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Abstract

Incorporating family decisions in a two-period.model of the world economy, we predict that trade liberalization raises the skill premium and reduces child labour in developing countries where the adult labour force is sufficiently well educated to attract production activities from abroad that will increase the demand for skilled relative to unskilled labour. Elsewhere, liberalization will reduce the skill premium, but it will not necessarily raise child labour. Our prediction is not rejected by the data, and it explains why child labour is negatively associated with trade openness in those developing countries where the labour force was relatively well educated when the liberalization took place, but not in the others.

JEL-Codes: D130, D330, F160, J130, J240.

Keywords: child labour, education, trade liberalization, skill endowments, skill premium.

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1 Introduction

Child labour is a matter of great concern not only for humanitarian reasons, but also because it reduces the quantity and quality of the time that a child spends studying,[1] and it is thus a major obstacle to economic development. Since the middle of the last century, the world economy has witnessed an unprecedented expansion of international trade and investment ("globalization"). In more recent decades, this has been accompanied by widespread changes in relative wage rates, and in the incidence of child labour. Is there a nexus between these three phenomena? A strand of economic literature views child labour as a direct consequence of extreme poverty. According to this line of reasoning, if parental income is sufficient to keep the entire family above subsistence level, children will not work. If it falls below that level, children will work. For an overview of the theory, see Basu and Van (1998). For empirical work along these lines, see Edmonds (2005). Another strand of economic literature (see Cigno and Rosati 2002) views child labour as the outcome of parental optimization. According to this second line of reasoning, decisions concerning the allocation of a child's time rest on a comparison of the immediate benefits of child labour with the expected future benefits of education. The two approaches are not irreconcilable. If parents cannot borrow and have no assets to draw on, current expenditure cannot exceed current income. In liquidity-constrained families, children will then work even if the expected return to education is higher than the return to child labour (Ranjan 2001, Cigno 2012).[2] For empirical work along these lines, see Dehejia and Gatti (2005). Without credit rationing, therefore, the allocation of a child's time would be the outcome of a portfolio decision. With credit rationing, the decision will depend also on parental income.

How does globalization come into the picture? The opportunity to trade and invest across national borders enlarges the opportunity set and raises per-capita GDP. Other things being equal, it could thus be expected to relax the liquidity constraints facing families with children, and to bring about a reduction in child labour. Other things are not equal however, because international trade and investment may alter relative factor prices. Heckscher-Ohlin (henceforth HO) theory predicts that, if a country opens itself up to trade, it will specialize further in the production of the goods that make more intensive use of its comparatively more abundant untradable factor. Stolper-Samuelson (henceforth SS) add that the rate of return to the comparatively more abundant factor will rise relative to that of the less abundant ones. If the non-tradable factors are capital and labour as in the standard North-South model, liberalization will then induce the labour-abundant South to specialize further in the production of labour-intensive goods, and the capital-abundant North to specialize further in that of capital-intensive

[1] See Cigno (2012) and references therein.

[2] An additional reason why children from poor families study less and work more than children from rich ones is that the return to education lies in the future and is consequently uncertain, while the return to child labour is immediate and consequenly certain. Assuming that risk-aversion is decreasing in income, rich parents will then be willing to risk more than poor parents.

goods. The wage rate will consequently rise relative to the return to capital in the South, and fall in the North. If the non-tradable factors are skilled (more educated) and unskilled (less educated) labour as in Wood (1994), liberalization will induce the skill-abundant North to specialize further in the production of goods with a high skill content, and the skill-poor South to specialize further in that of goods with a low skill content. With liberalization, therefore, the skilled-to-unskilled wage ratio (the "skill premium") will rise in the North, and fall in the South. This prediction is not borne out by the facts however. Leamer (1996, 1998) finds no trace of an SS effect. Feenstra and Hanson (1996), Robbins (1996), Wood (1997) and Freeman and Oostendorp (2001) report that greater openness is associated with a higher skill premium not only in the North, but also in parts of the South. After reviewing a substantial body of evidence on the distributional effects of globalization, Goldberg and Pavcnik (2007) conclude that "... the distributional changes went in the opposite direction from the one suggested by conventional wisdom: while globalization was expected to help the less skilled who are presumed to be the locally relatively abundant factor in developing countries, there is overwhelming evidence that these are generally not better off, at least not relative to workers with higher skill or education levels." More recent surveys like Cigno (2015), and Crozet and Orefice (2017), tell a more complicated story (essentially that not all developing countries are the same).

Does this mean that traditional trade theory is wrong? HO assumes that each country is endowed with fixed amounts of non-tradeable factors, including skilled and unskilled labour. It also assumes that all trading countries have access to the same technology, and that they trade in final goods only. But none of this is true in reality. First, the stock of unskilled labour is augmented by child labour, and the stock of skilled labour is augmented by educational investment. An early contribution by Findlay and Kierzkowsky (1983) introduces endogenous skill acquisition in the HO model. The dynamic implications are investigated by Harris and Robertson (2013), and Danziger (2017*)* in a small open economy framework. Second, not all of the technology is there for the taking. New production processes are typically invented in the North and initially available only to the firms that either invented or bought a licence to use them. In recent decades, with the reduction of obstacles to international trade and investment, more and more of these firms have found it advantageous to transfer ("offshore") the less skill-intensive segments of their production processes, new or old, to less developed countries where the cost of carrying them out is lower, and to keep only the more skill-intensive segments in the home country. This has effectively extended the range of production possibilities open to the South, and led to a sharp increase in the volume of international trade in intermediate goods. As pointed out by Feenstra and Hanson (1996), Zhu and Trefler (2005), and Grossman and Rossi-Hansberg (2017), if the activities so relocated were more skill-intensive than those originally carried out in the destination country, this will have caused the demand for skilled labour to shift upwards in the destination country, and thus put upwards pressure on that country's skill premium. The opposite will have happened if the relocated activities were less skill-intensive than those originally carried out in the destination country (but this possibility, briefly mentioned in Wood 2002, is overlooked in Feenstra and Hanson 1996, and Zhu and Trefler 2005).

The present paper argues theoretically and shows empirically that the skill premium will rise, and the child labour rate will fall, in developing countries that are sufficiently well-endowed with skilled labour when they open themselves up to foreign trade and investment. In the other developing countries, the skill premium will fall, and the child labour rate may rise. The paper develops as follows. Section 2 draws the reader's attention to some cross-country statistical regularities. Section 3 seeks to explain these broad facts. As we are ultimately interested in child labour, the analysis is designed to explain wage differences between skilled and unskilled workers, rather than wage inequality per se.[3] With that end in mind, we graft a simplified family model of education and child labour decisions along the lines of Ranjan (2001) and Cigno (2012) on to a two-period extension of the North-South trade model underlying Feenstra and Hanson (1996), and Zhu and Trefler (2005). As far as we are aware, we are the first to do that. The endogenization of skilled and unskilled labour via education and child labour, and the introduction of a time dimension in the decision process, make our analysis akin to that of Danziger (2017). Like the latter, we aim to predict the effects of trade liberalization. Unlike the latter, however, we focus on the child labour effects, and adopt a general equilibrium framework (furthermore, we distinguish between the date when liberalization is announced, and the date when it is actually implemented). We do not model the effect of trade on productivity, because that has already been done in several of the papers cited, but we allow for this effect in the empirical implementation. Section 4 finds empirical support for our explanation of the facts. Section 5 sums up and draws some tentative policy conclusions.

2 Stylized facts

The present section highlights a number of intriguing statistical regularities regarding 207 countries and 13 years (more about these data later). Figure 1 plots child labour against the log of per-capita GDP. The correlation is negative but small, suggesting the presence of other important co-variates. The same figure shows also the child labour rate predicted by a Generalized Linear Model regression with a binomial distribution and a logit link function (see Papke and Wooldridge, 1996).[4] As shown in Table A3 of Appendix 2, the marginal effect of per-capita GDP is negative, but it gets smaller as per-capita GDP gets larger. For low-income economies (those with per-capita GDP below 1000

[3] Cosar et al. (2016), Helpman et al. (2017) and several others examine the effects of international economic integration on wage inequalities across sectors or individual firms. Although Burstein and Vogel (2017) show that these inequalities are intertwined with those concerning differently skilled workers, we do not make any attempt at explaining the former because it would further complicate an already complicated model.

[4] By construction, this statistical model takes into account the nonlinearities arising from the fact that the dependent variable is constrained between 0 and 1.

PPP US dollars a year), a 1% increase in per-capita GDP is associated with a 10% reduction in child labour. For low-to-middle income economies (those with per-capita GDP between 1000 and 4000), the marginal effect is half that estimated for low-income economies. For upper-middle income economies (those with per-capita GDP above 4000), the reduction is less than 4%, falling to about 2% for higher-income countries. In light of our introductory discussion about different ways of explaining child labour, it would thus appear that income is the dominant factor in very poor countries, where a large share of the population is liquidity-constrained (and the government's ability to subsidize education out of general taxation is severely limited), but the return to education gains in importance and may eventually predominate as we move up the income scale. In other words, the common perception that child labour is associated with poverty is well founded where very low income countries are concerned, but not elsewhere.

