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Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

SIN WORKING PAPER SERIES

THE IMPORTANCE OF HUMAN CAPITAL FOR THE TRADE-GROWTH LINK

Anders Isaksson

Working Paper No 2
June 2002

Statistics and Information Networks Branch of UNIDO

The author is a staff member of the United Nations Industrial Development Organization (UNIDO), Investment Promotion and Institutional Capacity Building Division, Statistics and Information Networks Branch (correspondence to aisaksson@unido.org). The author thanks Helmut Forstner, Arne Bigsten, Ramos E. Mabugu and Ghislain Robyn for careful reading and commenting, as well as for many inspiring and fruitful discussions on the topic of the paper. The views expressed in the paper are those of the author and not necessarily those of UNIDO or its member states.

Abstract: Trade is important for transporting growth-enhancing factors like technological advances and knowledge. However, the benefits of international trade forego many countries because of a shortage of human capital needed to absorb these knowledge flows. Whereas theory would predict a strong statistical relationship between trade and growth, the robustness of the relation in macro-growth regressions can be disputed. Failure to take into account the importance of human capital for the trade-growth link might explain the weak statistical relationship between trade and growth. A regression analysis supports the notion that human capital is an important element in the trade-growth link.

1. Introduction

There are many proponents for the notion that a country's involvement in international trade activities produces positive growth effects [e.g. Grossman and Helpman, 1991] and that trade openness is good for growth [e.g. Dollar, 1992]. Some even go so far as to argue that trade causes growth [e.g. Frankel and Romer, 1999].[1] Such a notion finds considerable support in the theoretical literature. For instance, economic theory suggests that export activities make firms more productive because they have to compete in international markets. It is also asserted that export activities carry so-called learning-effects, which means that firms learn from participating in competition because they encounter products at different or higher technological levels.

Imports too are thought to generate numerous positive effects on growth. For instance, imports of machinery from relatively advanced economies can have spillover effects on the domestic manufacturing of machinery. And more generally, imports often bring technological advances from abroad that can be used effectively in domestic production.

If it is true that international trade activities have significant positive effects on economic growth, growth studies would demonstrate a positive and robust association between trade and growth, and perhaps even causation from the former to the latter. However, it has been found empirically, especially in studies undertaking sensitivity analysis, that the statistical link between trade volume and growth is weak or non-existent, particularly once other policy-outcome variables such as inflation are controlled for [Levine and Renelt, 1992; Sala-i-Martin, 1997]. One explanation for why there is only a weak link is that trade might affect growth only via investment [e.g. Baldwin and Seghezza, 1996]. And if a statistical association between trade and growth is found, it may not necessarily imply a causal relationship: what causes growth also causes trade [see e.g. Rodrik, 1998; Rodriguez and Rodrik, 1999]. Against such an argument stands the work by Frankel and Romer [1999] who show that trade indeed seems to cause growth.

Perhaps trade has a conditional impact on growth, i.e. provided that certain pre-requisites are met, trade has a pro-growth influence; otherwise not. One of the pre-requisites worth considering in this respect has to do with technology. While trade involves a large potential for technological diffusion, what remains unclear is the extent to which a relatively less advanced country can make use of the new technology being offered through trade. It appears that direct adoption or adaptation of relatively advanced technology, as well as imitation, requires a certain level of skill in the recipient country. And

therefore, it is quite possible that intensive trading takes place with new technological opportunities bypassing many countries, especially developing ones. If this is the case, the scope for trade to have dynamic growth effects seems limited and the weakness of the statistical association reported in a number of studies becomes understandable.

The hypothesis put at the center of this paper is that the ability to adopt, adapt, or imitate new technology crucially depends on a country's endowment of human capital.[2] And the prediction is that, on average, countries with a relatively large endowment of human capital enjoy *greater* benefits from trade activities than countries that are relatively poorly endowed with human capital.

The notion that trade interacts with human capital to produce growth effects is supported by the regression analysis presented below. The preferred regression is of the standard cross-country form. Here it is performed over 73 countries and with variables expressed as five-year averages over the time period of 1960-94. The specification is novel in that it centers on the inclusion of an interaction term for human capital and trade in order to capture the importance of human capital for benefiting from trade. Another non-standard feature of this paper is that human capital is introduced in a non-linear fashion, which follows the work by Krueger and Lindahl [1999].

Three indicators of trade are examined in this study: total trade, exports and imports. The results obtained show that these measures of trade by themselves cannot be associated statistically with growth of real GDP per capita. However, when it is taken into account that countries are different in their abilities to adopt and adapt knowledge transmitted through trade channels, a statistically significant association between trade and growth obtains for countries that are relatively abundant in human capital. Poor endowment with human capital means that important knowledge spillovers are foregone and, consequently, that the growth potential is reduced. Thus, the results question the view that there is an over-focus on trade. Rather, it seems warranted to pay attention to the relation between trade and growth if at the same time the role of human capital is accounted for.

