the full sample (around 4 for ε_{K,L_u} and ε_{L_s,L_u}, around 3 for ε_{K,L_s}) and for the non-OECD subsample (respectively around 4 and around 2). The high school threshold *always* generates realistic values for the elasticities of substitution between inputs, for all the samples with and without barriers: the estimated values of ε_{K,L_u} and ε_{L_s,L_u} are 2.5 for the full sample and 3.5 for the non-OECD subsample, while ε_{K,L_s} is around 2 for both samples.

One can guess from these results that the primary school threshold is inappropriate as a definition of skilled labor, since it generates unrealistic values of the elasticities of substitution: defining skilled those workers "who can at least read a simple text (e.g. a simple set of instructions or a newspaper article) and perform some basic arithmetic operations", as Caselli and Coleman (2006) describe the primary school threshold, seems to be too weak a requirement[6].

The fact that, at least for the full and non-OECD samples, the steady-state analysis of such an highly aggregate setting is able to generate elasticities of substitution consistent with those estimated by the microeconomic literature is remarkable: Hamermesh (1993) reports values for ε_{L_s,L_u} between 0.5 and 3 and lower values for ε_{K,L_s}, which is quite close to our estimates.

Nevertheless, $\frac{1}{\varepsilon_{L_s,L_u}} = 1 - \sigma$ gives a measure of the impact of a variation of the relative supply of unskilled labor on the skill-premium in a partial equilibrium setting, while (16) shows that the steady-state effect of such a change is measured instead by the coefficient $1 - \theta$: the estimated impact varies with the threshold and the sample and, not considering the primary school threshold, predicts for the full sample that a 10% increase in the $\frac{L_u}{L_s}$ ratio raises the steady-state skill-premium between 2.6% and 4.1%. On the other hand (16) also predicts the steady-state impact on the skill-premium of a variation in the effective saving rate: a 10% increase in $\frac{s}{\pi}$ has a near zero impact for the full sample in which there is weak evidence for CSC,

[6] Caselli and Coleman (2006) results on the existence of cross-country skill-biased technology differences is stronger when the primary school threshold is used: our results could suggest that the secondary or high scool thresholds should be used, which diminishes the amplitude of the observed skill-bias of technology differences.

while it generates a 3% increase of the skill premium in the non-OECD subsample, where CSC is effective.

- Regression analysis shows that observables have moderate explanatory power (R^2) with respect to cross-country dispersion of skill-premia: variation in the $\frac{L_u}{L_s}$ ratio and in effective saving rates $\frac{s}{\pi}$ can explain up to 27% of international variation in $\frac{\omega_s}{\omega_u}$ for the full sample an up to 32% for the non-OECD subsample, while they can explain very little for OECD countries. A great portion of observed dispersion is left unexplained, suggesting that unobservable forces have a role in shaping cross-country inequality. While the observation of cross-country income differences suggest that large productivity differences are needed, the dispersion of cross-country skill premia reinforces this perspective and calls for a theory of productivity differences able to simultaneously explain growth and inequality facts. Caselli and Coleman (2006) find, in a partial equilibrium framework, that the observed dispersion of skill-premia can be explained if skill-biased technological change is introduced: countries seem to use more efficiently the relative abundant factor, an observation that can be theoretically justified in an appropriate technology setting where a country technology choice depends on its factor endowment.

- The introduction of barriers to capital accumulation, contrary to the growth literature where it can change a lot in the empirical performance of some theoretical models, seems to have little effect, with the exception of the non-OECD subsample (Table 4 and 6): when barriers are introduced, the evidence for CSC increases (the difference $(\sigma - \theta)$ is estimated with more precision) and the R^2 grows a bit. This suggests that policy distortions that discourage capital accumulation, as measured by the relative price of investment goods, have a direct influence on inequality in developing countries: the industrial transition they are experiencing, and in which CSC seems to have a role, raises both capital intensity and the skill premium, so that lower barriers to capital accumulation increase wage inequality.

