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**Globalization, Technical Change, and the
Skill Premium: Magnification Effects from
Human-Capital Investments**

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Globalization, Technical Change, and the Skill
Premium: Magnification Effects from
Human–Capital Investments

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Abstract

This paper shows that endogenous adjustments in the composition of labor supplies magnify the effects of changes in commodity prices on the measured skill premium under quite plausible conditions. These composition effects arise from decisions of individuals with heterogeneous inherent abilities about acquiring human capital. They reinforce the well-known Stolper–Samuelson effect on the measured skill premium in countries with a sufficiently high relative supply of skilled labor, but compensate them otherwise. As a result, the model can account for the observation of a worldwide increase in the skill premium during the last two decades.

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1 Introduction

The development of wage inequality by skills has been studied extensively in the recent literature. Many industrialized countries have experienced sharp shifts in labor rewards favoring skilled labor since the beginnings of the 1980ies. For the United States, e.g., Katz and Autor (1999) report an increase in the skill premium—the wages of skilled workers (college graduates) relative to wages of unskilled workers—of about 25 percent between 1979 and 1995, despite of the fact that the relative supply of skilled labor expanded considerably over this time period. Additionally, they find that wage inequality within the different skill groups also increased considerably. Similar qualitative findings characterize the development of wage inequality in other industrialized countries, except for the unskilled's residual wage inequality which declined in countries like Germany (cf. Fitzenberger, 1999).

There are two popular theoretical explanations for rise in the skill premium. Standard trade theory predicts that increased international trade with newly industrialized or less developed countries, which typically have a comparative advantage in goods using unskilled labor intensively, should increase the demand for skilled labor in industrialized countries. Specifically, the rise in the industrialized countries' terms of trade resulting from globalization induces more than proportionate increases in skilled wages, whereas unskilled wages should decline (Stolper–Samuelson effects). As a result, several trade theorists emphasize globalization as the principal cause for the increase in wage inequality in that countries

(cf., e.g., Wood, 1994, 1998). This explanation, however, was challenged by empirical studies according to which changes in relative commodity prices are at best of minor size.¹ Thus, the scope for international trade as the cause of increasing wage inequality seems rather limited.²

The rival explanation (supported especially by labor economists but also by a group of trade theorists) argues that pervasive skill-biased technological change (SBTC) should induce all industries to apply more skill-intensive techniques and thus to raise the demand for skilled labor. Although there seems to be some empirical support for this thesis from several industry studies (e.g., Machin and van Reenen, 1998), this argument is not conclusive from a general-equilibrium

¹Cf. Slaughter (1998) for an overview of earlier empirical studies, and Harrigan and Balaban (1999) for a more recent study.

²The trade-based explanation has been criticized on other reasons as well. E.g., the theory predicts that the change in relative factor prices should induce all industries to adopt less skill-intensive techniques, which is also contrary to fact. The trade-based explanation also implies that developing countries should experience a decline in wage inequality due to the improvements of their terms of trade. These counterfactual implications have been taken up by an alternative explanation of rising wage inequality based on globalization developed by Feenstra and Hanson (1996). They emphasize specialization effects by increased fragmentation of production generating an increase in the relative demand for skilled labor in each country and thus similar developments in wage inequality for all trading partners. For the purpose of our paper it is inessential whether the change in relative factor prices is caused by trade or by international direct investment. We want to emphasize that the empirically measured skill premium is affected by composition effects in the labor supply which are caused by changes in relative factor prices. The force driving the change in factor prices is of no special interest here. For sake of simplicity, we draw on the standard trade approach.

perspective. In a multi-sectoral economy, *pervasive SBTC* per se, i.e. technical change that is complementary to skilled labor, but does not favor particular sectors of an economy,³ raises factor prices but does not affect relative factor prices. At unaltered commodity prices, pervasive adoption of more skill-intensive techniques only alters the composition of the production sector by generating a relative expansion of sectors using unskilled labor intensively. Only endogenous commodity-price adjustments that equilibrate commodity markets correct for this implication about an economy's sectoral adjustments, which is counterfactual as well.⁴ As a result, SBTC affects wage inequality only as far as it generates changes in relative commodity prices, and therefore the scope of the SBTC hypothesis in explaining the observed rise in the skill premium seems rather limited as well.

The present paper argues that changes in relative commodity prices affect the skill premium measured in empirical studies not only through the Stolper-Samuelson effects on factor prices, but also through adjustments in the composition of skilled and unskilled labor induced by that changes in factor prices. We emphasize the term 'measured skill premium', because wage incomes within skilled and unskilled labor obviously differ. Consequently, the skill premium is typically calculated using some average wage income for each group of labor.

³Cf. Haskel (2000) for a clear-cut distinction of possible forms of technical progress.

⁴Note that these endogenous adjustments of commodity prices do not occur in a small open economy. Cf. Krugman (2000) for a discussion about the small-open-economy perspective in that context.

Such average wage incomes, however, crucially depend on the composition of each group. As we will show, Stolper–Samuelson effects generate changes in the composition of each group that can reinforce the impact of changes in relative prices on the measured skill premium. Furthermore, from the perspective of theory, there is no limit about the size of this magnification effect. Since the above mentioned analyses do not account for this selection effect, the role of global market integration and/or SBTC for the rise in wage inequality has been underestimated.