The paper is organized as follows: In Section two, the link between GDP growth and trade on one hand, and the interaction between human capital and trade on the other, are discussed. The section also includes a brief, but quite exhaustive, summary of the empirical literature on the human capital-trade interaction. Section three describes the data used in the estimations and discusses estimation techniques. This includes the definitions of variables and the presentation of an estimable function. Estimation results are reported and analyzed in Section four. Section five concludes the paper.

2. International trade and growth: theory and empirics

This section first presents the conventional view on the dynamic effects of international trade on economic growth. Thereafter, the notion that human capital and trade interact to achieve such positive effects is introduced. A discussion of the empirical literature on trade and growth in which this interaction has been accounted for concludes the section.

2.1 Static and dynamic effects of trade on growth

Many developing economies embarked on import-substitution (IS) strategies in the 1970s. The goal was to protect domestic industry and to promote production of imported goods. Trade protection was combined with industrial regulation and an over-valued exchange rate to achieve these goals. The inward-orientation was to stimulate domestic production, but it had a clear anti-export, anti-labor, and anti-agriculture bias that deterred these countries from specializing in accordance with their perceived comparative advantages.[3]

When it became clear how poorly the IS strategy was working and that its efficiency costs essentially spelled lower growth and welfare, a shift to an outward-looking policy took place. Industry was de-regulated, trade barriers were reduced, and local currencies devalued. Resources could now be allocated more efficiently and the road was open for a new equilibrium at higher GDP. In a classical growth view, such a move from inward to outward-orientation, and the accompanying GDP increase, is static in that it involves a once and for all shift from one state to another. After the new GDP level has been attained, the economy returns to its previous growth path and there are no further gains.

However, the recent trade and growth literature introduces a dynamic perspective according to which trade feeds growth. Undoubtedly, theory has concentrated on trade openness rather than actual trade, and for that reason the following discussion makes no clear distinction between the two concepts. It is obvious, however, that some dynamic effects pertain to trade openness rather than to actual trade – like those due to increased competition – while other effects are due to goods being transported from one country to another, as in the case with technology embodied in capital goods.

In principle, five dynamic effects can be discerned in the literature on trade and growth: *spillover* effects, *scale* effects, *competition* effects, *imitation* effects, and effects of an *increased variety of intermediates*.

The *spillover* effects from trade can take several forms. For instance, researchers can benefit

from discoveries made elsewhere. This creates an incentive to do research rather than dwell on production activities, and such a shift of focus onto research could spur growth. Spillover must, however, fall on fertile ground to produce effects. Therefore, the extent of benefits in terms of knowledge externalities from increased openness depends upon whether the country is specialized in natural-resource based production or in manufacturing. While the former kind of production has a relatively low knowledge intensity, the latter could – depending on the level of development – be knowledge-intensive and more conducive to growth.

Technological differences are often assumed to be a source of comparative advantage. Whether technological advances are international or national decides whether such advantage should be viewed as exogenous, as in traditional trade models, or endogenous as in more recent theories. In the latter models, increased competition in product markets implies that there may be less incentive to do research, and labor would therefore move from research to production. If this happens, openness-induced specialization may reduce growth rather than promote it [Grossman and Helpman, 1991]. Trade liberalization could also induce countries to specialize in products in which the potential for learning has largely been exhausted. In such a case, dynamic effects from trade may be negligible [Aghion and Howitt, 1998].

Important *scale* effects may follow from trade liberalization, with the most obvious being that of trade liberalization leading to a larger market for exports. Another positive growth effect associated with a larger market arises from vacant monopoly rents that can be appropriated by successful innovators. Frankel and Romer [1999] have also suggested that a larger market means a larger number of firms, which creates positive knowledge externalities advantageous to growth.

However, if trade reduces the scale of activities of import-competing firms, and thereby diminishes the expected returns to research and development (R&D), there may be an incentive not to innovate. For the export sector, for which the market is expanded due to the trade liberalization, the opposite could be true as expected returns to innovation increase with scale.[4] Lucas [1988] has argued that to the extent that learning-by-doing is important for growth, industries producing on a large scale would grow faster than those producing on a relatively smaller scale. As the workers of exporting (comparative advantage) industries learn and improve production techniques, these industries will expand due to trade. Learning-by-doing, by the same token, would lead to the opposite effect for import-competing sectors. Moreover, as Roberts and Tybout [1997] have documented, entering

international markets is not free of cost, and scale effects cannot be capitalized on if such costs cannot be covered.

In the endogenous growth literature focusing on trade, the effect of increased *competition* and its impact on profitability has attracted much attention. Trade introduces competition, which in turn may generate productivity gains and even innovation. Furthermore, expected profits trigger investment in technological change and innovation; at least this may be expected to happen in the export sector. Competition may also lead to improvements in managerial skills due to pressure on managers to perform as sheltering trade barriers are removed. Moreover, the opening of the economy may induce managers to innovate in order to preserve rent mechanisms that had been acquired under less competitive conditions.