5 Conclusion

The CSC hypothesis links the skill premium to capital accumulation: observed cross-country differences in the skill premium are a natural testing ground for evaluating the existence of CSC. We derive a steady-state approximation of the skill premium as a linear function of observables that control the capital accumulation process, saving rates and barriers to investments. We find weak evidence in support for the CSC hypothesis for the full sample, but strong evidence in favour of CSC in the non-OECD subsample, strengthening the results obtained by Papageorgiou and Chmelarova (2005). There is increasing evidence that developing countries are undergoing a transition similar to that documented by Goldin and Katz (1998) for the U.S. during the first part of the twentieth century, when the shift from the classical factory to continuous production processes seems to have been characterized by CSC. We also obtain estimates of the elasticities of substitution between couple of inputs, so that we can proceed to a robustness check of our analysis comparing them to estimates obtained in other studies. Estimated elasticities of substitutions are consistent with those reported in microeconomic studies only when the threshold separating unskilled and skilled labor is sufficiently high: defining as skilled those workers who have completed only a primary cycle of education seems to be too weak a requirement, leading to unrealistic degree of substitutability between couple of inputs. Finally, we are able to obtain an estimate of the steady-state or long run impact on the skill-premium of a change in the effective saving rate: for OECD countries where CSC is ineffective the impact is null, while in non-OECD countries, where CSC acts, a 10% increase in the effective saving rate generates a 3% increase of the skill premium. As a final remark, observables quantities are able to explain only up to 30% of observed cross-country dispersion of skill-premia, suggesting that unobservable forces have a role in shaping cross-country inequality. If the analysis of cross-country income differences suggest that large international productivity differences are needed, the dispersion of cross-country skill premia reinforces this perspective and calls for a theory of productivity differences able to simultaneously explain growth and inequality facts.

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Appendix A

The logarithm of the steady-state level of total capital per unit of effective skilled labor is given by

$$\ln(\widetilde{x}^*) = \frac{1}{\sigma} \ln \left[\frac{(1-\alpha)\left(\frac{L_u}{L_s}\right)^{\sigma}}{[\frac{\pi(\delta+g)}{s}]^{\sigma} - \alpha} \right] \tag{A1}$$

which is a function $g(\sigma)$ of the elasticity parameter σ which measure the degree of substitutability between raw labor L_u and the physical-human capital aggregate X.

Approximating (A1) by a first-order Taylor expansion of $g(\sigma)$ in the neighborhood of $\sigma = 0$ gives

$$\ln(\widetilde{x}^*) \simeq \lim_{\sigma \to 0} g(\sigma) + \lim_{\sigma \to 0} g^{'}(\sigma) \cdot \sigma \tag{A2}$$

$$= 0 + \lim_{\sigma \to 0} \left\{ -g(\sigma) + \frac{\frac{\left([\frac{\pi(\delta+g)}{s}]^{\sigma} - \alpha\right)(1-\alpha)\left(\frac{L_u}{L_s}\right)^{\sigma} \ln\left(\frac{L_u}{L_s}\right)}{\left([\frac{\pi(\delta+g)}{s}]^{\sigma} - \alpha\right)^2}}{\left[\frac{(1-\alpha)\left(\frac{L_u}{L_s}\right)^{\sigma}}{[\frac{\pi(\delta+g)}{s}]^{\sigma} - \alpha}\right]} - \frac{\frac{(1-\alpha)\left(\frac{L_u}{L_s}\right)^{\sigma}[\frac{\pi(\delta+g)}{s}]^{\sigma} \ln[\frac{\pi(\delta+g)}{s}]}{\left([\frac{\pi(\delta+g)}{s}]^{\sigma} - \alpha\right)^2}}{\left[\frac{(1-\alpha)\left(\frac{L_u}{L_s}\right)^{\sigma}}{[\frac{\pi(\delta+g)}{s}]^{\sigma} - \alpha}\right]} \right\}$$

$$= \ln\left(\frac{L_u}{L_s}\right) - \frac{1}{(1-\alpha)} \ln[\frac{\pi(\delta+g)}{s}]$$