In order to clarify how this composition effect contributes to measured wage inequality, suppose that wage earnings are determined by the following regression function (cf. Taber, 2001)

$$Y_t = \alpha_t(s) + \gamma_t a + \epsilon_t,$$

where Y_t , a variable measuring earnings, is explained by years of schooling s , ability a , and a zero–mean stochastic disturbance term ϵ . The wage differential between two groups with different educational attainments s_H (skilled labor) and s_L (unskilled labor) is then described by

$$\begin{aligned} \mathbb{E}(Y_t|s = s_H) - \mathbb{E}(Y_t|s = s_L) &= \alpha_t(s_H) - \alpha_t(s_L) \\ &+ \gamma_t [\mathbb{E}(a|s = s_H) - \mathbb{E}(a|s = s_L)]. \end{aligned} \tag{1}$$

In (1), $\alpha_t(s_H) - \alpha_t(s_L)$ measures earning differences arising from different skills, while $\gamma_t [\mathbb{E}(a|s = s_H) - \mathbb{E}(a|s = s_L)]$ is the wage differential generated by differences in abilities across groups. This ‘ability bias’ depends on the returns to ability γ_t and on the distribution of abilities within skill groups. Changes in the skill premium as measured by (1) can then result from variations in the returns

to education or to ability, and from alterations of $E(a|s = s_H) - E(a|s = s_L)$, for which the selection of abilities into skill groups is crucial. Whereas the direct impact of changes in commodity prices (the Stolper–Samuelson effect) shows up in the differences arising from different skills, the magnification effect is comprised by the sorting effect which, moreover, impacts on the extent of inequality within skill groups through its influence on the degree of heterogeneity of the members.⁵ The empirical relevance of the ability bias has been demonstrated by Taber (2001).⁶ He has shown that the ‘ability bias’ explains a greater share of the rise in the US skill premium than the change in returns to education. Hence, the scope of the magnification effect seems important.

Our explanation of within–group wage differentials draws on heterogeneities of individuals with respect to their effective labor endowments. Specifically, agents are assumed to differ in their inherent abilities that determine the individuals’ effective labor supply, both for the skilled and the unskilled labor force. Individual wage incomes then differ, even though the prices of each effective unit of skilled or unskilled labor (factor prices) are identical. This allows for some explanation of residual wage inequality as well.

Differences in individual wage incomes also generate differences in the indi-

⁵Acemoglu (1999) analyzes an alternative magnification effect that works through endogenous skill–biased technological change. Thus, his magnification effect works through changes in the composition of labor demand. In contrast, the present approach emphasizes magnification arising from changes in the composition of labor supply.

⁶Of course, it is impossible to identify the components of the ability bias. We concentrate on the composition effect exclusively.

viduals' incentives to invest in education, thereby endogenizing the supply of skilled and unskilled labor. With the decision to become educated depending on relative factor prices, there is an additional channel through which changes in relative commodity prices affect the measured skill premium. Any increase in the skill premium causes additional skill acquisition. Counterintuitively, that induced growth of the relative supply of skilled labor can reinforce the Stolper–Samuelson effect on the measured skill premium.⁷

The paper now proceeds as follows. Section 2 analyzes the decisions about acquiring education of heterogeneous individuals and shows how the composition of labor supply affects our measure of the skill premium. In section 3, we derive the impact of exogenous changes in relative commodity prices on the measured skill premium. Section 4 concludes by shortly discussing the model's implications about within–group wage inequality and presenting possible extensions of the model that can account for the diverging empirical evidence with respect to this problem.

⁷Of course, an increase in the relative wage of skilled labor could also raise the relative supply of skills in an otherwise neoclassical model. However, this adjustment of relative labor supply does not affect wage inequality as long as production is fully diversified. Once the economy is driven into complete specialization or driven into another cone of diversification, an increase in the relative supply of skilled labor always *reduces* the effect of changes in commodity prices on wage inequality (cf. Haskel, 2000).

2 The model

We consider an otherwise standard two-sector model of the production sector with skilled and unskilled labor as the only factors of production. We denote the price of the good that uses skilled labor relatively intensively by p and normalize the price of the other good to unity. Furthermore, we abstract from factor-intensity reversals thus ensuring that factor prices are uniquely determined by commodity prices as long as production is diversified. Diversification is assumed throughout the analysis.

The composition of labor supply is endogenously determined by decisions of individuals with heterogeneous inherent abilities. The economy is populated by a continuum of agents indexed by their ability a with the mass normalized to 1. Inherent abilities are distributed according to some density function $f(a)$ on the interval $[0, 1]$. An individual with ability a can either enter the labor force as unskilled thereby supplying $(1 + a)$ units of unskilled labor and earn the wage rate w_L per unit of effective labor. Alternatively, an individual can choose to spend an exogenously given fraction λ of time in training to become a skilled worker. Education is assumed to raise individual abilities. For simplicity, we assume individual abilities of skilled workers to be ba , where $b > 1$ can be interpreted as a measure of the efficiency of the educational system. Thus, a skilled worker with ability a supplies $(1 - \lambda)(1 + ba)$ units of skilled labor and earns the wage rate w_H per unit of effective labor. The wage income of an individual with ability a then either is $(1 + a)w_L$ as an unskilled worker, or $(1 - \lambda)(1 + ba)w_H$ as a skilled

worker.