Figure 1: Child labour and per-capita GDP HERE

Figure 2 plots child labour against a measure of trade openness (exports minus imports, over exports plus imports), lagged five years.[5] Consistently with Cigno et al. (2002), and Edmonds and Pavcnik (2006), the correlation appears to be negative but low. The picture changes, however, if we cut the sample into two subsamples, one containing countries where the share of the adult population educated to tertiary level is higher than the sample median (13.06), and the other containing those where the share in question is lower. The median appears to mark a natural break in the data, because there are very few countries where the share of adults educated to that level is close to it. Figure 3 shows that child labour and trade openness are negatively associated in the first, better-educated, sub-sample (Panel a), but there appears to be no correlation between those two variables in the second, less well-educated, sub-sample (Panel b). It would thus seem that the sign of the correlation between child labour and trade exposure depends on the size of the skill endowment. As shown in Figure 4, the better educated countries include most of the ex-Soviet republics, and most Latin-American countries (among them Argentina, Brazil and, just about, Mexico), but also Iran, the Philippines and Viet Nam. The less well educated ones include most of Africa and the Middle-East, but also Indonesia and Portugal.[6] What are we to make of these stylized facts?

Figures 2: Child labour and trade openness HERE

Figure 3, Panels a and b: Child labour and trade openness by education level HERE

[5] The same figure with different lags (0, 1 and 3 years) is available on request from the authors. The picture is very similar.

[6] The criterion used in constructing Figure 4 is slightly different from the one used to construct Figure 3. In the former, we classify as less well educated the countries where the Low education variable (the share of the adult population with no schooling, or less than completed primary education) is above the sample median. In the latter, we classify as less well educated the countries where the Tertiary education variable (the share of the adult population with short tertiary, Master, PhD, etc.) is above the sample median. The motivation for having different criteria is to have as many country data as possible, but the ranking is not affected by the criterion used.

Figure 4: Countries with child labour, ranked by educational level HERE

3 An explanatory framework

In order to explain these stylized facts, we construct a general-equilibrium model of the world economy with two periods labelled $t = 1, 2$, and two countries labelled $i = N, S$ (where N stands for North and S for South). As we are ultimately interested in child labour, and this is concentrated in the South, we give only a summary account of what happens in the North. We assume that international trade barriers are prohibitively high in period 1. Regarding period 2, we envisage two alternative scenarios. One is that barriers will remain prohibitively high. The other is that they will be abolished. For analytical convenience, we specify log-linear production and utility functions (but the results extend to regular neoclassical functions in general).

There are two immobile factors of production, skilled labour H and unskilled labour L, two potentially tradeable intermediate goods, x_1 and x_2, a tradeable final good, A, and two non-tradeable final goods, B and C. We assume that x_1 could be made in either country using skilled and unskilled labour according to the constant-returns-to-scale technology

$$x_1 = L_{x_1}^{\varepsilon} H_{x_1}^{1-\varepsilon},\ 0 < \varepsilon < 1. \tag{1}$$

By contrast, x_2, can be produced only in the North. We may justify this assumption by saying that the technology used to produce this intermediate good cannot be imitated by competitors, because it is a complex skill-intensive technology that does not generate informational spillovers.[7] One of the final goods, B, is produced only in the South,[8] according to the constant-returns-to-scale technology

$$B = L_B^{\beta} H_B^{1-\beta},\ 0 < \beta < 1, \tag{2}$$

and another, C, only in the North.[9] The third final good, A, can be costlessly assembled from x_1 and x_2 in accordance with

$$A = x_1^{\alpha} x_2^{1-\alpha},\ 0 < \alpha < 1. \tag{3}$$

In principle, this could be done in either part of the world. For it to be done in the South, however, it must be possible to import x_2 from the North. In period 1, therefore, the North can produce and consume both A and C, but the South can produce and consume only good B. According to the first scenario, the same applies to period 2. According to the second scenario, by contrast, in

[7] See Thoenig and Verdier (2003).

[8] Like Wood (2002), we may assume that the B-producing sector is not just subsistence agriculture, but includes also a "modern sector" producing goods of less than export quality.

[9] As we do not model the North explicitly, we do not need to specify the production functions of x_2 and C.

period 2 the South can produce and consume also good A. Southern product and labour markets are assumed to be perfectly competitive in both periods.

In each period, each country is populated by a measure one of families. In period 1, each family consists of an altruistic mother and her school-age son.[10] Each mother is endowed with one unit of time, and each son with θ units of adult-equivalent time ($0 < \theta < 1$). The mother spends τ units of time looking after her son ($0 < \tau < 1$), and supplies the rest inelastically to the labour market. The son spends e units of adult-equivalent time ($0 \leq e \leq \theta$) studying, and the rest working. The amount of time a child spends studying in period 1 determines the probability that he will be a skilled worker in period 2. In period 2, each family will consist of a non-altruistic male adult (the now grown-up son) endowed with one unit of time. This adult will supply his entire time endowment inelastically to the labour market. A family is said to be of type H if its adult member is skilled, of type L if its adult member is unskilled. We denote by a_t ($0 < a_t < 1$) the share of type-H families, and by $1 - a_t$ that of type-L families, in the South in period t. Note that a_1 is a parameter, but a_2 is endogenous. We will refer to a_1 as the South's "skill endowment".

In period 1, a mother cannot finance her son's education on credit, because she will not be around next period to pay the loan back, and her son will not be legally obliged to honour a debt incurred on his behalf when he was little. Baland and Robinson (2002) call this the "rotten parents" problem.[11] As a consequence, some children will be sent to work rather than school even if the return to education is expected to be high. There are thus two channels through which the expectation that trade barriers will come down in period 2 may affect the demand for education, and the supply of child labour, in period 1. Via the expected return to education, because it alters the expected period-2 skill premium. Via family budget constraints, because it alters the distribution of period-1 income between type-H and type-L families.

Let q_{ti} denote the skilled wage rate, and w_{ti} the unskilled wage rate of country i in period t . We assume that, in equilibrium,

$$\frac{q_{tS}}{w_{tS}} > \frac{q_{tN}}{w_{tN}},\ t = 1, 2. \tag{4}$$

Put another way, we call North the country where technology, and the legislation concerning school attendance and child work are such, that the share of skilled adults is larger than in the country called South, not only in period 1, but also in period 2. We further assume that individuals hold rational expectations. Solving the model by backward induction yields a free-trade general equilibrium for the

[10] The assumption that there are no daughters allows us to limit the analysis to two periods. More elaborate models of family decisions have parents and children of both sexes, and parents overlapping with their children also in the second period. But the simpler model adopted here suffices for our purposes.

[11] More elaborate stories have parents borrowing on their children's behalf, and self-enforcing family rules ensuring that grown-up children will reimburse their parents even though they are not obliged to do so by a legally enforceable contract; see Cigno and Rosati (2005). But that will not ensure that educational investment is at the efficient level if parents are credit rationed anyway.

two countries together under the second scenario, and an autarchic general equilibrium for each country under the first one (in actual fact, we derive the free-trade equilibrium in detail, and then deduce what would have happened in the South under autarchy). As the analytical techniques are well known, we emphasize the economic interpretation.

3.1 Period 2

In this period, the share of type-H families (a_2 for the South) is given for both countries. We take the second (free-trade) scenario first, and then deduce what would happen in the first (autarchic) scenario.

3.1.1 Production and costs

With free trade, the South can assemble the final good A from the intermediate good x_1 produced locally and the intermediate good x_2 imported from the North. The minimum period-2 unit cost of producing x_1 in the South is

$$c_1 = q_{2S} h^*_{x_1} + w_{2S} l^*_{x_1}, \tag{5}$$

where $h^*_{x_1}$ and $l^*_{x_1}$ are the cost-minimizing inputs of, respectively, skilled and unskilled labour per unit of x_1 at the given $\frac{q_{2S}}{w_{2S}}$ (see Appendix 1). Recalling that (4) holds, we can realistically assume that this cost is lower than the similarly determined unit cost of producing x_1 in the North, and thus that x_1 will be produced only in the South. We interpret this as saying that Northern x_1 producers will relocate their factories to the South.[12]

Recalling that the other intermediate good, x_2, can be produced only in the North, and denoting the minimum period-2 unit cost of this good by c_2,[13] it then follows that the minimum period-2 unit cost of producing the final good A in the South is

$$c_A = c_1 x^*_1 + c_2 x^*_2, \tag{6}$$

where x^*_1 and x^*_2 are the cost-minimizing inputs (see Appendix 1) of the intermediate goods x_1 and x_2 per unit of A. The South's minimum period-2 unit cost of B will be

$$c_B = q_{2S} h^*_B + w_{2S} l^*_B,$$

where h^*_B and l^*_B are the cost-minimizing inputs of, respectively, unskilled and unskilled labour per unit of B at the given $\frac{q_{2S}}{w_{2S}}$ (see again Appendix 1).