Notice also that in the limit for $\sigma \to 0$ the production function (7) becomes a Cobb-Douglas aggregate of the physical-human capital composite X and of unskilled labor L_u (Barro and Sala-i-Martin (1995, pag.56)):

$$\lim_{\sigma \to 0} Y_t = \lim_{\sigma \to 0} A_t \left\{ \alpha X_t^{\sigma} + (1-\alpha) L_{u,t}^{\sigma} \right\}^{\frac{1}{\sigma}} = A_t X_t^{\alpha} L_u^{1-\alpha} \tag{A3}$$

and $(1-\alpha)$ becomes the share of GDP that goes to unskilled labor.

Appendix B - Data Description

Table B1 - Countries, Labor Stocks, Saving Rates and Barriers

Country	L_u^P	L_s^P	$\left(\frac{\omega_s}{\omega_u}\right)^P$	L_u^S	L_s^S	$\left(\frac{\omega_s}{\omega_u}\right)^S$	L_u^H	L_s^H	$\left(\frac{\omega_s}{\omega_u}\right)^H$	s	π	Year
Argentina	60	106	1.51	148	29	2.53	192	7	4.23	25.3	1.81	1989
Australia	17	129	1.24	85	56	1.63	146	15	2.13	31.5	1.08	1982
Bolivia	75	51	1.33	105	20	1.89	125	6	2.7	13.3	1.21	1989
Botswana	115	41	2.15	174	5	5.58	190	1	14.5	28.3	1.72	1979
Brazil	100	62	1.8	129	22	3.75	159	7	7.83	23.2	1.27	1989
Canada	7	134	1.23	83	56	1.6	159	6	2.07	23.3	1.23	1981
Chile	73	108	1.62	143	35	2.94	203	8	5.37	29.7	1.09	1989
China	65	50	1.22	105	13	1.57	124	1	2.01	20.3	1.69	1985
Colombia	83	76	1.75	138	22	3.53	180	5	7.1	18	1.35	1989
Costa Rica	83	77	1.55	126	28	2.67	156	10	4.6	14.7	1.61	1989
Cyprus	48	144	1.55	125	54	2.69	211	13	4.66	31.2	1.02	1984
Dominican Rep.	85	49	1.46	116	17	2.33	134	6	3.73	17.1	1.51	1989
Ecuador	69	107	1.6	126	39	2.89	171	13	5.22	24.4	0.85	1987
El Salvador	92	38	1.47	123	10	2.39	136	3	3.89	8	2.2	1990
France	46	112	1.49	130	33	2.46	183	7	4.06	26.2	1.04	1985
Ghana	84	35	1.4	123	5	2.15	130	1	3.29	9.1	2.02	1989
Greece	27	85	1.11	88	26	1.28	109	9	1.46	29.3	1.11	1985
Guatemala	98	43	1.81	133	11	3.82	151	3	8.05	8.8	1.84	1989
Honduras	102	75	2.02	152	21	4.87	217	3	11.75	13.8	1.56	1989
Hong Kong	38	99	1.28	97	39	1.73	151	6	2.35	19.9	1.54	1981
Hungary	37	89	1.29	111	22	1.47	128	8	1.83	16.7	1.75	1987
India	79	34	1.22	102	12	1.55	115	3	1.99	16.8	1.34	1981
Indonesia	85	72	1.97	177	11	4.62	222	1	10.8	13.9	1.33	1981
Israel	37	119	1.29	87	58	1.78	156	14	2.45	28.5	0.94	1979
Italy	43	66	1.1	91	20	1.23	110	4	1.38	24.9	1.03	1987
Jamaica	96	185	3.16	294	29	13.36	490	3	56.37	20.6	1.39	1989
Japan	28	119	1.3	106	43	1.79	152	12	2.48	36	1.21	1975
Kenya	109	34	1.93	159	4	4.38	166	1	9.93	17.4	1.68	1980