An individual chooses to become skilled iff its ability is not smaller than some threshold value t determined by

$$t(p) = \{a : (1 + a) - (1 + ba)(1 - \lambda)\omega(p) = 0\}, \quad \omega(p) := \frac{w_H}{w_L}(p). \quad (2)$$

Given our assumptions about factor intensities, ω is a function of p with $\omega'(p) > 0$. Figure 1 illustrates the determination of the threshold value $t(p)$. Provided that $2/(1 + b) \leq (1 - \lambda)\omega(p) \leq 1$, there exists a unique threshold value $t \in [0, 1]$.⁸ We assume this condition to be fulfilled in the following. Otherwise, either all or no individuals choose to become educated, a situation which is clearly contrary to fact.

[INSERT FIGURE 1 ABOUT HERE]

The education decision determines the aggregate supplies of unskilled and skilled labor (L and H) as functions of p :

$$L(p) = \int_0^{t(p)} (1 + a)f(a) da, \quad H(p) = \int_{t(p)}^1 (1 - \lambda)(1 + ba)f(a) da, \quad (3)$$

with $L'(p) < 0$, and $H'(p) > 0$. As a result, relative labor supply $h(p) := H(p)/L(p)$ depends on relative factor prices. Throughout our analysis, we assume that $h(p)$ lies in the cone of diversification bounded by $\underline{h}(p)$ and $\bar{h}(p)$.

In order to discuss the impact of a change in relative commodity prices on the skill premium we need to define a measure for the skill premium. Due to within-group heterogeneity there is no unique wage for workers of one educational group

⁸This condition can be easily checked using figure 1.

that naturally applies. Equation (1) suggests to use the ratio of the mean wage of skilled and unskilled workers. A major drawback with respect to practical application arises, since the mean is vulnerable to outliers. This might pose a serious problem in our model, because the wage distribution of the two groups is given by the upper or lower truncated distribution of inherent abilities which will most likely result in skewed distributions. Using the mean wage alone might overstate the measured skill premium. To tackle this problem we additionally use another measure of central tendency: the median wage of the skilled and unskilled workers.

We define the skill premium $x(p)$ as the ratio of the representative wage $m(w|s = s_i)$ ($i = L, H$) of the skilled to the unskilled workers given by one of our measures of central tendency. Since the wage function is a linear transformation of abilities, we express the mean/median wage as a function of the mean/median ability of the respective group:

$$x(p) := \frac{m(w|s = s_H)}{m(w|s = s_L)} = \frac{1 + bm(a|a > t(p))}{1 + m(a|a \leq t(p))} (1 - \lambda)\omega(p). \quad (4)$$

The skill premium decomposes into the relative wage (in efficiency units) of skilled labor, $\omega(p)$, weighted by the ratio of the representative efficiency units of skilled and unskilled labor. Since the international price ratio influences both the relative wage of skilled labor *and* the relative supply of skilled labor, there are two channels through which commodity–price changes affect the skill premium. First, $x(p)$ is affected directly via the change in $\omega(p)$; this is the Stolper–Samuelson effect known from the standard neoclassical model with fixed factor endowments. Sec-

ond, $x(p)$ is affected by the change of the relative effective supply of skilled labor through the composition of the labor force as reflected by changes in $m(a|a > t(p))$ and $m(a|a \leq t(p))$. As we will show in the following, the resulting change in relative labor supply can affect the skill premium in a counterintuitive way (cf. footnote 7): an increase in the relative supply of labor can *raise* the skill premium. Furthermore, the impact of a change in the composition of the labor force can be substantial even for minor changes in commodity prices. Slight changes in relative commodity prices are thus sufficient for a significant change of the skill premium.

3 Price changes and the skill premium

We model global market integration or SBTC as a change in relative commodity prices. As long as the economy remains fully diversified, factor prices are completely determined by commodity prices. The effects of trade or SBTC on factor prices are given by the Stolper–Samuelson theorem: An increase in the relative price of the skilled–labor intensive product—this is thought to be the typical consequence of either global market integration for industrialized countries or of pervasive SBTC in a world (resp. closed) economy—raises the relative wage of skilled labor. According to empirical studies, however, this direct effect of international trade on the skill premium explains only a minor part of the observed rise in the skill premium.

With endogenous education, changes in commodity prices also alter relative

labor supplies. From (2), a change in relative factor prices alters the threshold value $t(p)$ according to

$$t'(p) = \frac{(1 - \lambda) [1 + bt(p)]}{1 - (1 - \lambda)b\omega(p)} \omega'(p) < 0. \quad (5)$$

Obviously, t declines as p increases as long as the denominator is smaller than zero which is true as long as $t \in [0, 1]$. Note that the change in t can be substantial even for minor changes in relative factor prices. This is the case, if the marginal wage difference $w_L - b(1 - \lambda)w_H$ is small.

