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Journal of Health Economics 25 (2006) 538–554
JOURNAL OF HEALTH ECONOMICS
www.elsevier.com/locate/econbase

Does trade affect child health?

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Received 7 March 2005; received in revised form 27 September 2005; accepted 14 October 2005
Available online 21 November 2005

Abstract

Frankel and Romer [Frankel, J., Romer, D., 1999. Does trade cause growth? American Economic Review 89 (3), 379–399] documented positive effects of geographically determined trade openness on economic growth. At the same time, critics fear that openness can lead to a "race to the bottom" that increases pollution and reduces government resources for investments in health and education. We use Frankel and Romer's gravity model of trade to examine how openness to trade affects children. Overall, we find little harm from trade, and potential benefits largely through slightly faster GDP growth.

JEL classification: 118; 112; F10

Keywords: Infant mortality; Trade; Economics openness

1. Introduction

Economists generally agree that economic openness is a good thing. The basis for this support ranges from the theory of comparative advantage and political economic theories of rent seeking (e.g., Krueger, 1974) to empirical evidence such as longitudinal studies correlating trade opening with rising living standards (Dollar and Kraay, 2004). One of the most convincing studies is Frankel and Romer (1999), which showed that even the portion of trade determined by plausibly exogenous geographic factors predicts higher GDP per capita.

The hypothesis that trade improves living standards is more controversial outside of economics (e.g., Weissman, 2003; Tabb, 2001; Danaher and Burbach, 2000; Mayda and Rodrik, 2001 provide

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0167-6296/$ – see front matter
doi:10.1016/j.jhealeco.2005.10.001

the case against the claim that trade improves living standards from within economics). Some critics are dubious that trade promotes economic growth. Others argue that even if trade grows the economy, trade's benefits either do not trickle down to most citizens or are outweighed by its costs. These potential costs may include environmental degradation, increased exposure to disease, decreased public spending due to lower ability to tax capital, increased exposure to international financial crises, and increased demand for low-skill labor and subsequent reduced returns to human capital acquisition.

In this paper, we ask whether openness to the international economy affects children's health. This question goes to the center of the debate about globalization. Children's health is an important end in its own right (Sen, 1999). Health is also an important means to achieving long-run economic growth. Even if trade promotes short-run economic growth, it is unlikely to drive long-run growth if it harms health substantially.

A simple correlation between trade and a measure of children's health does not necessarily reveal the causal effect of trade (Rodrik and Rodríguez, 2001; Helpman, 1988; Harrison, 1996). For one, countries that trade more might be different from countries that trade less in ways related to children. For example, high prevalence of tropical disease might reduce both trade and health (McArthur and Sachs, 2001). Intuitively, traders avoid malarial regions. Also, the causality might be reversed. Healthy children tend to become more productive adults. If higher incomes lead to greater demand for variety, countries that have healthier children might choose to trade more.

Building on the work of Frankel and Romer (1999), we address these concerns about causality by predicting how much countries trade using exogenous geographical characteristics. To determine the exogenous portion of trade, we first estimate a "gravity" model of trade as a share of GDP. In the gravity model, trade between two nations is assumed to depend on such factors as whether they have a coastline, share a border, are near each other, and are large in terms of population and area. Cumulating predicted bilateral trade flows across all potential trading partners provides an estimate of predicted trade for each nation. This estimate of predicted trade is highly correlated with actual trade and is also plausibly exogenous; we do not believe child welfare has an effect on the location of nations.[1] Intuitively, Chad is a land-locked nation far from the population centers of the globe, and so the gravity model predicts low trade for Chad. We, then, use the predicted geographic component of trade estimated from the gravity model to obtain a cross-sectional estimate of the effect of trade on children's welfare. Frankel and Romer (1999) used this method to examine the relation between openness and economic growth; others have extended it to look at outcomes ranging from pollution (Frankel and Rose, 2005) to child labor (Edmonds and Pavcnik, 2004).