[12] In Tang and Wood (2000), this is induced by a fall in co-operation cost that makes it advantageous to transfer entrepreneurs, designers, engineers and other professionals from the North to the South. In Feenstra and Hanson (1996), offshoring is made profitable by the fall in in the cost of production of the South relative to that of the North. This fall is explained by capital flows lowering the interest rate in the South relative to the North. In Zhu and Tefler (2005) it is the Southern catch up that makes profitable relocating the production of some goods from the North to the South. All these arguments could be applied also to our model. For simplicity, however, we have directly assumed that trade liberalization makes it possible and advantageous for the North to import x_1 from the South.

[13] As we have not modelled the production of x_2, we treat c_2 as a parameter.

3.1.2 Demand

Recalling that, in this period, each family consists of just one adult, we may specify that the utility of a Southern type-j family ($j = H, L$) is given by

$$U_{S2} = \ln B_j + \gamma \ln A_j, \ 0 < \gamma < 1,$$

where A_j and B_j are the quantities of the two final goods consumed by each type-j Southern adult. A similar function, with C_j in place of A_j, will determine the utility of a Northern type-j family. Recalling that a fraction a_2 of Southern families is of type H, and the rest of type L, the average Southern family then solves

$$\begin{aligned} & Max\ U_{S2} \\ \text{s.t. } Y_{S2} &= P_{B2}B + P_{A2}A, \end{aligned}$$

where P_{A2} and P_{B2} are the current prices of goods A and B, and

$$Y_{S2} = a_2 q_{2S} + (1 - a_2) w_{2S}$$

is the average income. Using the first-order conditions, we can derive the South's period-2 average demands for the two final goods,

$$\begin{aligned} A_{S2}^D &= \frac{\gamma}{1+\gamma}\frac{Y_{S2}}{P_{A2}} \\ B_2^D &= \frac{1}{1+\gamma}\frac{Y_{S2}}{P_{B2}}. \end{aligned} \tag{7}$$

Hence,

$$\frac{A_{S2}^D}{B_2^D} = \gamma \frac{P_{B2}}{P_{A2}}. \tag{8}$$

Recalling that we are assuming free trade, but x_1 can be produced only in the North, the derived demands for the two intermediate goods are then

$$\begin{aligned} x_{S1}^D &= x_1^* \left(A_{N2}^D + A_{S2}^D \right) \\ x_{S2}^D &= x_2^* A_{S2}^D, \end{aligned} \tag{9}$$

where A_{N2}^D is the North's period-2 demand for the final good A, obtained following the same steps as for the South.

3.1.3 Equilibrium

For the zero-profit condition, prices equal unit costs. Therefore,

$$P_{A2} = c_A = x_1^* l_{x_1}^* w_{2S} + x_1^* h_{x_1}^* q_{2S} + x_2^* c_2 \tag{10}$$

and

$$P_{B2} = c_B = l_B^* w_{2S} + h_B^* q_{2S}. \tag{11}$$

The South's labour-market clearing conditions are

$$a_2 = h_B^* B_2 + x_1^* h_{x_1}^* (A_{N2} + A_{S2}) \tag{12}$$

and

$$1 - a_2 = l_B^* B_2 + x_1^* l_{x_1}^* (A_{N2} + A_{S2}). \tag{13}$$

Similar conditions apply to the North. Together with goods-markets clearing conditions for North and South, these equations determine prices, wages and quantities produced in both countries

Let us now make the standard No-Factor-Intensity-Reversal (NFIR) assumption. For any $\frac{q_{2S}}{w_{2S}}$, we will then have that either

$$\frac{x_1^* h_{x_1}^*}{x_1^* l_{x_1}^*} > \frac{h_B^*}{l_B^*} \tag{14}$$

or

$$\frac{x_1^* h_{x_1}^*}{x_1^* l_{x_1}^*} < \frac{h_B^*}{l_B^*}. \tag{15}$$

In view of (3), the competitive share of x_2 in the value of A is $x_2^* c_2 = (1-\alpha)P_{A2}$, *(10)* -(11) imply a two-way relationship between $\frac{P_{A2}}{P_{B_2}}$ and $\frac{q_{2S}}{w_{2S}}$ such that

$$\frac{P_{A2}}{P_{B2}} = \frac{1}{\alpha}\varphi(\frac{q_{2S}}{w_{2S}}), \text{ with } \varphi' > 0 \text{ for } (14)\,,\, \varphi' < 0 \text{ for } (15)\,. \tag{16}$$

Substituting from (16) into (8), and then into $(12) - (13)$, yields two equations in the two unknowns q_{2S} and w_{2S}. Solving these equations gives us the period-2 skill premium, $\frac{q_{2S}}{w_{2S}}$, as a function of a_2, α and γ,

$$\frac{q_{2S}}{w_{2S}} = G(a_2,\alpha,\gamma),\, G_{a_2} < 0. \tag{17}$$

The function $G\,(.)$ will differ according to whether (14) or (15) holds true. Denoting the first case by the superscript U, and the second case by the superscript D, it can be easily shown that, for any (a_2, α, γ),

$$G^U(a_2,\alpha,\gamma) > G^D(a_2,\alpha,\gamma),\, G_\alpha^U > 0,\, G_\gamma^U > 0,\, G_\alpha^D < 0 \text{ and } G_\gamma^{'D} < 0. \tag{18}$$

How would things differ if we were in the first (autarchic) scenario, instead of the second (free-trade) one? As trade barriers would then be prohibitively high, the South could produce and consume only good B as in period 1. Having established that, with free trade, $\frac{h_B^*}{l_B^*}$ may be either lower or higher than $\frac{x_1^* h_{x_1}^*}{x_1^* l_{x_1}^*}$ for all $\frac{q_{2S}}{w_{2S}}$, it then follows that, in autarchy, the period-2 equilibrium skill premium, denoted by $G^M(a_2)$, will lie between $G^U(a_2,\alpha,\gamma)$ and $G^D(a_2,\alpha,\gamma)$,

$$G^D(a_2,\alpha,\gamma) < G^M(a_2) < G^U(a_2,\alpha,\gamma). \tag{19}$$

The intuition is straightforward. If the intermediate good x_1 is more skill-intensive than the final good B, liberalization will raise the South's period-2 skill premium (the SS effect). Otherwise, it will lower the South's period-2 skill premium (an anti-SS effect). Which will be the case depends, as we will argue at the end of this section, on a_1.

3.2 Period 1

Having obtained $\frac{q_{2S}}{w_{2S}}$ as a function of a_2 , we are now ready to investigate how e and consequently a_2 are determined in the current period, given the South's skill endowment a_1, in the two alternative scenarios under consideration. Keep in mind that, in the current period, the economy is closed under either scenario. Given, however, that the function relating $\frac{q_{2S}}{w_{2S}}$ to a_2 differs according to whether the economy will be open or closed in the next period, current family decisions and consequently the current equilibrium will still depend on the choice of scenario. We will look in some detail at family decisions, but will skip the derivation of the cost relationships (analogous to those obtained for period 2).

3.2.1 Consumption and education

The family decision maker is now the mother. Recall that, in type-j families ($j = H, L$), the son spends e_j units of his adult-equivalent time studying, and $1 - e_j$ working. Let $\pi(e_j)$ denote the probability that the son will be a skilled worker in period 2. For simplicity, we assume $\pi(e_j) = e_j$. As child labour is obviously unskilled, and having assumed that it substitutes for unskilled adult labour at the constant rate θ, the opportunity-cost of education per unit of adult-equivalent time is then w_{S1} (we abstract from out-of-pocket costs). To avoid carrying too many constants around, we set $\theta = \tau = \frac{1}{2}$. We use B as the numeraire good.

Having assumed that mothers care about their children's future consumption (hence future earning capacity), and given that the outcome of educational investment is uncertain, type-j mothers maximize an expected utility function,

$$EU_{S1}^{j} = \ln B_j + \delta\left[e_j \ln q_{2S} + (1 - e_j)\ln w_{2S}\right],\ 0 < \delta < 1.$$

A type-j Southern family then solves

$$\begin{aligned} & Max\ EU_{S1}^{j}, \\ \text{s.t. } 0 \ \leq\ & e_j \leq \theta \\ R_j \ =\ & B_j \end{aligned}$$

where R_j is its income, determined by either

$$R_H = \frac{1}{2}\left[(q_{1S} + (1 - e_H)w_{1S}\right]$$

or

$$R_L = \frac{1}{2}\left[(w_{1S} + (1 - e_L)w_{1S}\right]$$

Let B_{j1}^{D} denote the period-1 consumption of B, and e_j^D the demand for education, of a type-j Southern family. At an interior solution,

$$B_{j1}^{D} = \frac{w_{1S}}{2\gamma \ln \frac{q_{2S}}{w_{2S}}},\ j = H, L,$$

$$e_H^D = 1 + \frac{q_{1S}}{w_{1S}} - \frac{1}{\gamma \ln \frac{q_{2S}}{w_{2S}}} \tag{20}$$

and

$$e_L^D = 2 - \frac{1}{\gamma \ln \frac{q_{2S}}{w_{2S}}}. \tag{21}$$

The South's aggregate period-1 demand for the final good good,

$$B_1^D \equiv a_1 B_{H1}^D + (1 - a_1) B_{L1}^D = \frac{w_{1S}}{2\gamma \ln \frac{q_{2S}}{w_{2S}}},$$

is then increasing in the current unskilled wage rate, and decreasing in the expected skill premium. Its aggregate demand for education,

$$e^* \equiv a_1 e_H^D + (1 - a_1) e_L^D = 2 + a_1 \left(\frac{q_{1S}}{w_{1S}} - 1 \right) - \frac{1}{\gamma \ln \frac{q_{2S}}{w_{2S}}}, \tag{22}$$

is increasing in both the current and the expected skill premium.