The following proposition then follows immediately from (3) and (5):

Proposition 1 *An increase in the relative price of the skill-intensive good raises both the relative factor price ω and the relative supply of skilled labor.*

The adjustment in relative labor supply represented by a change in $t(p)$ affects the wage income of the skilled and unskilled workers since the representative quality of labor or amount of efficiency units will change. Calculating the complete effect of a change in p on x from (4) gives:⁹

$$x'(p) \frac{p}{x} = \omega'(p) \frac{p}{\omega} + |t'(p)| p G(t) \quad (6)$$

where

$$G(t) := \left[\frac{m'(a|a < t)}{1 + m(a|a < t)} - \frac{bm'(a|a \geq t)}{1 + bm(a|a \geq t)} \right] \quad (7)$$

The function $G(t)$ measures the difference in the rate of change of the representative supply of effective labor units for both skill groups that is caused by

⁹For notational convenience we drop the functional argument p in $t(p)$ in the following.

a change in the threshold value $t(p)$. Changes in relative labor supply magnify (compensate) the effect of a change in relative factor prices on the skill premium iff the term $G(t)$ is positive (negative). The greater the difference in mean supply growth rates, the greater is the magnification effect of adjustments in $h(p)$.¹⁰

Magnification occurs, iff $G(t) > 0$, which essentially depends on the underlying distribution of abilities $f(a)$ and on the efficiency of the educational system b . Of course, there exist combinations of specific distribution functions and specific values of b such that $G(t) > 0$ holds. In the following we discuss two specific examples that do not rely on extreme assumptions on the distributional functions of inherent abilities in order to demonstrate that magnification occurs under quite plausible conditions. In each case, we analyze our two measures of central tendency, the mean and the median.

Magnification with uniformly distributed abilities

We first suppose that inherent abilities are distributed uniformly within the interval $[0, 1]$. This assumption is primarily made because it turns out to be the limiting case of more plausible distributions of innate abilities.¹¹ It implies

¹⁰Deardorff (2000) also endogenizes the decision about acquiring education in a similar setting of individuals with heterogeneous inherent abilities. However, he assumes that abilities do not affect effective labor supplies of the unskilled. As a result, endogenous adjustment of labor supply always compensates the effect of a change in relative factor prices.

¹¹Although the assumption of uniformly distributed abilities is by no means realistic, it is frequently applied in theoretical analyses (cf., e.g., Galor and Moav, 2000) on grounds of its tractability.

$f(a) = 1 \forall a \in [0, 1]$, and $F(a) = a$, where $F(a)$ is the distribution function of abilities. The truncated distributions are also uniform, and the mean and the median coincide. Thus, we concentrate on the mean.

The mean abilities of the respective groups are given by $E_L = t/2$ and $E_H = (1 + t)/2$. Calculating $G(t)$ gives us the following condition for magnification:

$$b < 2. \tag{8}$$

We arrive at the following proposition:

Proposition 2 *With abilities distributed uniformly over the admissible support, an increase in the relative supply of skilled labor raises the skill premium iff the returns to education in terms of effective labor supply are not too great. In this case, the effect of price changes on skill premium are magnified by endogenous labor supply reactions.*

Note that (5) implies that the smaller the value of b , the greater is *ceteris paribus* the change in t in absolute terms, and the less is the growth rate of the high-skilled mean effective labor supply. Hence, the greater is the magnification effect on the skill premium.

Magnification with symmetric and unimodal distribution of abilities

In our second example we discuss a more general class of distributional functions that includes our first example as a special limiting case. Assume inherent abilities to be distributed in the interval $[0, 1]$ according to a symmetric and unimodal

distribution with the following properties:

$$f(0) = f(1) = c \geq 0 \text{ and } \lim_{a \rightarrow 0} f'(a) = - \lim_{a \rightarrow 1} f'(a) > 0$$

We have to analyze the mean and the median separately, because the upper (lower) truncated distribution will be left (right) skewed. Obviously, the skill premium is always higher when measured by the mean wage income rather the medians' wage income.

The median ability of unskilled $a_L(t)$ and skilled $a_H(t)$ labor is implicitly defined by:

$$a_L(t) := F^{-1} \left[\frac{F(t)}{2} \right], \quad a_H(t) := F^{-1} \left[\frac{1 - F(t)}{2} \right].$$

The change of the median position resulting from changes in the threshold can be calculated as

$$\frac{da_L(t)}{dt} = \frac{1}{2} \frac{f(t)}{f(a_L(t))}, \quad \frac{da_H(t)}{dt} = \frac{1}{2} \frac{f(t)}{f(a_H(t))}.$$

Since the median positions rise as t increases, the sign of $G(t)$ is ambiguous in general. After replacing $m(\cdot)$ and $m'(\cdot)$ in (7), factor-price changes are magnified iff

$$G(t) = \frac{1}{2} \left[\frac{f(t)}{f(a_L(t))} \frac{1}{1 + a_L(t)} - \frac{f(t)}{f(a_H(t))} \frac{b}{1 + ba_H(t)} \right] > 0.$$

We arrive at the following proposition:

Proposition 3 *With abilities distributed symmetrically and single peaked over the admissible support with $f(0) = f(1) = c \in [0, 1/2)$, and using the median as a representative measure of the skill premium, the effect of price changes on the*

skill premium is magnified by endogenous labor–supply reactions iff the relative supply of skilled labor is sufficiently high.