However, the effect of competition on growth is ambiguous, since increased competition for the import-competing sector may reduce the returns to some industries, and hence, expected profitability and, as a consequence, spending on R&D may decrease.[5] Furthermore, under imperfect competition, and with firms deriving their profits from existing technologies, there may be an incentive for firms not to innovate [Baldwin, 1992]. Grossman and Helpman [1991] have also shown that under certain conditions free trade could instigate a move of labor from research into production, with a consequent reduction of technical change and growth.

Trade facilitates *imitation* and both export and import sectors could improve productivity and accelerate technological change through that channel [Grossman and Helpman, 1991]. Trading firms, through their foreign contacts could – at least in theory – take advantage of learning effects [see, for instance, World Bank, 1993].[6]

Finally, imports can enhance growth by allowing for an *increased variety of intermediates* and, hence, access to better production techniques (besides allowing for larger quantities). This could happen because intermediate goods from abroad that are not available in the home market may embody advanced foreign technologies, which could impact on technological change [Bayoumi, Coe, and Helpman, 1996].

2.2 The interaction of international trade with human capital

This section reviews papers that focus on the interaction between actual trade and human capital, i.e. their combined effect on growth. The idea that outward-orientation interacts with human capital is not

entirely new. Edwards [1992], Harrison [1996] and Miller and Upadhyay [2000] are three previous sources that mention a possible interaction between openness and human capital, while Frankel [1998] talks about the interaction as if it were obvious. In Keller [1996], an interaction between human capital and trade can be said to be implied by the model. The study shows that outward-orientation is not enough to close the gap between rich and poor countries; for such closure there is also a need to increase the growth rate of skill formation in the labor force.

While the idea of the above interaction has been expressed in several places, there are, it would seem, only two instances of empirical tests having been conducted in a direct way: Harrison [1996] and Miller and Upadhyay [2000]. As an introduction to discussing these two papers, the following three issues shall briefly be surveyed: the preference for focusing on actual trade rather than trade openness, the issue of causality, and the role of human capital in the trade-growth link.

It appears as somewhat unfortunate that the trade share has been used as a proxy for openness at the cost of the role of trade itself.[7] No doubt trade openness is essential to any economy because it provides an enabling environment.[8] However, in order to exploit the full effects of trade liberalization, trade must occur, for it is mainly through trade that new technology crosses borders. While openness seems to be a necessary condition for the enhancement of growth, actual trade appears to be a sufficient one. Hence, the growth literature would benefit from a shift of attention towards actual trade, at some cost to trade openness *per se*.

The unresolved issue of identifying the direction of causality still plagues the empirical literature on trade and growth. It has been argued at several occasions [for instance, by Baldwin and Seghezza, 1996] that trade affects growth only indirectly through its impact on investment. However, the work of Krishna, Ozyildirim, and Swanson [1998] seems promising in addressing the causality issue. They find that for a majority of countries trade affects growth positively in a direct manner. Furthermore, for 70 percent of the countries analyzed causality was uni-directionally in favor of exports and/or imports causing growth. Likewise, the work by Frankel and Romer [1999] and Frankel, Romer, and Cyrus [2000] points to trade not only being associated with growth, but in fact causing growth.

What is the role of human capital in all this? Although trade is the principal channel for the flows of ideas, knowledge, and advanced technology, it is not clear to what extent the recipient country can make use of these flows. Adoption, adaptation, and imitation crucially depend on the stock of human capital in the recipient country, and also on how the different components of human capital (e.g.

on-the-job-training versus academic training) are distributed.[9]

Turning to the review of Harrison [1996] and Miller and Upadhyay [2000], it is important to note that both papers are about trade openness and growth/productivity, and not about actual trade. Harrison [1996] proxies openness with several variables, among them actual trade. In a similar fashion, Miller and Upadhyay [2000] use actual trade as a proxy for trade openness. While human capital is not at the center of their work, in both papers it is made to interact with openness (and actual trade), and it is towards these results that attention is directed here.

Harrison [1996] uses seven proxies for trade openness, one of them being total trade as a share of GDP. She estimates several specifications for 17 to 51 countries over the sample period 1960-1987. The trade variable is, as are many of the other openness measures, seldom statistically significant. The trade share is statistically significant only with annual data in differences, but the author argues that this result could be due to business cycle effects. In the "robustness part" of the paper, the openness variables are made to interact with the stocks of primary and secondary education. For the estimations — using five-year averages and the level of trade policy — the parameter of the interaction term is statistically significant in only three cases out of ten. Among the three statistically significant parameters, there is that when trade share interacts with secondary education. Among the 12 interactions with change in trade policy, none is statistically significant and the effect on growth from the interaction term with the trade share is negative.

Miller and Upadhyay [2000] first calculate – for 83 countries over the period 1960-1989 – total factor productivity (TFP) levels from an estimated production function, with and without human capital. They attempt to explain TFP by several variables, among them (the log of) the export share, which is their preferred proxy for openness. For low-income countries, they find that the effect from exports is reinforced when it interacts with human capital, whereas this is not the case for other sub-groups of countries. The parameter for exports is always statistically significant.