Table B1 - Continued

Country	L_u^P	L_s^P	$\left(\frac{\omega_s}{\omega_u}\right)^P$	L_u^S	L_s^S	$\left(\frac{\omega_s}{\omega_u}\right)^S$	L_u^H	L_s^H	$\left(\frac{\omega_s}{\omega_u}\right)^H$	s	π	Year
Malaysia	59	82	1.46	127	22	2.33	169	2	3.73	23.2	1.31	1979
Mexico	81	92	1.76	144	28	3.56	196	7	7.2	19.5	1.51	1984
Netherlands	24	128	1.34	119	40	1.95	169	10	2.82	25.8	1.14	1983
Nicaragua	91	40	1.47	114	15	2.39	126	6	3.89	14.5	1.96	1978
Pakistan	85	30	1.47	107	9	2.39	120	2	3.89	12.2	1.86	1979
Panama	63	139	1.73	142	47	3.43	227	11	6.81	26.1	1.23	1989
Paraguay	88	68	1.58	141	19	2.82	170	5	5	11.7	1.88	1989
Peru	65	75	1.38	106	30	2.07	139	10	3.11	12	1.45	1990
Philippines	46	97	1.38	103	37	2.05	141	13	3.06	14.9	1.87	1988
Poland	19	98	1.12	98	24	1.3	119	7	1.5	21.73	1.07	1986
Portugal	64	59	1.49	118	14	2.46	142	3	4.06	22.5	1.33	1985
Singapore	71	89	1.71	150	22	3.34	196	4	6.53	32.2	1.36	1974
South Korea	28	159	1.53	114	61	2.6	219	12	4.41	22.3	1.38	1986
Sri Lanka	51	76	1.32	117	18	1.88	149	1	2.66	14.8	2.62	1981
Sweden	28	133	1.31	78	67	1.83	170	13	2.55	24.5	1.15	1981
Switzerland	22	142	1.37	87	64	2.04	192	8	3.02	29.7	1.15	1987
Taiwan	36	97	1.27	95	37	1.72	143	7	2.32	20.7	1.50	1972
Thailand	87	65	1.52	143	16	2.55	152	8	4.29	18	1.72	1989
Tunisia	82	36	1.38	104	14	2.05	122	3	3.06	13.8	2.09	1980
UK	36	115	1.31	121	36	1.84	163	9	2.59	18.4	1.22	1972
USA	6	229	1.48	65	116	2.43	237	27	3.94	21.1	1	1989
Uruguay	62	97	1.47	139	28	2.39	176	7	3.89	11.8	2.60	1989
Venezuela	69	71	1.4	111	27	2.13	141	8	3.24	11.4	1.46	1989
West Germany	41	94	1.22	122	22	1.55	145	5	1.99	28.5	0.97	1988

Note: L_u^j and L_s^j for $j = P, S, H$ are the stocks of unskilled and skilled labor for the primary, secondary and high school threshold, taken from Caselli and Coleman (2006) and discussed in the main text. $\left(\frac{\omega_s}{\omega_u}\right)^j$ for $j = P, S, H$ is the skill premium for the primary, secondary and high school threshold, also taken from Caselli and Coleman (2006). s and π are respectively average investment share of GDP and average relative price of investment over consumption over the period 1960-1985, the former taken from Mankiw, Romer and Weil (1992), the latter computed from PWT 6.1."Year" refers to the time when the Mincerian coefficient used to calculate the skill premium has been estimated.