There are also two possible corner solutions, one with $e_j^D = 0$ and the other with $e_j^D = \theta$. The former could realistically apply to unskilled parents ($j = L$), who might be so poor, that they do not invest in their children's education at all. The latter can only apply to skilled parents ($j = H$), who might be rich enough to want their children to study more than full time (but obviously cannot).[14] In the first case, the aggregate demand for education will still depend on both the current and the expected skill premium, but the effect of the latter will be weaker. In the second, it will depend only on the expected skill premium. In the extreme case where both types are at a their respective corners, it will be a constant.

3.2.2 Equilibrium

Perfect competition requires

$$h_B^* q_{1S} + l_B^* w_{1S} = 1,$$

where h_B^* and l_B^* are the period-1 cost-minimizing inputs of, respectively, skilled and unskilled labour per unit of B. By analogy with period 2, we can then write

$$h_B^* = (\frac{\beta}{1-\beta} \frac{q_{1S}}{w_{1S}})^{-\beta} \tag{23}$$

and

$$l_B^* = (\frac{\beta}{1-\beta} \frac{q_{1S}}{w_{1S}})^{1-\beta}. \tag{24}$$

[14] This comes from the simplifying assumption that education has only an opportunity-cost. If we considered also the monetary cost, we would find that, from the point where a child studies full-time onwards, parents raise the ratio of money to time invested in education by sending the child to a more expensive school, and spending more for educational material; see Cigno and Rosati (2005).

The market-clearing conditions are now

$$\frac{1}{2}a_1 = h_B^* B_1 \tag{25}$$

and

$$\frac{1}{2}((1-a_1) + \frac{1}{2}(1-a_2)) = l_B^* B_1, \tag{26}$$

for the two types of labour, and

$$B_1 = B_1^D = \frac{w_{1S}}{2\gamma \ln\left(\frac{q_{2S}}{w_{2S}}\right)}.$$

for good B Dividing (25) by (26) term by term, and using (23) – (24), we find

$$\frac{q_{1S}}{w_{1S}} = \frac{1-\beta}{\beta}\frac{2-a_1-a_2}{a_1}. \tag{27}$$

If the family optimization has an interior solution, and given that $a_2 = e$, substituting (27) into (22) gives us

$$a_2 = 2 + a_1\left(\frac{1-\beta}{\beta}\frac{2-a_1-a_2}{a_1} - 1\right) - \frac{1}{\gamma \ln G^m(a_2)},$$

whence

$$2 - a_1 - a_2 = \frac{1-\beta}{\gamma \ln\left(G^m(a_2, \alpha, \gamma)\right)}. \tag{28}$$

Proposition 1 *If the choice of e_H and e_L is interior, there exists a unique equilibrium relationship $a_2^m(a_1)$ such that $a_2^U(a_1) > a_2^M(a_1) > a_2^D(a_1)$ for all a_1.*
Proof. *See Appendix 1.* ■

This tells us that, assuming interior solutions, if trade and foreign investment barriers are expected to come down in period 2, and the activities expected to be relocated from North to South in that period are more skill-intensive than those already in place, educational investment will be higher, and child labour lower, than it would have been without that expectation. Conversely, if trade barriers are still expected to come down in period 2, but the activities expected to be relocated from North to South are less skill-intensive than those already there, educational investment will be lower, and child labour higher, than it would have been without that expectation. What lies behind this prediction? As already noted, the expectation that trade barriers will be removed in period 2 affects period 1 decisions not only because it alters the expected $\frac{q_{2S}}{w_{2S}}$ and thus the expected return to educational investment, but also because it alters $\frac{q_{1S}}{w_{1S}}$ and thus the current distribution of income between H and L type families.[15]

[15] The two effects are not distinguishable in Harris and Robertson (2013), and Danziger (2017), where periods 1 and 2 are rolled into one.

Substituting $a_2^m(a_1)$ into (27) does in fact show that, if the economy is expected to become open in period 2, $\frac{q_{1S}}{w_{1S}}$ will be either lower or higher than it would otherwise be, depending on whether (14) or (15) holds true. In the second case, the expected liberalization will redistribute current income in favour of L-type families. Given that e^* is increasing in $\frac{q_{1S}}{w_{1S}}$, this distributional effect will reinforce the expected-skill-premium effect. In the first case, by contrast, the expected liberalization will redistribute current income in favour or H-type families, and thus dampen the expected-skill-premium effect, but the net effect will still be the one stated in the Proposition.

All of that was on the assumption that neither family type is at a corner. As pointed out earlier, if the L type is at a corner, the aggregate educational investment effect of the expected skill premium will be weaker. If that were the case, the net effect of trade liberalization *could* change sign. By contrast, if the H type is at a corner, the distributional effect vanishes, and the net effect of liberalization is then the one predicted by the Proposition. In the extreme (and unlikely) case where both types are at a corner, liberalization does not affect education and child labour at all.

3.3 Testable implications

In reality, what we call the South consists of different countries,[16] all skill-poor compared with the North, but some more than other. Let us then relax the assumption made so far that the South is a homogeneous entity. Let us also suppose that the intermediate good x_1 (tradable in period 2 under the second scenario) can be produced by a continuum of technologies indexed $0 < z < 1$.[17]. Given $\frac{q_2}{w_2}$, each unit of the good produced with technology z will employ $h(z)$ units of skilled labour, and $l(z)$ units of unskilled labour. Arrange inputs so that $\frac{h(z)}{l(z)}$ is increasing in z. Let $c(z)$ denote the unit cost of producing x_1 with technology z. For any $\frac{q_2}{w_2} > 1$, $c(.)$ is increasing and continuous in z. By way of example, suppose there are only two developing countries, labelled S_1 and S_2, differentiated only by their skill endowments. Suppose that S_1 has a higher skill endowment than S_2. By definition, the North, labelled N,. has a higher skill endowment than either S_1 or S_2. Then, in equilibrium,

$$(\frac{q_2}{w_2})^N < (\frac{q_2}{w_2})^{S_1} < (\frac{q_2}{w_2})^{S_2}.$$

In Figure 5, adapted from Feenstra and Hanson (1996), the straight lines labelled C_N, C_{S_1} and C_{S_2} are the graphs of $c(z)$ for, respectively, N, S_1 and S_2. The higher is a country's wage ratio, the steeper is the line representing the unit cost of producing x_1 in that country at different values of z. That allows us to identify two critical values of z, Z_1 and Z_2. For $z < Z_1$, C_{S_2} lies below both C_N and C_{S_1}. For $z > Z_2$, C_{S_2} lies above both c_N and C_{S_1}. For

[16] The same may be said about the North, but that is of no consequence for present purposes.

[17] Grossman and Rossi-Hansberg (2017) talk of different tasks, rather than of different ways of producing the same intermediate good.

$Z_2 < z < Z_1$, C_{S_1} lies below both C_{S_2} and C_N. This tells us that liberalization will make it advantageous for the North to relocate its x_1 producing factories of skill intensity $Z_1 < z < Z_2$ to country S_1, and those of skill intensity $0 < z < Z_1$ to country S_2. Those of skill intensity greater than Z_2 will stay in the North.

In general, therefore, the better endowed with skilled labour a developing country is period 1, the more likely it is that its skill premium will rise if trade is expected to be liberalized in period 2. If a country's endowment of skilled labour is sufficiently small, the skill premium will likely fall (the Stolper-Samuelson effect) . In light of the second part of our Proposition, this implies that, the better endowed with skilled labour a developing country is, the more likely it is that liberalization will raise educational investment and reduce the child labour rate in that country. These are testable predictions.

Figure 5: Skill endowment thresholds HERE

4 Empirical analysis

In this section, we test our theoretical predictions using a country panel and the collapsed dataset that we used to construct Figures 1 to 4. The panel includes 13 years (from 2000 to 2012) of country data concerning 207 countries.[18] The data were obtained merging the ISCED (International Standard Classification of Education), UNICEF, UNESCO and World Bank (World Development Indicators) databases, which provide comparable information on child labour, trade, FDI and skill endowments, with the UNIDO (United Nations Industrial Development Organization) Industrial Statistics Database, which provides information on manufacturing sector wages. The child labour data are those harmonized by the ILO. The individual variables and their sources are described in Table A1 of Appendix 2. Summary pooled statistics are reported in Table A2 of the same Appendix, separately for the whole sample and for the collapsed sample used for child labour estimates.