Unfortunately, the findings of the paper ought to be viewed with great caution because the ranking of countries by TFP levels appears to be highly surprising. The most plausible TFP calculation – in terms of the resultant ranking – is the one with human capital included in the estimation. In that case, the United States tops the TFP list, followed by Bangladesh, while Brazil, Iran, and Trinidad & Tobago obtain ranks five to seven. Countries such as Japan, Sweden, Norway, Finland, and Iceland are found on places 17, 27, 44, 47, and 64, respectively. Such TFP ranking is hard to reconcile with actual

observations of technological change over the sample period, and this odd ranking of countries makes it difficult to interpret the results outlined above.

3. Data and definitions of variables

This section starts with a description of the data used in this exercise. It goes on to deal with the issues of data frequency and estimation methods. A discussion of the expected signs of coefficients leads up to the presentation of results in Section IV.

3.1 Description of the data

The analysis uses data on 73 developed and developing countries for the sample period 1960-1994, where inclusion of a country is governed by data availability (see Table AI in Appendix I for the coverage of countries). Data come from four different sources: human capital variables from Barro and Lee [2000]; real per capita income growth, inflation, and black market exchange rate premium from Levine, Loayza, and Beck [2000]; the investment rate, financial depth, and trade variables from World Bank [2000]; and the log of real GDP per capita in 1960 (initial income) from Summers and Heston [1991]. More detail about how the variables are defined is provided in Table AII in Appendix II.

Data were transformed into five-year averages in order to purge them of the influence of business cycle effects, resulting in a maximum of seven data points across the whole time period.[10] It is sometimes suggested in the literature [e.g. Islam, 1995] that panel-data methods (e.g. the fixed-effects estimator) are superior to average or pooled cross-country regressions. However, a major problem with the fixed-effects estimator is that it removes between-country variation and leaves only within-country variation. Many explanatory variables, like one of the key variables in this paper, human capital, have low within-country variance and may thus fail to explain high within-country growth variation. This is probably the reason why many studies using panel-data analysis have failed to find a statistically significant effect of human capital on growth.

In some cases, notably when cross-sectional variance is large relative to time-series variance and when measurement-error variance is large relative to the cross-sectional one, the fixed-effects estimator will aggravate the degree of measurement error and, therefore, increase the attenuation bias [Pritchett, 2000].[11] In contrast, the main problem of not using panel-data estimators is that the parameter for the convergence variable is rendered biased and inconsistent because the omitted individual (fixed) effects are correlated with the explanatory variable representing convergence.

However, since the issue of convergence is not the main focus of this paper, the shortcomings of non-panel analysis seem to be acceptable.

3.2 Definition of Variables and the Estimable Function

The variable to be explained is growth of real GDP per capita. Among the explanatory variables, special attention is paid to the effect of three trade variables on growth: the first is total trade (exports plus imports) as a share of GDP, while imports and exports as shares of GDP, respectively, are the other two variables. Special interest attaches also to the association between human capital and growth, since the paper argues for the importance of an interaction between human capital and trade to benefit growth. Human capital is proxied here by the average schooling years of the population aged 15 years and more, although preferably a human capital measure should also capture other various facets of human capital, such as quantity and quality of schooling as well as work experience and specific and general training.

There are good reasons for human capital to enter the regression in non-linear fashion. It is easy to imagine a situation, where after a certain amount of education, the marginal benefit for growth from another "unit" of human capital is negative. And an inverted U-shaped education-growth profile indicates that, from a certain point onwards, private utility derived from education outweighs social utility. This could occur under certain conditions when the government channels resources towards research at the expense of production [Aghion and Hewitt, 1998]. Krueger and Lindahl [1999] show that after 7.5 years of education the education-growth profile is downward-sloping.

In the present paper, a number of control variables are included in the regression as well. These are the initial level of GDP (typically assumed to capture convergence), the investment rate, the black market exchange rate premium (as a measure of openness), financial depth (to account for the effect of financial development on growth), inflation (representing macro policy outcome), and time dummy variables. All variables, except human capital, are calculated as arithmetic averages over five years. Human capital is observed only once in five years and its value is that of average years of schooling for each five-year period.

Except for the squared human capital term, equation (1) below – the first equation to be estimated – is a fairly standard growth regression:

$$\Delta y = \alpha + \beta_1 T + \beta_2 H + \beta_3 H^2 + \delta X + \gamma t + \varepsilon \quad . \tag{1}$$

Suppressing variable subscripts, α denotes the intercept, Δy is growth of real GDP per capita, T represents one of three trade variables (total trade, exports, or imports), H and H^2 constitute a non-linear representation of human capital, X is a vector of control variables with parameter vector δ, t a vector of time dummy variables with parameter vector γ, and ε is a normally distributed error term.