We use two pairs of measures of children's health: (1) mortality rates for infants and for children up to age 5; (2) anthropometric measures of child stunting (low height for age) and wasting (low weight for height). We find that trade predicts lower infant and child mortality and lower stunting (height for age) but has no statistically discernible relationship with wasting (weight for height). We, also, find that trade predicts higher life expectancy. Our results imply that for the average country a 15-percentage point increase in predicted trade as a share of GDP (an increase of about 1 standard deviation) corresponds to approximately 4 fewer infant deaths per 1000 births and 4 fewer deaths before age 5 per 1000 births. Each of the mortality declines is about 10% of both the mean and the standard deviation; thus, the effects of trade are economically important. We,

[1] We discuss the final criterion for a good instrument, which is that it is uncorrelated with important omitted variables, below.

also, find that trade predicts higher income, higher immunization rates for measles, and larger expenditures on public health as a share of GDP, and that some of the benefits of trade on child health appear to operate through these causal channels. The remaining effects of trade may operate through unmeasured channels such as flows of information or may be due to mismeasurement of incomes and the other observed channels.

2. Potential links between openness and children's outcomes

Trade might affect children's health through a number of pathways. These include: income, public and private incentives, public policy, environmental quality, urbanization, and Westernization. We, briefly, discuss each potential pathway.

Trade might affect children's welfare by increasing economic growth. Since Adam Smith and David Ricardo, economic theories have predicted that trade increases income. In turn, rising incomes appears to improve health (Pritchett and Summers, 1996). Channels may include: improved nutrition for mothers and for children (Fogel, 1994); improved access to clean water (from bottled water, treated drinking water and/or better community sanitation); and improved access to health care (especially if many parents are liquidity constrained (Becker and Tomes, 1986) or if governments invest tax revenue in public health).

Trade might also affect children's health by influencing the degree to which governments are willing and able to fund public health. On the one hand, openness to the international economy can lead to financial crises and debt build-up, which can increase the influence of the IMF and World Bank.[2] Critics of these organizations emphasize cases where such international institutions frequently pushed governments to reduce spending on social services (Weissman, 2003). Moreover, in open economies governments have a hard time taxing capital; in the extreme, bidding wars for factories can reduce resources for investments in children. At the same time, the increased risk associated with greater openness to the international economy can increase public demand for government safety nets, and children may benefit from this if these government safety nets are disproportionately targeted toward health (Rodrik, 2000). As noted above, any increase in economic growth might also increase the government's tax revenue, which can increase spending on children's health.

Trade might also affect children's health by affecting environmental quality. Outward-oriented industrialization initiatives are closely related to trade, and factories emit air and water pollution. Air pollution is a major source of acute respiratory infections such as pneumonia, which are a common cause of infant mortality. Encouragingly, Frankel and Rose (2005) test whether openness (as predicted by the gravity model) predicts higher pollution. They find that trade does not increase pollution, and might even reduce it.

Factories also tend to be located in or around cities. Whether this is good or bad for children is not possible to predict. On the one hand, person-to-person and water-borne pathogens are more easily transmitted in urban settings, and air pollution tends to be worse. On the other hand, children in cities are usually closer to health care than children in rural areas. In addition, indoor coal and wood fires—major sources of indoor air pollution—are less prevalent in urban areas.

Openness can also help spread infectious diseases, as seen in the European arrival in the Western Hemisphere 500 years before our sample and in the epidemic spread of HIV/AIDS

[2] See, for example, Cutler et al. (2000) for an analysis of the harms to health due to the Mexican exchange rate crises, although Levine and Ames (2003) do not find harmful health effects from the 1997–1998 financial crisis in Indonesia. The dimension of openness, we study, has not been implicated in financial crises.

along many highways (although HIV/AIDS only affected national mortality rates after our study period).

Finally, the gravity model's measures of openness to trade presumably capture openness to cultural influences. For example, centuries ago Islam spread along trade routes to long expanses of coastline Africa and East Asia, while Western science and culture have spread around the globe along with traded goods. To the extent that openness as measured by the gravity model increases understanding of the germ theory of disease, the value of immunizations, and the value of literacy and science, openness to trade can improve children's outcomes. At the same time, if openness brings greater recreational drug use, more consumption of Coca-Cola, and less breastfeeding (in the pre-HIV epidemic era we study), then, openness might reduce children's health.

3. Empirical analysis

The net result of the forces described above is unclear from theory, and so, we proceed to our empirical analysis. We present the gravity model, describe our data, and present results. We, then, look at several of the channels noted above: income, immunization rates, urbanization, and public expenditures on health to see if they mediate the links between trade and children's outcomes.