To get a measure of the skill premium for each UNIDO country in each year, we divided the average wage rate paid by industries classified by the OECD as "high or medium-high technology" into the average wage rate paid by industries classified as "low technology". We are aware that this is not an entirely satisfactory proxy for the skilled-to-unskilled wage ratio (because both types of industry employ skilled and unskilled workers, albeit in different proportions), but it is the only one available at country level for countries with child labour

[18] The time period is limited because the child labour data come from different sources, and they are not always comparable. Twenty-two datasets are based on Statistical Information and Monitoring Programme on Child Labour (SIMPOC) surveys, ten on Multiple Indicator Cluster Surveys (MICS), thirteen on national labour force surveys, and the rest on a variety of other sources (for fifteen countries, there are more than one dataset making a total of 77 different datasets). The ILO has harmonized and made public child labour data for 53 countries covering the 2008-2012 period. We used these ILO data and updated them with the information available on May 18th on the ILO website.

data.[19]

The child labour rate is the share of children in the 5-14 age range recorded as working. In the theoretical analysis of the last section, the fraction of the time that a child spends working, and the fraction that he or she spends studying, are assumed to add up to unity. In reality, these two variables are negatively correlated, but the correlation coefficient is lower than unity because, in developing countries, many children are enrolled at school, and work at the same time.[20] These part-time students have typically less time left for rest and homework, attend school less regularly, and are less receptive when they do attend, than full-time students. For this reason, the child labour rate, rather than the complement to one of the school enrolment rate, is arguably the better measure of forgone educational investment,[21] and this is the variable we use.

The skill endowment is measured by two alternative sets of indicators, one drawn from the World Bank's World Development Indicators, and the other from the UNESCO-UIS dataset.[22] In the first case, they measure the share of the labour force, in the second the share of the population aged 25 or over, that achieved a certain level of education. We tried also the survival rate to the final grade of primary education, and the average number of years in education drawn from the dataset in Barro and Lee (2010), but the results were inferior, because the overlap between this and the child labour dataset is even smaller than when we use different measures of the skill endowment. As all these skill endowment measures are stock variables (showing the cumulative effect of past educational investments), they are little affected by flow variables such as the number of persons receiving education or reaching any particular educational level in any given year. Trade openness is proxied by the ratio of exports minus imports to exports plus imports, but we allow also for other forms of internationalization, such as the GDP share of the net inward foreign direct investment flow (FDI).[23]

According to the theory developed in the last section, the skill intensity of foreign direct investment, the skill premium and the child labour rate are simultaneously determined. Unfortunately, however, we do not have country-level data on the skill content of FDI, and the number of countries and years for which we have information on *both* the skill premium and the child labour rate is very small. The latter is due to the fact that many countries either do not have child labour or do not record it, that few of the countries that have child labour

[19] Data concerning the wages of workers with different skill levels have been recently provided by the Occupational Wages around the World (OWW) Database, prepared by R. Freeman and R. H. Oostendorp. This database contains occupational wage data for 161 occupations in 171 countries from 1983 to 2008. The data are derived from the ILO October Inquiry database (http://laborsta.ilo.org) by calibrating the data into a normalized wage rate for each occupation. The normalized wages refer to average hourly or monthly wage rates for adult workers. Unfortunately, however, we cannot use these data for our purposes because the overlap with the child labour dataset is very small; see http://www.nber.org/oww/

[20] See, among others, Cigno and Rosati (2002, 2005).

[21] For a fuller discussion of this issue, and a policy analysis, see Cigno (2012).

[22] This dataset has a better match with the countries with child labour, and presents a higher level of disaggregation.

[23] We tried also the Chinn-Ito index of foreign investment openness (kaopen), but it was never significant (results available on request from the authors).

data have them for more than one year, and that some countries have education but not child labour data, while other have child labour but not education data. All we can do, therefore, is to separately estimate a reduced-form skill premium equation and a reduced-form child labour equation using two different datasets, a larger one for the former, and a smaller one, obtained by collapsing the larger dataset,[24] for the latter. In both equations, the right-hand-side variables are trade openness (a policy variable), some measure of the skill endowment (a predetermined variable), and various controls, including FDI, and the log of per-capita GDP (in PPP dollars). As an additional control, we tried also a dummy taking value 1 if the country subscribed to international convention C138 (setting a minimum child labour age), zero otherwise. Given, however, that it is never significant and makes no difference to the sign, value or statistical significance of the other parameters, we excluded it from the analysis.[25] Year dummies are used to account for the fact that the date when the skill premium and the child labour rate are recorded varies from country to country (usually between 2007 and 2012).

To allow for the fact that it takes time for trade exposure to fully deploy its effects conditional on the skill endowment, we lag both these variables five years.[26] For each country, the first date to which our lagged trade openness and skill endowment measures refer coincides roughly with the date when that country's trade barriers were first lowered. To test the theoretical prediction that the effect of the former is conditional on the size of the latter and thus explain the facts highlighted in Figures 2 and 3, we introduce an interaction term, and test for its significance. To allow for the possibility that per-capita GDP is endogenous, we carry out IV estimates using as instruments several lagged values of per-capita GDP.

The empirical model used to estimate the skill premium is

$$\begin{aligned} Skillpremium_t &= \beta_0 + \beta_1 Skillendowment_{t-5} + \beta_2 Tradeopenness_{t-5} + \beta_3 FDI_t \\ &+\beta_4 Tradeopenness_{t-5} * Skillendowment_{t-5} + \beta_5 GDP_{t-1} + \varepsilon_{ist}. \end{aligned}$$

Table 1 reports alternative OLS estimates of this equation.[27] The skill endowment is proxied by the WDI estimate of either Primary education or Secondary education. In all the regressions, the skill premium turns out to be negatively and significantly related to trade openness, and to the skill endowment, both lagged five years, but positively and significantly related to the product of the two. This sign pattern suggests the presence of a critical value of the skill endowment below (above) which trade openness affects the skill premium negatively (positively). Consistently with the proposition that the skill premium

[24] In other words, we wanted to know the mean of the variables, and to do so we "collapsed" the entire dataset (using the "collapse" command in Stata).

[25] Almost all the countries in our child labour sample signed up; see http://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:12100:0::NO::P12100_ILO_CODE:C138.

[26] We tried also shorter or longer lags, but the results did not change significantly. For instance, lagging trade openness one year instead of five affects the numerical value of the parameters sligthly, but not their sign or significance.

[27] We tried also IV estimations (results available on request from the authors). As it made no difference, we opted for lagging GDP one year in the OLS estimates.

is affected by the (endogenously determined) skill content, rather than by the volume of foreign direct investment, FDI turns out to be either insignificant, or significant only at the 10 per cent level. As was to be expected in a relative-wage equation, GDP has no significant effect. The Wald test (reported in Table A4, Panel a, of Appendix 2) confirms the joint significance for some of the variables used in the regressions where the skill premium is measured by the share of the adult population educated to secondary level. Differentiating the skill premium totally with respect to trade openness, and setting the derivative equal to zero, we find that openness affects the premium, five years hence, positively if the former is above a certain threshold, negatively if it is below it.[28] This finding is consistent with our theoretical prediction that liberalization raises the skill premium in countries endowed with a sufficiently well educated labour force, and lowers it elsewhere.

Table 1: Skill premium and trade openness HERE

Table 2 reports alternative IV estimates of the child labour equation,

$$\begin{aligned} Childlabour_t &= \beta_0 + \beta_1 Skillendowment_{t-5} + \beta_2 Tradeopeness_{t-5} + \beta_3 GDP_{t-1} \\ &\quad + \beta_4 Tradeopeness_{t-5} * Skillendowment_{t-5} + \varepsilon_{ist}. \end{aligned}$$

The skill endowment is now proxied by the UIS estimate of either Education (the share of adults with at least some primary education) or Tertiary education. The instruments used are the logs of per-capita GDP lagged 1 and 5 years. As the annual data do not perfectly overlap for all the variables used, we cannot exploit the panel dimension of the child labour dataset. We thus limit ourselves to analyzing a cross-section of averaged annual data concerning only the subset of countries for which we have child labour *and* skill endowment data. In both regressions, the effect of trade openness is significantly positive, and that of the trade openness and skill endowment interaction term significantly negative. The Wald test (Panel b in Table A4 of Appendix 2) supports the view that the variables are jointly significant (as also suggested by the F-test reported directly in Table 2). Differentiating child labour totally with respect to trade openness, and setting the derivative equal to zero, we find that opening the economy affects child labour, after five years, negatively if the skill endowment is above a certain threshold, positively if it is below it. [29] The effect of GDP is significantly negative. To make doubly sure that the sign of the trade effect depends on the size of the skill endowment, we cut the sample at the median of either the Secondary education, or the Tertiary education variable, and estimate child labour as a function of trade openness and GDP separately for each subsample. The results, reported in Table 3, are remarkably consistent. Trade openness reduces child labour in the better educated subsample (regressions 2 and 4),

[28] No matter whether the skill endowment is measured by the Primary education or the Secondary education variable, the threshold is 0.79, almost identical to both the mean and the median of the latter, but higher than both the mean and the median of the former.

[29] If the endowment is measured by the Education variable, the threshold is 0.66, lower than both the mean and the median of that variable. By contrast, if the endowment is measured by the Tertiary education variable, the estimated threshold is 0.48, higher than both the mean and the median of the variable in question.

but not in the less well educated one (regressions 1 and 3). The effect of GDP is significantly negative everywhere. The results presented in Table 2 are thus confirmed. Taken together with those of Table 1, they confirm the prediction that trade openness raises the skill premium, and reduces child labour, in developing countries that had a sufficiently well-educated labour force when liberalization took place. Elsewhere, trade openness lowers the skill premium. If productivity rises, however, child labour may fall even in a less educated country.