Table B2 - Descriptive statistics - Full Sample

	Mean	Std. Dev.	Min	Max	Obs
$(L_u/L_s)^P$	0.99	0.83	0.026	3.21	52
$(L_u/L_s)^S$	6.95	7.43	0.56	39.75	52
$(L_u/L_s)^H$	45.28	50.86	8.78	222	52
s	20.41	6.9	8	36	52
π	1.47	0.4	0.85	2.62	52

Table B3 - Descriptive statistics - OECD Subsample

	Mean	Std. Dev.	Min	Max	Obs
$(L_u/L_s)^P$	0.36	0.29	0.026	1.08	17
$(L_u/L_s)^S$	3.34	2.02	0.56	8.43	17
$(L_u/L_s)^H$	20.65	9.6	8.78	47.33	17
s	24.82	5.02	16.66	36	17
π	1.19	0.21	0.97	1.75	17

Table B3 - Descriptive statistics - Non-OECD Subsample

	Mean	Std. Dev.	Min	Max	Obs
$(L_u/L_s)^P$	1.30	0.84	0.31	3.21	35
$(L_u/L_s)^S$	8.69	8.44	1.5	39.75	35
$(L_u/L_s)^H$	57.24	58.19	10.84	222	35
s	18.27	6.72	8	32.2	35
π	1.59	0.41	0.85	2.62	35

Note: $(L_u/L_s)^j$ for $j = P, S, H$ is relative supply of unskilled labor respectively for the primary, secondary and high school threshold (Source: Caselli and Coleman (2006)). s and π are respectively average investment share of GDP and average relative price of investment over consumption over the period 1960-1985, the former taken from Mankiw, Romer and Weil (1992), the latter computed from PWT 6.1.

Table 1 - Cross-country skill premia without barriers to capital accumulation ($\pi = 1$ for all countries in the sample)

Skill Threshold			
	Primary (P)	Secondary (S)	High School (H)
Constant	0.2422378 (0.1898754)	0.044101 (0.4678897)	-0.2724844 (0.8573914)
$\ln\left(\frac{L_u}{L_s}\right)$	0.0740959^{**} (0.0291791)	0.2602965^{***} (0.0755516)	0.4196514^{***} (0.1451645)
$\ln(s)$	0.0603812 (0.0679365)	0.1417124 (0.1373441)	0.0698606 (0.1890973)
Implied θ	0.9259041^{***} (0.0291791)	0.7397035^{***} (0.0755516)	0.5803486^{***} (0.1451645)
Implied σ	0.9458299^{***} (0.0209356)	0.7864686^{***} (0.0610165)	0.6034026^{***} (0.1292275)
R^2	0.1254	0.2124	0.2700
$\varepsilon_{K,L_u} = \varepsilon_{L_s,L_u}$	18.18	4.67	2.51
ε_{K,L_s}	10.91	3.41	2.31
CSC	Yes (*weak*)	Yes (*weak*)	Yes (*weak*)
Obs.	52	52	52

Note: OLS estimate of equation (17). Robust standard errors in parentheses.*,** and *** mean significantly different from 0 at the 10%, 5% or 1% level.

Weak means that the estimated difference $(\sigma - \theta)$ is not statistically significant different from 0 at the 1%, 5% or 10% level. With $\varepsilon_{K,L_u}, \varepsilon_{L_s,L_u}$ and ε_{K,L_s} are denoted the implied Allen partial elasticities of substitution between each couple of inputs, computed using equation (18).

Table 2 - Cross-country skill premia with barriers to capital accumulation. Full Sample.

	Skill Threshold		
	Primary (P)	Secondary (S)	High School (H)
Constant	0.3349269*** (0.095667)	0.1867583 (0.3248323)	−0.285988 (0.6971067)
$\ln\left(\frac{L_u}{L_s}\right)$	0.07325 ** (0.0290676)	0.2691474*** (0.0805223)	0.4297168*** (0.1483474)
$\ln\left(\frac{s}{\pi}\right)$	0.0327603 (0.0411259)	0.1005613 (0.0964054)	0.0712556 (0.1345215)
Implied θ	0.926 75 *** (0.0290676)	0.730852 6*** (0.0805223)	0.5702832*** (0.1483474)
Implied σ	0.9375609*** (0.0218323)	0.7640379*** (0.0641453)	0.5937976*** (0.1325261)
R^2	0.1224	0.2141	0.2719
$\varepsilon_{K,L_u} = \varepsilon_{L_s,L_u}$	15.87	4.23	2.45
ε_{K,L_s}	12.33	3.43	2.25
CSC	Yes (weak)	Yes (weak)	Yes (weak)
Obs.	52	52	52