The paper posits that β_1 is higher for high skill countries compared with low skill countries. Hence, for reasons stated earlier in the paper, the positive association between trade and growth is stronger for countries richly endowed with human capital. In other words, the parameter β_1 increases with the stock of human capital in a fashion, which is assumed to be linear:

$$\beta_1 = \varphi_1 + \varphi_2 H \tag{2}$$

Substituting (2) into (1) results in equation (3), which is the main regression around which most of the discussion will evolve:

$$\Delta y = \alpha + \varphi_1 T + \varphi_2 T^* H + \beta_2 H + \beta_3 H^2 + \delta X + \gamma t + \varepsilon \quad . \tag{3}$$

Here the crucial interaction term between human capital and trade (H^*T) is included, based on the hypothesis that dynamic growth effects from trade can only be expected in cases where there is sufficient human capital available to the (trade) receiving country.

4. Estimation results

The results of estimating equations (1) and (3) are presented in Table I and discussed in the following way: First, the results obtained from regressions without the human capital-trade interaction terms are briefly analyzed (columns 1, 3, and 5). Thereafter, the results of regressions including the interaction term are discussed at some length (columns 2, 4, and 6). Finally, a few remarks on testing for robustness of the obtained results are made.

Table 1 shows that the control variables enter with the expected signs throughout. In addition,

conditional convergence is seen to be slow, at about 0.7 percent annually.[12] This figure is smaller than the one reported, for instance, in Barro and Sala-i-Martin [1995], but not at all unlikely, given the apparent diverging developments of OECD countries and Least Developed Countries.

The investment rate has a strong impact throughout, where an increase in the investment rate by one percentage point is on average associated with an increase in the growth rate by a tenth of a percentage point. While convergence was comparatively slow, the investment parameter seems quite large. With a magnitude of 0.1, it is between two and three times larger than the (statistically insignificant) parameters reported in Barro and Sala-i-Martin [1995, table 12:3, all columns except *SUR*]. By contrast, the estimated parameter here is much smaller than the one obtained in the much-cited study by De Long and Summers [1991], the reason, of course, being that those authors study the effects of equipment investment only on growth. For most countries, equipment investment is only a trifle of total investment, the investment variable used in this paper.

Trade openness, measured by the extent of rationing in the foreign-exchange market (the log of the black market premium +1), appears to be conducive to growth. The parameter is statistically significant at the one percent level and a 100 percent decrease in the premium is associated with an increase in growth by 0.01 percentage points. It is worth noting that inclusion of the trade openness indicator does not substantially affect the parameters related to the trade variables. This can be taken as support for the claim that actual trade and trade openness have separate associations with growth.[13]

Inflation, approximating macroeconomic imbalances, is negatively associated with growth. An increase in the inflation rate by 10 percentage points retards growth by 0.1 percentage points. Hence, on average inflation does not seem to be of great concern for growth. The coefficient for financial depth is positive and statistically significant, and a financial deepening of 10 percentage points entails an increase in growth by 0.16 percentage points. Thus, the effect of financial development is positive, albeit not of the order of the effect of, for instance, an increase in investment.

Turning to the variables of central interest — trade and human capital, when no interaction effects are taken into account — the overall impression is that human capital has an independently positive effect on growth. However, this effect is diminishing as higher levels of education are attained. All three versions of a trade variable are statistically insignificant. Such insignificance would almost be expected given the results of Levine and Renelt [1992], who showed that inclusion of the investment share and of policy outcome variables renders the parameters of a trade variable insignificantly

distinguishable from zero in a statistical sense.

In contrast to the above, interaction between trade and human capital produces results that demonstrate growth effects in all three cases, but only in countries where there is sufficient human capital available to absorb knowledge flows. This outcome is very much in line with the predictions of the theoretical work started by Nelson and Phelps [1966] and successfully continued by Grossman and Helpman [1991].

Studying the estimation results of human capital and trade more closely, one can start with the columns excluding the interaction terms. They show that human capital enters the relationship in a non-linear fashion. The inverted U-shape of the human-capital growth curve implies that, on average, education is beneficial for growth up to a certain level of education and that, thereafter, growth effects of human capital increases are negative.

An increase in human capital associated with a one-year expansion of education implies a large growth effect of 0.5 percentage points (31 percent). This effect is twice as large as what is usually obtained from micro studies and regarded as the maximum effect on earnings arising from human capital. Mincerian wage equations tend to produce estimates between 5-15 percent. And this result obtains despite the introduction of non-linearity, which is almost always ignored by other studies.[14]

Although it might be the case that an endogeneity bias exaggerates the human-capital effect, it is a widely held view that measurement errors underestimate the full human-capital effect to the same extent as the endogeneity bias overestimates it. Another argument in favor of the plausibility of a large estimate is that social returns, which cannot be captured in micro studies, may by far exceed private ones. In other words, there may be important externalities involved.[15] However, it cannot be excluded that human capital to some extent proxies for institutions, since good institutions most likely are an important a pre-requisite for higher education.