Table 3: Child labour and trade openness by groups HERE

5 Conclusion

In the theoretical part of our analysis we use a bare-bones model of the family highlighting education and child labour decisions, immersed in a model of the world economy emphasizing trade in intermediates and technology transfer via offshoring, to explain the striking fact that the child labour rate is negatively associated with trade exposure in developing countries where a sufficiently large share of the adult labour force is well educated, but not elsewhere (see Figure 5). The theory predicts that trade liberalization will either raise or lower a country's skill premium according to whether the country's initial stock of skilled adults is or is not large enough to attract productive activities from abroad with a higher skill requirement than those originally carried out there. Other things being equal, child labour will fall in the first case, and rise in the second. If trade liberalization raises per-capita income as a host of trade and development models predict, however, child labour may well fall even in countries where the skill premium does not rise (albeit by a smaller amount than in countries where the skill premium does rise). These theoretical predictions are not rejected by the data.

An implication of these theoretical and empirical results is that trade liberalization creates a divide between developing countries that, having started out on the right foot, will specialize in low-skill activities less than they would have done without liberalization and will eventually become developed countries, and developing countries that, having started out on the wrong foot, will specialize even further in low-skill activities. Where the second group of countries is concerned, our analysis yields qualitatively the same results as HO and SS theory. For the first group of countries, by contrast, it predicts the exact opposite. But this does not mean that child labour will necessarily rise there. If liberalization enhances efficiency and thus raises per capita-income as one would expect, the share of parents whose educational investment decisions are liquidity constrained will in fact decline, and the child labour rate may thus fall even in countries where the skill premium and thus the incentive for parents to invest in their children's education falls. Having established (see Table A3 of Appendix 2) that the child labour reducing effect of per-capita income diminishes rapidly and tends to vanish as a country moves up the income scale, however, the benefit of trade liberalization can be expected to be initially substantial in countries where the share of liquidity-constrained parents was very high, but to quickly loose importance as income rises and the skill premium reducing effect of trade liberalization becomes preeminent.

Going beyond the formal model, it thus seems reasonable to hypothesize that trade liberalization could initially reduce the incidence of child labour no matter how large the country's initial skill endowment is, but that this effect will fizzle out if the said endowment is so low, that the production activities attracted from abroad raise the demand for unskilled relative to skilled labour, because the domestic skill premium will then fall. These insufficiently well-endowed countries (those ranked low in Figure 4) will become less poor, but they will remain underdeveloped unless corrective policy is undertaken. Liberalization on its own will help development only in countries (like those ranked high in Figure 4) sufficiently well educated in the first place.

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Figure 1: Child labour and per-capita GDP

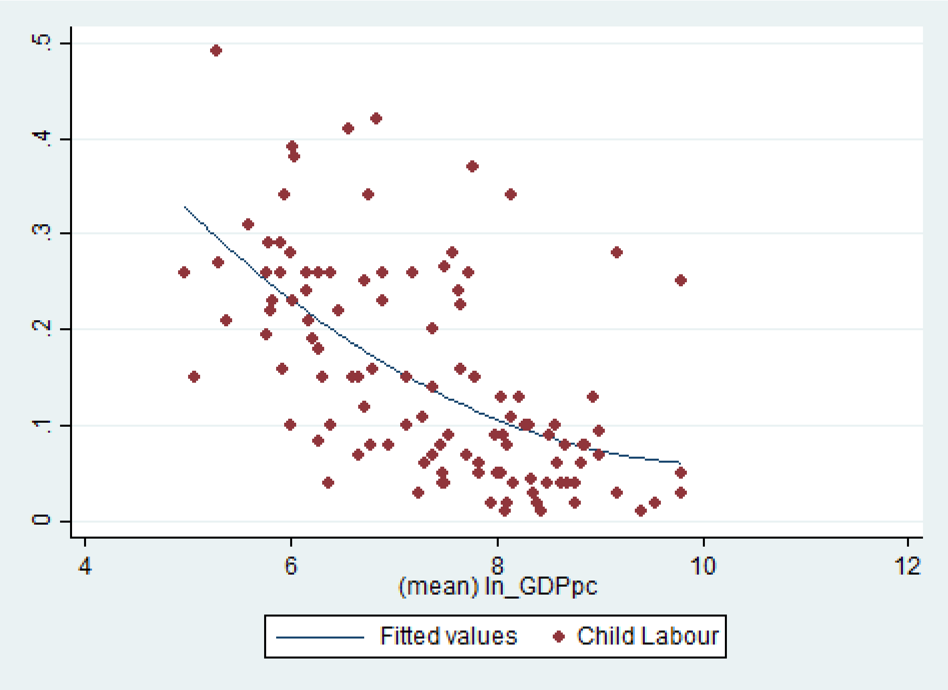


Figure 2: Child labour and trade openness

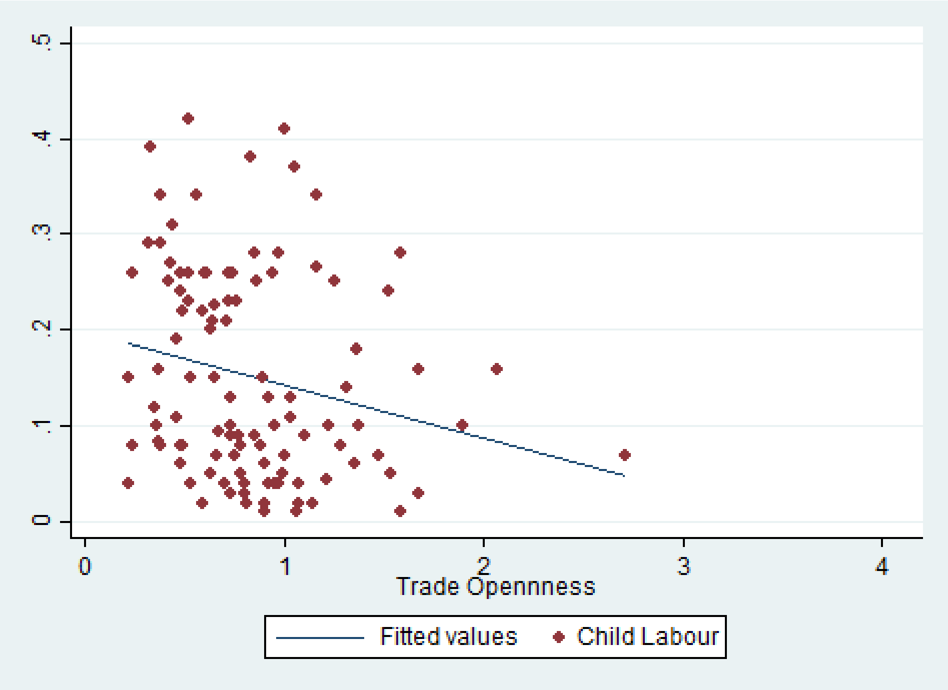
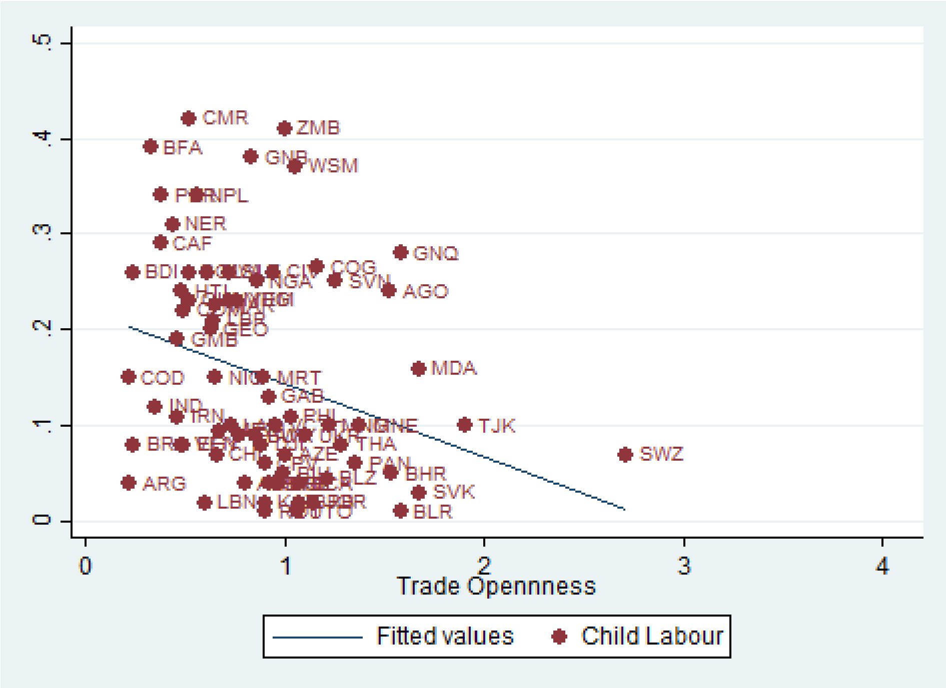