Proof. The proof is in two steps. We first prove that the function $G(t)$ can have at most one root. We then show that both $\lim_{t \rightarrow 0} G(t) > 0$ and $\lim_{t \rightarrow 1} G(t) < 0$ hold for all $c \in [0, 1/2)$.

In order to simplify the first part of our proof, we define the function

$$Q(t) := \frac{1 + ba_H(t)}{b(1 + a_L(t))} - \frac{f(a_L(t))}{f(a_H(t))} > 0.$$

Obviously, the sign of the function $Q(t)$ determines the sign of $G(t)$. We now show that $Q(t)$ can have at most one root $\tilde{t} \in [0, 1]$.

Symmetry and single peakedness of f guarantee that $d[f(a_L)/f(a_H)]/dt > 0$.

Furthermore, we have

$$d\left(\frac{1 + ba_H}{b(1 + a_L)}\right)/dt = -\frac{f(t)}{2(1 + a_L)f(a_L)} \left[\frac{(1 + ba_H)}{b(1 + a_L)} - \frac{f(a_L)}{f(a_H)} \right].$$

This implies that

$$\text{sgn} \left[d\left(\frac{1 + ba_H}{b(1 + a_L)}\right)/dt \right] = -\text{sgn}[Q(t)].$$

Combining these results yields that for all t with $Q(t) \geq 0$ we have $Q'(t) < 0$. Consequently, the function $Q(t)$ —and hence the function $G(t)$ —can have at most one root.

For the second part we consider the limit of $G(t)$ at the lower and upper bound

of the support:

$$\begin{aligned}\lim_{t \rightarrow 0} G(t) &= \left[1 - \frac{zb}{1 + b/2} \right] / 2 \\ \lim_{t \rightarrow 1} G(t) &= \left[\frac{2}{3z} - \frac{b}{1 + b} \right] / 2,\end{aligned}$$

where $z := c/f(1/2)$. Single peakedness of f implies $f(1/2) > 1$ and therefore $z \in [0, c)$. Hence, the condition $c < 1/2$ is sufficient for $\lim_{t \rightarrow 0} Q(t) > 0$ and $\lim_{t \rightarrow 1} Q(t) < 0$ to hold.

Together with our result that there can be at most one root, and since $G(t)$ is a continuous function, the intermediate value theorem guarantees the existence of \tilde{t} such that $G(\tilde{t}) = 0$. We then have $G(t) \leq 0 \forall t \geq \tilde{t}$, and $G(t) < 0 \forall t > \tilde{t}$.

■

Note that the constraint $c < 1/2$ is not very restrictive, because it is most unlikely that extremes of high and low abilities are very frequent within a population.¹² Allowing for $c \geq 1/2$ gives us two additional cases where either only magnification or only compensation occurs for all admissible t . Which of these cases applies depends on the return to education, b . We can dispense with an in-depth analysis of these cases because they give us quite similar results as the analysis of the uniform distribution.¹³ It is noteworthy that for a symmetric distribution with plausible upper-bound and lower-bound weights the return to education has no influence whether magnification or compensation can occur in

¹²This point will be clearer at the end of the section where we calculate the function $G(t)$ for a specific distribution using empirical estimates of its parameters.

¹³Indeed, the condition $b < 2$ is sufficient, though not necessary, for magnification to occur.

general. The parameter b , however, directly controls the determination of relative labor supply.

Next we consider the function $G(t)$ for the mean–wage–income formulation:

$$G(t) = \frac{E'_L(t)}{1 + E_L(t)} - \frac{bE'_H(t)}{1 + bE_H(t)},$$

where $E_L(t)$ and $E_H(t)$ are the mean ability of the respective groups:

$$E_L(t) = \frac{1}{F(t)} \int_0^t af(a)da, \quad E_H(t) = \frac{1}{1 - F(t)} \int_t^1 af(a)da.$$

The derivatives $E'_L(t)$ and $E'_H(t)$ can be calculated as

$$E'_L(t) = \frac{f(t)}{F(t)} [t - E_L(t)], \quad E'_H(t) = \frac{f(t)}{1 - F(t)} [E_H(t) - t]$$

Both derivatives are positive over the whole support.

Magnification requires $G(t) > 0$, which leads us to the next proposition:

Proposition 4 *With abilities distributed symmetrically and single peaked over the admissible support with $f(0) = f(1) = c \in [0, 1/2)$, and using the mean as a representative measure of the skill premium, the effect of price changes on the skill premium is magnified by endogenous labor–supply reactions iff relative labor supply of skilled labor is sufficiently high.*

Proof. We again derive the limits of $G(t)$:

$$\begin{aligned} \lim_{t \rightarrow 0} G(t) &= E'_L(0) - \frac{b}{1 + b/2} \frac{c}{2} \\ \lim_{t \rightarrow 1} G(t) &= \frac{c}{3} - \frac{b}{1 + b} E'_H(1), \end{aligned}$$

with $E'_L(0) = E'_H(1)$ amounts to $2/3$ for $c = 0$, and to $1/2$ for $c > 0$ (cf. Appendix).

For $c \in [0, 1/2)$ we get $\lim_{t \rightarrow 0} G(t) > 0$ and $\lim_{t \rightarrow 1} G(t) < 0$, independent of b . Since $G(t)$ is a continuous function, the intermediate value theorem guarantees the existence of at least one t^* such that $G(t^*) = 0$. ■

As for the median, allowing for $c \in [1/2, 1]$ gives rise to two additional cases with either $G(0) < 0$ and $G(1) < 0$, or $G(0) > 0$ and $G(1) > 0$, depending on the value of b .