If one assumes a linear growth effect, that is, disregards the squared human capital term, a full percentage-point increase in growth arising from a doubling of human capital is the result. Another important aspect, not covered here, is that an increase of human capital in a poor country probably has a larger effect than a similar increase in an OECD country, where human capital has already attained a high level. Put differently, some OECD countries are likely to be on the downward-sloping part of the curve, whereas all developing countries must be expected to be on the upward-sloping portion. If interaction effects with trade are ignored, the maximum growth effect occurs at 10 years of education.[16]

Taking into account the interaction effects, the effect of human capital on growth is in all three cases smaller than without interaction with trade (columns 2, 4, and 6 of Table 1). It is smaller despite the interaction term parameters because these are not large enough to offset the fall in the point estimate of human capital by 20 percent (from 0.01 to 0.008). When human capital is made to interact with total trade, an increase of one year in human capital is associated with a 0.54 percentage point (32 percent) increase in growth. The second largest of the economically significant effects is obtained from the interaction between imports and human capital. There, a year's increase in human capital gives a 0.39 percentage point increase in growth (23 percent). When human capital interacts with exports, the effect is somewhat smaller (0.35 or 20 percent).[17] That the effect pertaining to interaction with imports is larger than that for interaction with exports is no surprise; imports of capital goods and intermediates may be assumed to embody a significant amount of (relatively) advanced technology, while exports may be seen more as a means to obtain foreign exchange to allow for imports.[18]

It seems that trade is associated with growth only in countries with a sufficiently high level of human capital, an observation which is in line with the working hypothesis of the paper. Exports and imports have large growth effects, namely, 0.33 percentage points (19 percent) and 42 percentage points (25 percent), respectively. In total, imports actually have a minor negative effect of -0.06 percentage points (-3.5 percent), which is due to a statistically significant parameter for the import share, i.e. larger than the effect from the interaction term. The overall negative association between imports and growth might emanate from the increased competition in import-competing sectors, which should be especially severe in developing countries where these sectors have been heavily protected.[19]

The smallest impact of trade on growth comes from total trade, which is explained by the fact that negative import effects cancel out positive effects of exports. The total effect of a 10-percentage point increase in total trade is negligible (only 0.02 percentage points or one percent), but for human capital-abundant countries the impact is 19 percentage points (11 percent).

The results obtained so far suggest that the benefits from trade materialize mainly when there is enough human capital to absorb all new ideas, knowledge, and technology transferred through trading. Countries with scant human capital experience less dynamic growth effects of trade — the typical situation of the developing country. It is sometimes argued that trade affects growth only via its effects on investment. This argument is not supported by the results presented here: investment has been controlled for in these estimations and yet there is a significant association between trade and growth.

Finally, a brief summary of extensive checks of robustness shall be provided here.[20] Robustness was tested against several alternatives: a different definition of human capital; allowing trade and human capital to be endogenous; allowing trade to enter non-linearly; and changing the estimation method to that of fixed-effects estimation.

When rates of enrolment in secondary schooling were chosen to replace average years of schooling as a proxy of human capital, the trade-growth link weakened somewhat. This result is not too surprising because enrolment rates represent flows rather than stocks of human capital and theory is concerned more with the relation between the latter and growth. Allowing trade and human capital to be endogenous has qualitatively the same effect as that reported in Table 1. However, this weakens the trade-growth link slightly, while the effect of human capital is strengthened. The most dramatic effect of allowing trade to enter in a non-linear fashion is the change to a positive sign for imports. Overall, including trade non-linearly seems to strengthen the association between trade and growth.

Lastly, fixed-effects estimation distorts the results considerably in that human capital tends to be associated negatively with growth. On the other hand, interaction terms are no longer needed to find a strong link between total trade and growth and exports and growth. However, in the case of imports the parameters are no longer statistically significant. For control variables, parameters also tend to shift signs and leads to highly unexpected results. What happens when between-country variation is wiped out is more or less what Pritchett [2000] predicted. Given that the issue of convergence is of negligible interest in this paper, it remains to be the case that the preferred estimation method is that of pooled regression.

5. Conclusions

This paper has looked into the relationships between human capital, international trade, and economic growth. It was argued that trade is an important carrier of technical advances and knowledge across countries and that, therefore, there are reasons to hypothesize a positive trade-growth link. In order for a country to take advantage of the knowledge transfer intrinsic in trading, it must have an adequate level of human capital. If it is poorly endowed with human capital, much of the knowledge bypasses the country and growth does not benefit from trade as much as it could.

A regression analysis was carried out with total trade, exports, and imports as explanatory variables, together with a host of other regressors. In accordance with the results of Levine and Renelt

[1992], none of the trade shares was found to be statistically significant. In contrast, when trade was made to interact with human capital there was a clear positive association of all three trade variables with growth. This was, however, the case only for countries with sufficient human capital. These results can be viewed as providing evidence of the importance of human capital for the much discussed trade-growth link.

From the above it seems clear that policies promoting trade have a potential for spurring growth. The results of this paper suggest that dynamic growth effects may be limited by lack of human capital that would be needed to absorb knowledge flows. This hints at some policy options. One of them would be to target countries with the appropriate institutions and human capital already in place. A perhaps better approach is to adopt strategies that increase a country's human capital for the sake of increasing the benefits arising from expanded trade.