Figure 3: Child labour and trade openness by education level

Panel a: Countries with share of adult population educated to tertiary level above sample median



Panel b: Countries with share of adult population educated to tertiary level below sample median

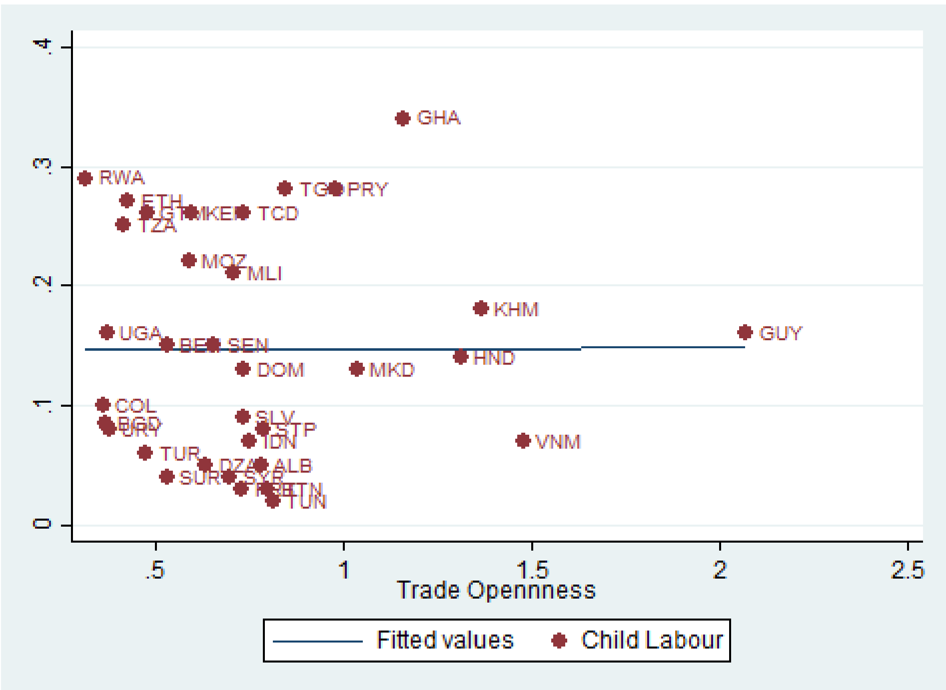


Figure 4: Countries with child labour, ranked by educational level

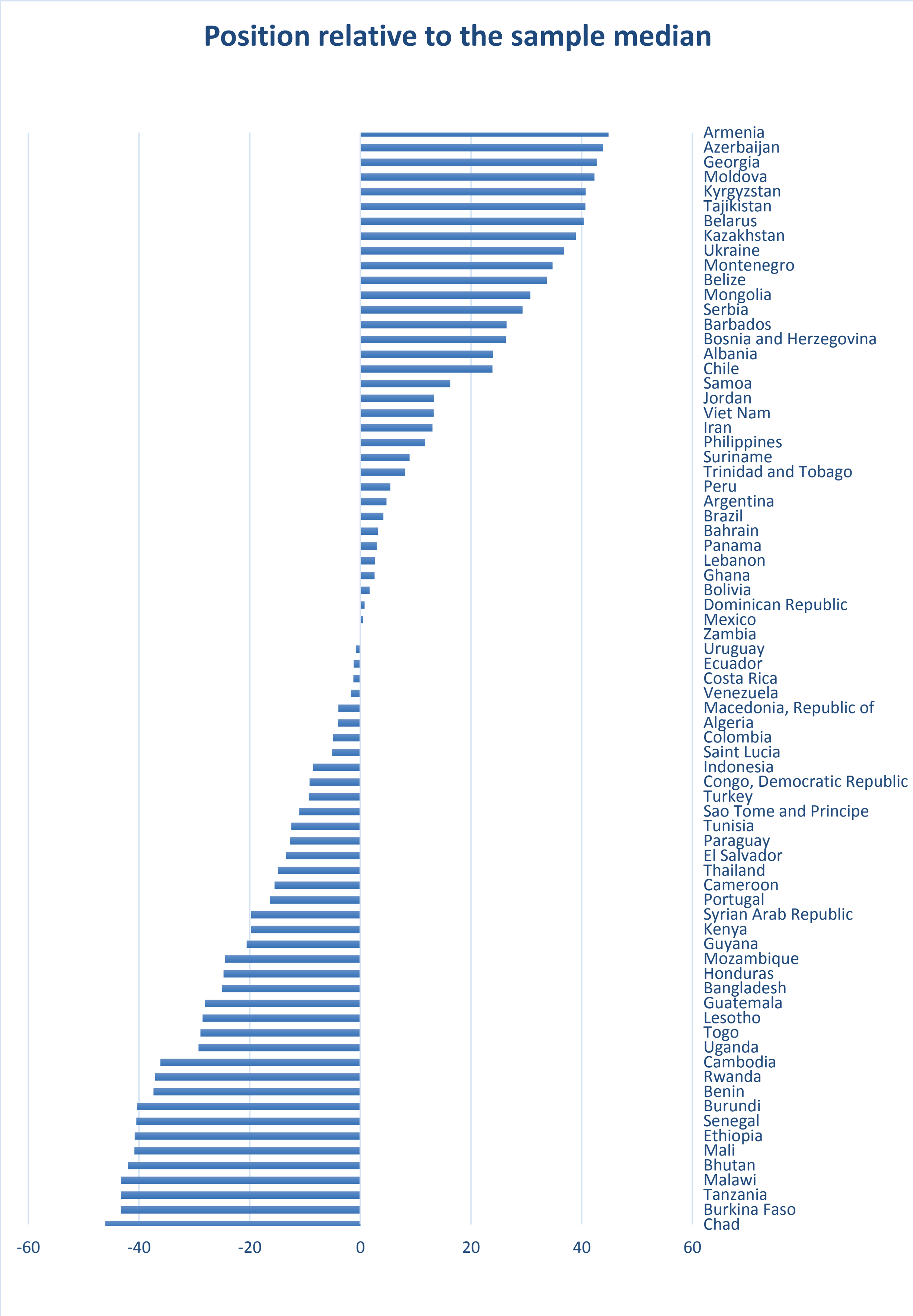
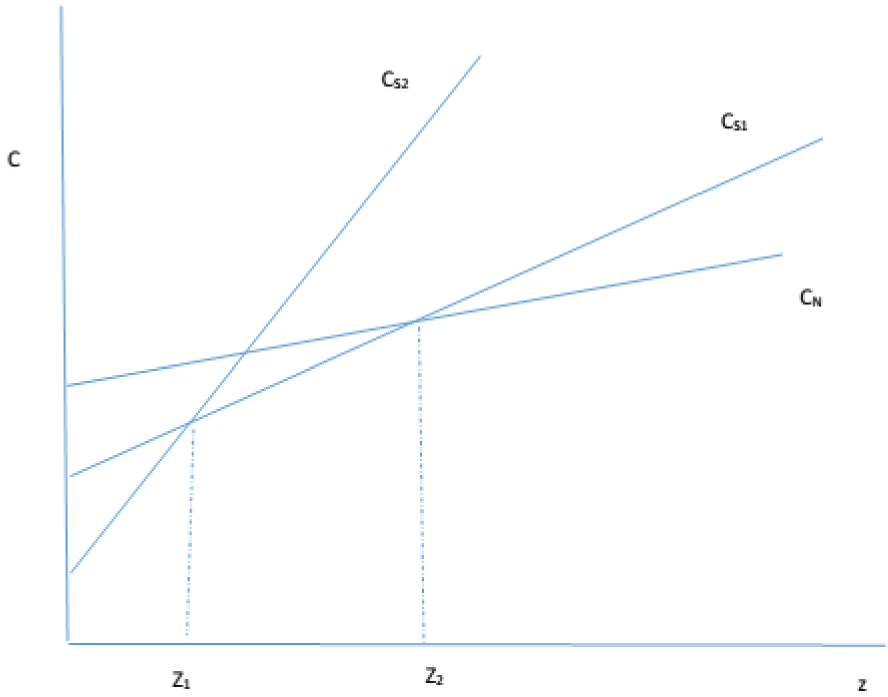


FIGURE 5: Skill endowment thresholds



Tables

Table 1: Skill Premium and trade openness, OLS estimates

Dependent Variable: Skill Premium	(1)	(2)	(3)	(4)
Trade Openness (lagged 5 years)	-4.745**	-4.776**	-4.745**	-4.776**
	(2.266)	(2.272)	(2.239)	(2.248)
Primary Education (lagged 5 years)	-10.3***	-10.4***		
	(2.653)	(2.663)		
Primary Education*Trade openness (both lagged 5 years)	5.985**	6.067**		
	(2.901)	(2.914)		
Secondary Education (lagged 5 years)			-10.33**	-10.38**
			(4.925)	(4.948)
Secondary Education*Trade Openness (both lagged 5 years)			5.985**	6.067**
			(2.848)	(2.869)
FDI		-0.003		-0.00320*
		(0.008)		(0.00176)
GDP (lagged 1 year)	0.007	0.0113	0.00727	0.0113
	(0.131)	(0.132)	(0.0743)	(0.0750)
Constant	9.433***	9.427***	9.433**	9.427**
	(2.343)	(2.347)	(3.848)	(3.852)
Observations	220	220	220	220
F-test (P-value)	0,000	0,0001	0,255	0,240
R-squared	0.114	0.115	0.114	0.115
Robust standard errors in parentheses				
*** p<0.01, ** p<0.05, * p<0.1				