Similar to the median wage income formulation, we always have magnification *and* compensation as long $c < 1/2$, depending on the relative supply of skilled labor. With the mean as representative wage income, however, there is a theoretical possibility of more than one root, i.e., we have an alternating pattern of magnification and compensation as t changes. But the following numerical calculations of $G(t)$ provide considerable support for the existence of only one root for plausible distributions of inherent abilities.

We illustrate the graph $G(t)$ for the two different measures of the representative wage used to calculate the skill premium with the abilities distributed according to a truncated normal distribution represented by

$$f(a) = \frac{\phi(a, \sigma)}{\Phi(1, \sigma) - \Phi(0, \sigma)},$$

where $\phi(\cdot)$ and $\Phi(\cdot)$ are the density and the distribution function of the normal distribution with parameters $\mu = 0.5$ and $\sigma > 0$, respectively. The applied distribution has positive weights at the lower and upper support, these are approximately zero when the standard deviation is sufficiently small. We use a standard deviation of $\sigma = 0.075$ corresponding to the normal distribution usually

found in IQ-Studies.¹⁴ In figures 2 and 3, G_1 and G_2 represent the calculation of $G(t)$ by the median with $b = 1.3$ and $b = 100$, respectively. G_3 and G_4 represent the calculation of $G(t)$ by the mean using the same parameter values for b . Using these extreme values for b lets us sketch the upper and lower bound of $G(t)$. As one easily observes, using the median results in higher absolute values for both magnification and compensation than using the mean. This is due to faster change of the median compared to the mean. Our computations also show that a higher b slightly compresses the interval for magnification. However, as equation (5) indicates, this movement in b lowers the threshold t significantly.

INSERT FIGURES 2 AND 3 ABOUT HERE

4 Conclusions

This paper has emphasized endogenous adjustment of relative labor supply as an additional channel through which changes in relative commodity prices caused by globalization or SBTC affect the empirically measured skill premium. These composition effects arise from decisions of individuals with heterogeneous inherent abilities about acquiring human capital. Under plausible conditions, they magnify the traditional Stolper–Samuelson effect implying that even minor changes in relative prices can generate substantial changes in the skill premium. According

¹⁴To describe the distribution of abilities within a population, Wechsler (1939) used the normal distribution which is standard in psychology today. The mean is standardized to 100. Typical estimates for the standard deviation are 10 or 15. Our $\sigma = 0.075$ used in the simulation corresponds to a standard deviation of 15.

to our analysis, magnification is comprehensible for countries with high relative supplies of skilled labor. Thus, we should expect considerable increases in the skill premium in the US and other highly industrialized countries. On the other hand, endogenous labor–supply adjustments are likely to work against the Stolper–Samuelson effect in developing countries, where the relative supply of skilled labor typically is rather low. Since this counteracting effect arising from labor–supply adjustment is in no way limited by the extent of the change in factor prices, it clearly can dominate the Stolper–Samuelson effect on measured skill premium. As a result, the skill premium in developing countries does not necessarily decline when these countries experience adjustments of commodity prices in the process of globalization that are exactly the opposite of those in industrialized countries.

Our model also gives some first results on wage inequality within different groups of labor (residual wage inequality). As globalization or SBTC drive down the threshold ability, the group of skilled labor becomes more heterogeneous, and residual wage inequality (measured by, e.g., the Gini coefficient) increases. This may explain the observed rise in wage inequality within the group of skilled labor. On the other hand, the group of unskilled labor becomes less heterogeneous, and residual wage inequality declines. Although this is contrary to empirical observations, one must bear in mind that the evidence for an increase in within–group wage inequality is less strong for the unskilled. Additionally, within–group wage inequality for unskilled labor may have been primarily affected by institutional changes (cf., e.g., DiNardo, Fortin and Lemieux, 1996).

Appendix

We assume that the distribution of abilities is given by the following unimodal and symmetric distribution:

$$f(0) = f(1) = c \quad c \in [0, 1) \text{ and } \lim_{a \rightarrow 0} f'(a) = -\lim_{a \rightarrow 1} f'(a) > 0.$$

We can use the following properties of the truncated mean to derive the limit of the first derivative of mean wage for skilled and unskilled workers with respect to the threshold value:

$$\lim_{t \rightarrow 0} E'_L(t) = \lim_{t \rightarrow 1} E'_H(t)$$

$$\lim_{t \rightarrow 1} E'_L(t) = \lim_{t \rightarrow 0} E'_H(t).$$

Therefore we concentrate on the derivation of $\lim_{t \rightarrow 0} E'_L(t)$ and $\lim_{t \rightarrow 1} E'_L(t)$. We start with the $\lim_{t \rightarrow 0} E'_L(t)$:

$$\lim_{t \rightarrow 0} E'_L(t) = \lim_{t \rightarrow 0} t \frac{f(t)}{F(t)} - \lim_{t \rightarrow 0} \frac{f(t)}{F(t)^2} \int_0^t af(a)da. \quad (\text{A.1})$$