Note: OLS estimate of equation (17). Robust standard errors in parentheses.*,** and *** mean significantly different from 0 at the 10%, 5% or 1% level.

Weak means that the estimated difference $(\sigma - \theta)$ is not statistically significant different from 0 at the 1%, 5% or 10% level. With $\varepsilon_{K,L_u}, \varepsilon_{L_s,L_u}$ and ε_{K,L_s} are denoted the implied Allen partial elasticities of substitution between each couple of inputs, computed using equation (18).

Table 3 - Cross-country skill premia without barriers to capital accumulation ($\pi = 1$ for all countries in the sample). OECD countries.

	Skill Threshold		
	Primary (P)	Secondary (S)	High School (H)
Constant	0.734241 (0.5358456)	1.827379 (1.102006)	1.736924 (2.070185)
$\ln\left(\frac{L_u}{L_s}\right)$	0.0074225 (0.0384143)	−0.0577962 (0.0905088)	0.2024358 (0.2426112)
$\ln(s)$	−0.14015469 (0.1593802)	−0.3591214 (0.3412107)	−0.4269681 (0.5465613)
Implied θ	0.992577*** (0.0384143)	1.057796*** (0.0905088)	0.7975642*** (0.2426112)
Implied σ	0.945906*** (0.0697545)	0.9382087*** (0.1617834)	0.6553838*** (0.267698)
R^2	0.0534	0.0688	0.0898
$\varepsilon_{K,L_u} = \varepsilon_{L_s,L_u}$	18.18	16.12	2.89
ε_{K,L_s}	178.40	−34.38	5.93
CSC	No (weak)	No (weak)	No (weak)
Obs.	17	17	17

Note: OLS estimate of equation (17). Robust standard errors in parentheses.*,** and *** mean significantly different from 0 at the 10%, 5% or 1% level.

Weak means that the estimated difference $(\sigma - \theta)$ is not statistically significant different from 0 at the 1%, 5% or 10% level. With $\varepsilon_{K,L_u}, \varepsilon_{L_s,L_u}$ and ε_{K,L_s} are denoted the implied Allen partial elasticities of substitution between each couple of inputs, computed using equation (18).

Table 4 - Cross-country skill premia without barriers to capital accumulation ($\pi = 1$ for all countries in the sample). Non-OECD countries.

	Skill Threshold		
	Primary (P)	Secondary (S)	High School (H)
Constant	0.0218487 (0.1896246)	−0.7159364 (0.4248941)	−0.8387523 (0.9218354)
$\ln\left(\frac{L_u}{L_s}\right)$	0.0689963 (0.0554479)	0.3193019*** (0.0682426)	0.3610596** (0.1541133)
$\ln(s)$	0.1474071** (0.0661237)	0.3939003*** (0.1345685)	0.3809114* (0.2126599)
Implied θ	09310037*** (0.0554479)	0.6806981*** (0.0682426)	0.6389404*** (0.1541133)
Implied σ	0.9800902*** (0.0477861)	0.8118668*** (0.0636234)	0.7657839*** (0.1397072)
R^2	0.0714	0.2882	0.2515
$\varepsilon_{K,L_u} = \varepsilon_{L_s,L_u}$	50	5.29	4.25
ε_{K,L_s}	−3.26	2.04	2.01
CSC	Yes	Yes	Yes (weak)
Obs.	35	35	35

Note: OLS estimate of equation (17). Robust standard errors in parentheses.*,** and *** mean significantly different from 0 at the 10%, 5% or 1% level.