Table 2: Child labour and trade openness, IV estimates

	(1)	(2)
Dependent variable: Child labour		
Trade openness (lagged 5 years)	0.0710**	0.0585**
	(0.0305)	(0.0277)
Education	0.0261	
	(0.0520)	
Education*Trade openness (both lagged 5 years)	-0.106**	
	(0.0470)	
High education		0.0105
		(0.0787)
High education*Trade openness (both lagged 5 years)		-0.121*
		(0.0686)
GDP	-0.0426***	-0.0405***
	(0.00903)	(0.00880)
Constant	0.446***	0.439***
	(0.0542)	(0.0542)
Observations	108	108
F-test	0.0000	0.0000
R-squared	0.319	0.327

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Instruments: GDP lagged 1 and 5 years

Table 3: Child labour and trade openness by educational level, IV estimates

Dependent variable: Child labour	(1) Secondary education < median	(2) Secondary education > median	(3) Tertiary education< median	(4) Tertiary education > median
Trade openness	0.0465	-0.0676**	0.0215	-0.0914**
	(0.0379)	(0.0344)	(0.0243)	(0.0449)
GDP	-0.0375***	-0.0609***	-0.0524***	-0.0335**
	(0.0101)	(0.0200)	(0.00752)	(0.0151)
Constant	0.410***	0.655***	0.533***	0.452***
	(0.0726)	(0.186)	(0.0574)	(0.149)
Observations	70	38	80	23
F-Test	0.0008	0.0080	0.0000	0.0348
R-squared	0.162	0.248	0.315	0.288

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Instruments: GDP lagged 1 and 5 years

Appendix 1

1 Cost-minimizing inputs into the production of x_1, A and B

Minimizing the period-2 cost of producing a unit of x_1 in the South subject to (1) yields

$$h^*_{x_1} = (\frac{\varepsilon}{1-\varepsilon}\frac{q_{2S}}{w_{2S}})^{-\varepsilon}$$

and

$$l^*_{x_1} = (\frac{\varepsilon}{1-\varepsilon}\frac{q_{2S}}{w_{2S}})^{1-\varepsilon}.$$

Similarly minimizing the cost of producing a unit of B subject to (2), and a unit of A subject to (3), we find

$$x^*_1 = (\frac{\alpha}{1-\alpha}\frac{c_2}{c_1})^{1-\alpha},$$

$$x^*_2 = (\frac{\alpha}{1-\alpha}\frac{c_2}{c_1})^{-\alpha},$$

$$h^*_B = (\frac{\beta}{1-\beta}\frac{q_{2S}}{w_{2S}})^{-\beta}$$

and

$$l^*_B = (\frac{\beta}{1-\beta}\frac{q_{2S}}{w_{2S}})^{1-\beta}.$$

2 Proof of the proposition

Let

$$H(a_2) = 2 - a_1 - a_2,\ H'_{a_2} < 0,$$

and

$$K^m(a_2) = \frac{1-\beta}{\gamma \ln G^m(a_2, \alpha, \gamma)},\ K'^m_{a_2} > 0.$$

It follows from (**??**) that, for $0 < a_2 < 1$,

$$1 - a_1 < H(a_2) < 2a_1$$

and

$$0 < K^m(a_2) < \infty.$$

From monotonicity, $K^m(a_2)$ can cross $H(a_2)$ only once, and this will surely happen since $K^m \to \infty$ as $a_2 \to 1$. Noting that $K^U(a_2) < K^M(a_2) < K^D(a_2)$ $\forall\ a_2$, the result $a_2^U(a_1) > a_2^M(a_1) > a_2^D(a_1)$ $\forall\ a_1$ immediately follows.

Appendix 2

Table A1: Description of the variables used and of their sources

Variable	Description	Unit of Measurement	Data Source
Skill premium	Wage differential between medium-high tech on lower tech industries	Ratio	UNIDO
Child labour	Share of children aged 5-14 reported working	% of total	UNICEF, UNICEF global databases, 2016, based on DHS, MICS and other nationally representative surveys
GDP	Per-capita Gross Domestic Product in PPP dollars	log	WDI
Trade openness	Exports minus imports over exports plus imports	Ratio	WDI
Primary education	Share of the total labor force that attained or completed at least primary education	% of total	WDI
Secondary education	Share of the total labor force that attained or completed at least secondary education	% of total	WDI
Low education	Share of the adult population with no schooling, incomplete primary, or completed primary education	% of total	Unesco- UIS, http://data.uis.unesco.org/
Secondary education	Share of the adult population that completed at least primary education	% of total	Unesco- UIS, http://data.uis.unesco.org/
High education	Share of the adult population with completed primary and at least some tertiary education	% of total	Unesco- UIS, http://data.uis.unesco.org/
Tertiary education	Share of the adult population with short tertiary, Master, PhD or unknown further studies	% of total	Unesco- UIS, http://data.uis.unesco.org/
Education	Share of the adult population with at least incomplete primary education	% of total	Unesco- UIS, http://data.uis.unesco.org/
kaopen	Index of capital openness	By construction, the series has zero mean	Chinn and Ito (2008).
FDI	Net FDI inflows as a percent of GDP	Ratio	WDI

Table A2: Summary statistics

VARIABLES	(1) N	(2) mean	(3) median	(3) sd	(4) min	(5) max
Sample						
Skill premium	868	1.413	1.267	1.203	0	18.11
Trade openness (lagged 5 yrs)	1,176	0.951	0.822	0.595	0.145	4.633
Primary education	657	0.727	0.554	0.113	0.109	1
Secondary education	470	0.733	0.743	0.115	0.109	1
FDI	2,203	5.244	3.264	9.884	-161.2	172.7
GDP	2,691	8.283	8.273	1.660	4.384	12.11
Collapsed sample						
Child Labour	119	0.154	0.130	0.111	0.010	0.490
Trade openness (lagged 5 years)	180	0.939	0.837	0.556	0.214	4.131
Trade openness (lagged 1 year)	180	0.956	0.834	0.567	0.222	4.281
Low education	105	0.466	0.466	25.52	0.107	0.94
Secondary education	105	0.364	0.361	0.185	0.223	0.845
Tertiary education	105	0.161	0.131	0.128	0.488	0.619
Education	107	0.735	0.837	0.266	0.163	1
GDP	208	8.276	8.158	1.617	4.963	11.75
GDP (lagged 1 year)	208	8.241	8.111	1.625	4.924	11.73
GDP (lagged 5 years)	207	8.068	7.956	1.659	4.707	11.60

Table A3: Marginal Effects for different GDP levels

GDP per capita ($)	dy/dx	Std. Err.	z	P>z	[95% Conf.	Interval]
100	-0.123	0.018	-6.92	0	-0.158	-0.088
200	-0.111	0.017	-6.43	0	-0.145	-0.077
500	-0.090	0.013	-6.71	0	-0.116	-0.064
1,000	-0.073	0.010	-7.60	0	-0.092	-0.054
2,000	-0.057	0.006	-9.32	0	-0.069	-0.045
3,000	-0.049	0.004	-10.88	0	-0.057	-0.040
5,000	-0.039	0.003	-13.53	0	-0.045	-0.034
10,000	-0.029	0.002	-16.50	0	-0.033	-0.026
20,000	-0.021	0.002	-14.05	0	-0.024	-0.018

Note: the marginal effects are calculated for different levels of (a discrete variable). Column 1 describes the thresholds. The low standard errors suggest a high significance.

Table A4: Wald Test on the joint coefficients

Panel a: Wald tests on Table 1			
Regression	Null Hypothesis	Chi2	P-Value
(1)	beta_Trade openness = beta_Interaction = 0	2.22	0.1114
(1)	beta_Primary education = beta_Interaction = 0	12.06	0.0000
(2)	beta_ Trade openness = beta_Interaction = 0	2.27	0.1062
(2)	beta_Primary education = beta_Interaction = 0	2.25	0.1077
(3)	beta_Secondary education = beta_Interaction = 0	2.23	0.0000
(3)	beta_Secondary education = beta_ Trade openness = 0	2.26	0.1071
(4)	beta_Secondary education = beta_Interaction = 0	2.25	0.1077
(4)	beta_Secondary education = beta_ Trade openness = 0	2.27	0.1062

Panel b: Wald tests on Table 2			
Regression	Null Hypothesis	Chi2	P-Value
(1)	beta_Trade openness =beta_Education = 0	8.32	0.0156
(1)	beta_Trade openness = beta_Interaction = 0	5.94	0.0514
(2)	beta_Trade opennness = beta_ High education=0	7.46	0.0240
(2)	beta_ Trade openness = beta_ Interaction =0	4.57	0.1016