The limit of the first term in (A.1) $\lim_{t \rightarrow 0} t \frac{f(t)}{F(t)}$ gives us after applying L'Hospitals rule:

$$\lim_{t \rightarrow 0} t \frac{f(t)}{F(t)} = \lim_{t \rightarrow 0} \frac{f(t) + tf'(t)}{f(t)}.$$

For $c > 0$ we get $\lim_{t \rightarrow 0} t \frac{f(t)}{F(t)} = 1$. For $c = 0$ we have to apply L'Hospitals rule a second time:

$$\lim_{t \rightarrow 0} t \frac{f(t)}{F(t)} = \lim_{t \rightarrow 0} \frac{f(t) + tf'(t)}{f(t)} = \lim_{t \rightarrow 0} \frac{2f'(t) + tf''(t)}{f'(t)} = 2.$$

Collecting things we get for the first term in (A.1) the following result:

$$\lim_{t \rightarrow 0} t \frac{f(t)}{F(t)} = \begin{cases} 2 & \text{for } c = 0 \\ 1 & \text{for } c > 0 \end{cases} \quad (\text{A.2})$$

Next we turn to the second term in (A.1):

$$\lim_{t \rightarrow 0} \frac{1}{F(t)^2} f(t) \int_0^t af(a)da = \lim_{t \rightarrow 0} \frac{f'(t) \int_0^t af(a)da}{2F(t)f(t)} + \frac{1}{2} \lim_{t \rightarrow 0} \frac{tf(t)}{F(t)}. \quad (\text{A.3})$$

The limit of the second term in (A.3) is the same as in (A.2) but the first term is undecidable. Therefore we have to apply L'Hospital's rule again for that expression

$$\lim_{t \rightarrow 0} \frac{f'(t) \int_0^t af(a)da}{2F(t)f(t)} = \lim_{t \rightarrow 0} \frac{f''(t) \int_0^t af(a)da + f'(t)tf(t)}{2[F(t)f'(t) + f(t)^2]}.$$

For $c > 0$ the limit of that expression is zero but for $c = 0$ the limit is again undecidable and we get:

$$\lim_{t \rightarrow 0} \frac{2f''(t)tf(t) + f'''(t) \int_0^t af(a)da + f'(t)f(t) + f'(t)^2t}{2[F(t)f''(t) + 3f(t)f'(t)]}.$$

Since the limit of this term is again undecidable, we once again apply L'Hospital's rule. Dropping all expressions that include $f(t)$, t , $F(t)$ and $\int_0^t af(a)da$ after differentiation (since they are equal to zero), we arrive at

$$\lim_{t \rightarrow 0} \frac{2f'(t)^2}{6f'(t)^2} = \frac{1}{3}$$

As a result the limit of the second term in (A.1) is:

$$\lim_{t \rightarrow 0} \frac{f(t)}{F(t)^2} \int_0^t af(a)da = \begin{cases} \frac{4}{3} & \text{for } c = 0 \\ \frac{1}{2} & \text{for } c > 0. \end{cases} \quad (\text{A.4})$$

Collecting terms from (A.2) and (A.4), we finally derive the limit $\lim_{t \rightarrow 0} E'_L(t)$:

$$\lim_{t \rightarrow 0} E'_L(t) = \begin{cases} \frac{2}{3} & \text{for } c = 0 \\ \frac{1}{2} & \text{for } c > 0. \end{cases}$$

The limit $\lim_{t \rightarrow 1} E'_L(t)$ is given by:

$$\begin{aligned} \lim_{t \rightarrow 1} E'_L(t) &= \lim_{t \rightarrow 1} \frac{f(t)}{F(t)} [t - E_L] \\ &= \frac{1}{2} \lim_{t \rightarrow 1} f(t) = \begin{cases} 0 & \text{for } c = 0 \\ \frac{c}{2} & \text{for } c > 0. \end{cases} \end{aligned}$$

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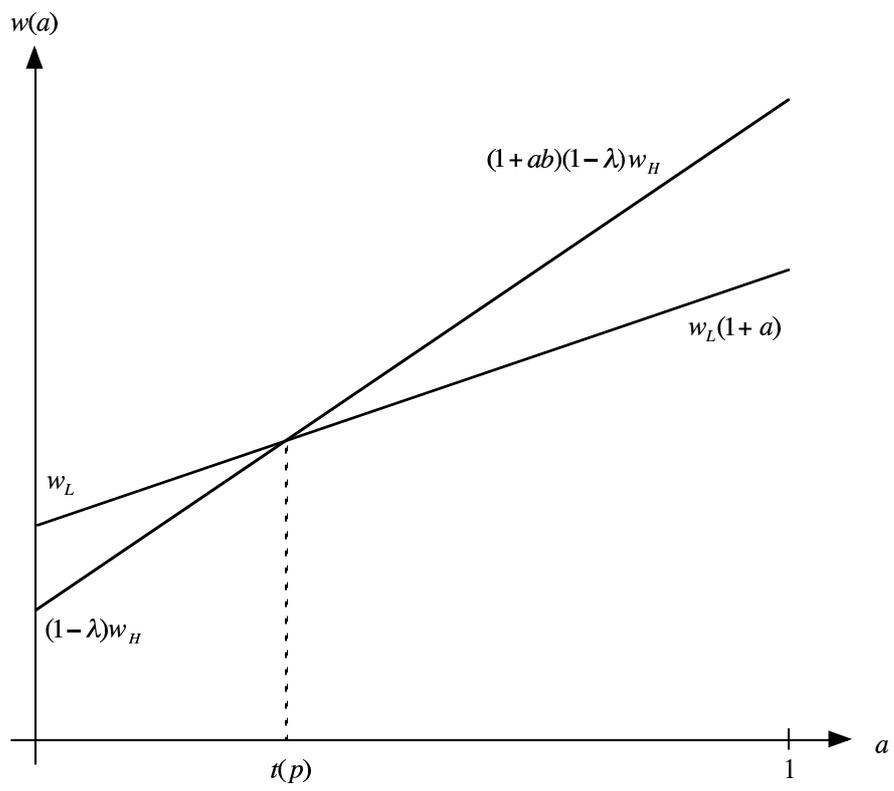