Weak means that the estimated difference $(\sigma - \theta)$ is not statistically significant different from 0 at the 1%, 5% or 10% level. With $\varepsilon_{K,L_u}, \varepsilon_{L_s,L_u}$ and ε_{K,L_s} are denoted the implied Allen partial elasticities of substitution between each couple of inputs, computed using equation (18).

Table 5 - Cross-country skill premia with barriers to capital accumulation. OECD countries.

	Skill Threshold		
	Primary (P)	Secondary (S)	High School (H)
Constant	0.6470729 (0.4284682)	1.657689 (0.9471502)	1.573698 (1.79007)
$\ln\left(\frac{L_u}{L_s}\right)$	0.0015069 (0.03746)	-0.0754686 (0.0876136)	0.1832508 (0.2463101)
$\ln\left(\frac{s}{\pi}\right)$	-0.1218957 (0.1355466)	-0.3171386 (0.3036006)	-0.378183 (0.4614799)
Implied θ	$0.998\,493\,1^{***}$ (0.03746)	$1.075\,469^{***}$ (0.0876136)	$0.816\,7492^{***}$ (0.2463101)
Implied σ	0.9582675^{***} (0.0582546)	0.9708128^{***} (0.1368016)	0.6907008^{***} (0.2480848)
R^2	0.0907	0.1200	0.1219
$\varepsilon_{K,L_u} = \varepsilon_{L_s,L_u}$	23.80	33.33	3.22
ε_{K,L_s}	738.09	-36.66	6.53
CSC	No (weak)	No (weak)	No (weak)
Obs.	17	17	17

Note: OLS estimate of equation (17). Robust standard errors in parentheses.*,** and *** mean significantly different from 0 at the 10%, 5% or 1% level.

Weak means that the estimated difference $(\sigma - \theta)$ is not statistically significant different from 0 at the 1%, 5% or 10% level. With $\varepsilon_{K,L_u}, \varepsilon_{L_s,L_u}$ and ε_{K,L_s} are denoted the implied Allen partial elasticities of substitution between each couple of inputs, computed using equation (18).

Table 6 - Cross-country skill premia with barriers to capital accumulation. Non-OECD countries.

	Skill Threshold		
	Primary (P)	Secondary (S)	High School (H)
Constant	0.2043267^{**} (0.0971852)	-0.4040731 (0.2946899)	-0.6389869 (0.7441409)
$\ln\left(\frac{L_u}{L_s}\right)$	0.0700158 (0.056435)	$0.3523\ ^{***}$ (0.0749346)	0.3895418^{**} (0.1543199)
$\ln\left(\frac{s}{\pi}\right)$	0.0982335^{**} (0.0406909)	0.3100589^{***} (0.0923469)	0.3239627^{**} (0.1516815)
Implied θ	0.929984^{***} (0.056435)	$0.6477\ ^{***}$ (0.0749346)	$0.610\,458\,2^{***}$ (0.1543199)
Implied σ	0.9627254^{***} (0.050473)	0.7510427^{***} (0.0616687)	0.7184349^{***} (0.1366979)
R^2	0.0734	0.3245	0.2796
$\varepsilon_{K,L_u} = \varepsilon_{L_s,L_u}$	$26,31$	$4,01$	$3,54$
ε_{K,L_s}	$7,96$	$2,24$	$2,07$
CSC	Yes	Yes	Yes
Obs.	35	35	35

Note: OLS estimate of equation (17). Robust standard errors in parentheses.*,** and *** mean significantly different from 0 at the 10%, 5% or 1% level.

Weak means that the estimated difference $(\sigma - \theta)$ is not statistically significant different from 0 at the 1%, 5% or 10% level. With $\varepsilon_{K,L_u}, \varepsilon_{L_s,L_u}$ and ε_{K,L_s} are denoted the implied Allen partial elasticities of substitution between each couple of inputs, computed using equation (18).