With respect to the results presented here, a few caveats need to be mentioned. One of them has to do with the issue of causality, a topic which has not been specifically dealt with here, but only discussed in terms of results obtained in other research. Another caveat relates to the area of endogeneity bias, where still more work needs to be done. However, preliminary results of this research suggest that in the case of trade, endogeneity tends to only slightly change parameter values. Furthermore, only two human capital variables have been used in this paper, while there is certainly scope for more work here. In particular, it would be interesting to see the effect of an interaction between trade and the *quality* of human capital.

Finally, while this study demonstrated an impact on growth of the most broadly defined trade flows, it is reasonable to expect that a stronger link would be observed between knowledge-intensive trade and growth, or for that matter, between manufacturing trade and growth. This seems to be an interesting avenue for future research on the topic of this paper.

Endnotes

[1] The growth effects dealt with in this paper are the dynamic ones so elegantly treated in Grossman and Helpman [1991]. Static effects, such as those obtained from a 'textbook' move from autarky to some degree of openness, are not the issue here, simply since they only entail a transition from one state to another, even though the transition can take considerable time.

[2] This is obviously a simplification because what matters is not necessarily the volume of human capital *per se*, but that a country has the *'appropriate'* kind of human capital. If a country is richly endowed with human capital, but is trading in a commodity in which it has little knowledge, trade might still have a weak association with growth. It might also be the case that a country trading only a few commodities has just a little overall knowledge, but the knowledge it has is 'appropriate' for those few commodities that it trades in. In general, however, it is more likely that a human-capital rich country also possesses the 'appropriate' knowledge, or at least some of it, compared with a country poorly endowed with human capital.

[3] See Rodrik [1995] for an excellent overview.

[4] Scale is important to the returns to R&D spending because of the high fixed cost component.

[5] Lawrence and Weinstein [1999] and Aghion and Hewitt [1998] provide good discussions on this ambiguity.

[6] However, it should be noted that in analyses based on plant-level data, neither Clerides *et al* [1998], nor Bernard and Jensen [1999], find evidence of learning effects.

[7] If trade were solely the outcome of opening up, it would be a valid proxy for openness. However, Anderson [2000] discusses several cases why countries are unable to capitalize on new trade possibilities and, therefore, tend to trade less than predicted by theoretical models. Furthermore, as indicated above, trade could increase or decrease for many reasons other than policy, for instance, due to exogenous changes in the terms of trade. Opening up may also have distinct growth effects that are not necessarily related to increases in the trade share. For instance, increased competition has effects on the drive to innovate, and hence on growth. The distinction between actual trade and trade policy is also made, for instance, in Rodrik and Rodriguez [1999].

[8] Edwards [1993; 1998] and Harrison [1996] provide excellent surveys of the literature on trade liberalization, openness, and growth.

[9] Acemoglu and Zilibotti [2001] present a model where productivity differences between North and South develop because the South cannot make efficient use of the North's (relatively advanced)

technologies. The bottleneck in their model is the supply of appropriate skills. Dessy and Pallage [2001] argue that a higher degree of inequality in many poor countries creates an environment conducive to the tolerance of informal and low-productivity activities. This, they argue, could explain why such (poor) countries do not adopt the highly productive technologies available abroad.

[10] For some countries, data availability problems reduced the number of data points to less than seven with the minimum being four. However, for the vast majority of countries in the sample, seven data points were obtained. Balancing the sample – by deleting the countries with less than seven data points – did not have a significant impact on the estimation results.

[11] Pritchett [2000] further argues that the endogeneity bias may be exacerbated and that there are problems with dynamic misspecification. In addition, Durlauf and Quah [1999] argue that panel-data analysis aggravates problems for the interpretation of the convergence parameter.

[12] The formula for computing the convergence rate is $- (1 - e^{-0.008*T})/T$, where T equals the number of years of the sample.

[13] That is, to the extent that the black market exchange rate premium is a good proxy for trade openness. Rodrik and Rodriquez [1999] argue that the black market premium is a proxy for macroeconomic problems. In this paper, the latter has been approximated by inflation and still the parameter for the proxy of openness is statistically significant across different specifications.

[14] An important exception is Krueger and Lindahl [1999].

[15] However, work by Acemoglu and Angrist [2000] suggests that for the case of the United States externalities are negligible.

[16] Due to rounding, Table 1 shows a point estimate of –0.001 for the squared human capital parameter, while in fact the estimated parameter is only half that amount (-0.0005).

[17] Using the actual (as opposed to the rounded) parameters, the corresponding maximum growth effects of human capital interacted with total trade, exports, and imports occur at 9.3, 9.8, and 8 years of educational attainment, respectively.

[18] For arguments along these lines, see Rodrik [1998]

[19] Without doubt there is a fine line between association and causality. To the extent that Frankel and Romer [1999] as well as Krishna, Ozyildirim, and Swanson [1998] have been able to tackle and resolve the issue of causality, it seems less problematic to adopt a view of trade causing growth.

[20] A full set of test results can be obtained from the author upon request.