Figure 1: The determination of the threshold value $t(p)$

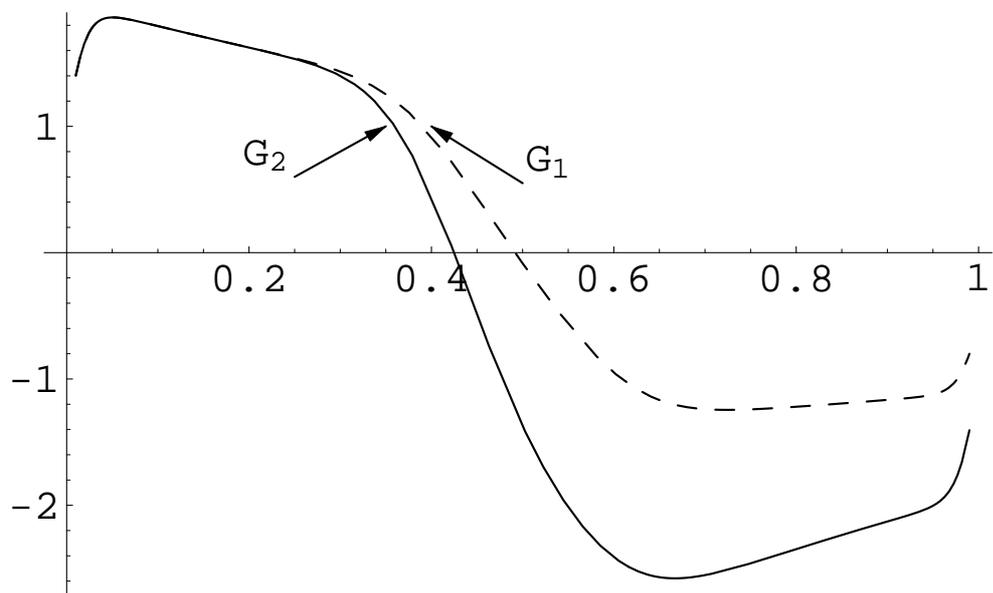


Figure 2: $G(t)$ using the median wage representation. The graph G_1 uses $b=1.3$ and G_3 uses $b=100$

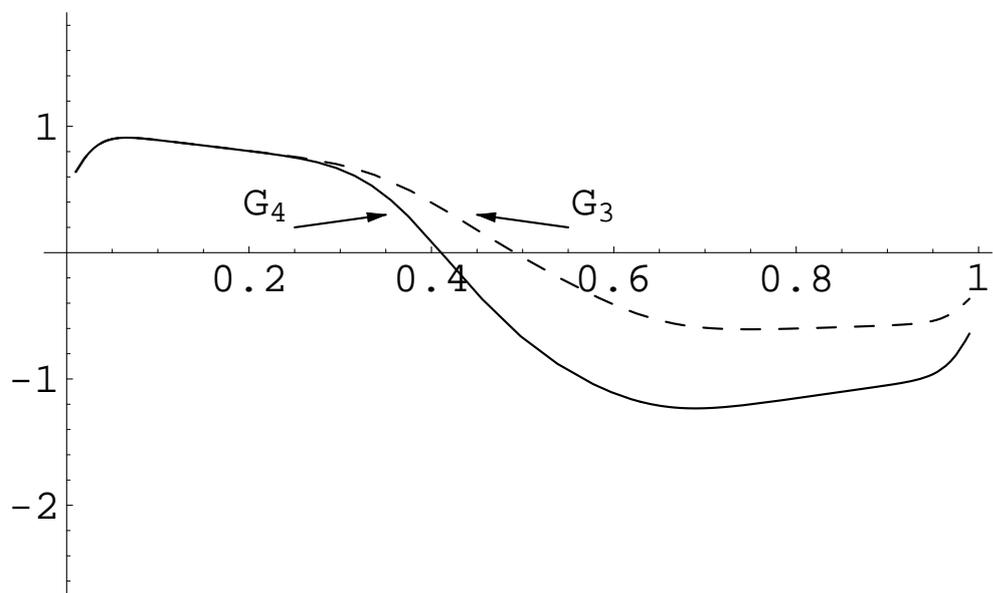


Figure 3: $G(t)$ using the mean wage representation. The graph G_3 uses $b=1.3$ and G_4 uses $b=100$