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Table 1. Pooled Cross-Country Regressions, 1960-94

Dependent Variable: Average Growth Rate Of Real GDP Per Capita

	(1)	(2)	(3)	(4)	(5)	(6)
	Total Trade	Total Trade	Exports	Exports	Imports	Imports
Constant	0.031**	0.041***	0.030**	0.037***	0.032**	0.044***
	(2.418)	(3.222)	(2.229)	(2.653)	(2.512)	(3.373)
Log Initial income	-0.008***	-0.008***	-0.008***	-0.008***	-0.008***	-0.008***
	(3.557)	(3.719)	(3.550)	(3.568)	(3.663)	(3.834)
Investment	0.098***	0.107***	0.096***	0.100***	0.102***	0.118***
	(4.860)	(5.075)	(3.550)	(4.956)	(5.236)	(5.886)
Log of Openness	-0.010***	-0.011***	-0.010***	-0.011***	-0.011***	-0.011***
	(2.850)	(2.986)	(2.746)	(2.832)	(2.835)	(2.936)
Inflation	-0.010**	-0.009**	-0.009**	-0.008**	-0.010**	-0.009**
	(2.241)	(2.102)	(2.160)	(2.105)	(2.348)	(2.287)
Financial depth	0.017***	0.016***	0.016***	0.016***	0.017***	0.017***
	(2.929)	(2.979)	(2.883)	(2.879)	(2.939)	(2.997)
Human capital	0.010***	0.008***	0.010***	0.008***	0.010***	0.007***
	(4.705)	(3.167)	(4.597)	(3.430)	(4.732)	(2.781)
Human capital sq.	-0.001***	-0.000***	-0.001***	-0.001***	-0.001***	-0.000***
	(3.952)	(3.320)	(3.842)	(3.620)	(3.966)	(3.177)
Trade share	-0.000	-0.017*				
	(0.109)	(1.897)				
Export share			0.008	-0.026		
			(0.969)	(1.266)		
Import share					-0.007	-0.048***
					(0.823)	(2.938)
Trade*Human capital		0.004**				
		(2.274)				
Export*Human capital				0.007**		
				(2.108)		
Import*Human capital						0.009***
						(3.266)
N	428	428	428	428	428	428
Adjusted R^2	0.34	0.35	0.35	0.35	0.35	0.36
Joint $\beta = 0$ [a]	17.03***	16.49***	17.12***	16.38***	17.12***	16.82***
Heteroscedasticity [b]	59.82***	62.31***	60.50***	62.96***	58.26***	61.29***

Note: ***, **, and * indicate significance at 1 %, 5 %, and 10 % respectively. Absolute t-values are in parenthesis. Results for time dummy variables are not reported. Covariance-variance matrix has been adjusted for heteroscedasticity. N stands for number of observations.

[a] F-test of slope parameters jointly zero, F [df]

[b] Breusch-Pagan test of H_0: no heteroscedasticity, $\chi 2$[df].

Appendix I

Table AI. Countries included in the sample (73 Countries)

Argentina	Iran	Sudan
Australia	Israel	Sweden
Austria	Italy	Switzerland
Belgium	Jamaica	Syria
Bolivia	Japan	Togo
Brazil	Kenya	Thailand
Cameroon	Mexico	Trinidad and Tobago
Canada	Korea	Venezuela
Central African Republic	Lesotho	Uruguay
Chile	Malta	USA
Colombia	Malawi	Zimbabwe
Congo	Malaysia	
Costa Rica	Mauritius	
Cyprus	Nepal	
Dem Rep. of Congo	Netherlands	
Denmark	New Zeeland	
Dominican Republic	Nicaragua	
Ecuador	Niger	
Egypt	Norway	
Finland	Pakistan	
France	Papua New Guinea	
Gambia, The	Paraguay	
Ghana	Peru	
Great Britain	Philippines	
Greece	Portugal	
Guatemala	Rwanda	
Haiti	Senegal	
Honduras	Slovakia	
India	South Africa	
Indonesia	Spain	
Ireland	Sri Lanka	

Appendix II

Definition and Sources of Variables

All variables are taken from Barro and Lee [2000], Levine, Loayza, and Beck [2000], World Bank [2000], and Summers-Heston [1991] as indicated by (BL), (LLB), (WB), or (SH) in the third column. The definitions are according to the second column.

Table AII. Definition and Sources of Variables.

Variable name	Definition	Source
Real per capita growth	-----	LLB
Initial income	Log of GDP per capita 1960	SH
Investment rate	Gross fixed capital formation / GDP	WB
Black exchange rate premium	Log (((black market exchange rate / official exchange rate) -1) +1)	LLB
Inflation	Average annual inflation	LLB
Financial depth	Liquid liabilities / GDP	WB
Trade share	(Exports + Imports) / GDP	WB
Export share	Exports / GDP	WB
Import share	Imports / GDP	WB
Human capital1	Enrolment into secondary schooling	BL
Human capital2	Average years of schooling for population aged 15+	BL
Interaction Human * Trade	Human Capital1*Trade share	BL, WB
Interaction Human * Exports	Human Capital1*Exports share	BL, WB
Interaction Human * Imports	Human Capital1*Imports share	BL, WB