3.1. Geographical gravity model

We use the cross-sectional gravity model from Frankel and Romer (1999). The amount of trade between any two countries i and j is modeled as a function of the distance between them (D_{ij}), their populations (N_i), their areas (A_i), whether or not they are landlocked (L_i), whether or not they share a common border (B_{ij}), and several interactions:

$$\ln\left(\frac{T_{ij}}{\mathrm{GDP}_i}\right) = b_0 + b_1 \ln D_{ij} + b_2 \ln N_i + b_3 \ln A_i + b_4 \ln N_j + b_5 \ln A_j + b_6(L_i + L_j) + b_7 B_{ij} + b_8 B_{ij} \ln D_{ij} + b_9 B_{ij} \ln N_i + b_{10} B_{ij} \ln A_i + b_{11} B_{ij} \ln N_j + b_{12} B_{ij} \ln A_j + b_{13} B_{ij}(L_i + L_j) + e_{ij}. \quad (1)$$

The fitted values from Eq. (1) are the predicted geographic components of each country's trade with each other country in the world. For each country, these fitted values are summed to obtain the total predicted geographic component of trade:

$$\hat{T}_i = \sum_{ij} \mathrm{e}^{\hat{\mathbf{b}}'\mathbf{X}_{ij}}, \quad (2)$$

where $\mathbf{b}$ is a vector of coefficients in Eq. (1), (b_0, b_i, . . ., b_{13}), and $\mathbf{X}_{ij}$ is the vector of right-hand side variables (1, $\ln D_{ij}$, . . ., B_{ij} [$L_i + L_j$]).

3.2. Specification

Our cross-sectional specification uses either actual trade as a share of GDP or the predicted level of trade as a share of GDP, $\left(\hat{S}_i = \frac{\hat{T}_i}{Y_i}\right)$, and a vector of control variables ($\mathbf{Z}$), to predict child welfare (W):

$$\ln(W_i) = b_0 + b_{1\_i} + \mathbf{Z}_i\boldsymbol{\beta} + e_i. \quad (3)$$

Table 1
Summary statistics

Variable	Obs.	Mean	S.D.	Minimum	Maximum
GDP per capita (1995 constant US$)	130	6189	9454	100	45952
Infant mortality rate (per 1000 live births)	130	55.4	46.3	4.6	191
Child mortality rate (per 1000 live births)	128	83.5	77.1	6.4	323
Life expectancy (at birth)	129	63.43	11.23	35.20	78.84
Stunting (percent of children 0–5 who are 2 standard deviations low in height for age)	102	28.63	16.83	0	72.30
Wasting (percent of children 0–5 who are 2 standard deviations low in weight for height)	97	6.67	5.31	0	23.20
Actual trade share	130	0.74	0.465	0.138	3.18
Geographical trade share	130	0.256	0.201	0.023	0.981
Immunization rate for measles (% children under 12 months)	122	75.14	17.74	25.00	99.00
Expenditures on public health (% of GDP)	113	2.93	1.92	0	7.60
Urbanization rate (% of total)	130	49.71	24.71	5.33	100
Tropics (% of land in tropics)	130	61	43.9	0	100
log(GDP per capita)	130	7.54	1.63	4.61	10.74
log(Infant mortality rate)	130	3.57	1.04	1.53	5.25
log(Child mortality rate)	128	3.89	1.14	1.86	5.78
log(Life expectancy)	129	4.13	0.19	3.56	4.37
log(Stunting)	101	3.10	0.88	−0.22	4.28
log(Wasting)	96	1.50	1.02	−1.20	3.14

Notes: Data are from 1990 when possible. GDP per capita, infant mortality rate, child mortality, life expectancy, immunization rate, expenditures on public health and urbanization rate are from the World Development Indicators; actual trade share and geographical trade share are from Frankel and Romer (1999); percentage of population living in tropics is from McArthur and Sachs (2001); wasting and stunting data are from WHO and UNICEF.

3.3. Data

Table 1 contains summary statistics of our cross-sectional sample. Depending on the variables, we analyze the sample consists of data for 100–130 countries. Our primary selection criterion was data availability. For 134 countries, we had a complete set of observations for infant mortality, GDP per capita, geographical trade share and actual trade share. Given this base sample, the only countries we omitted from our primary analysis were Bulgaria, Hungary, Poland and Romania. We left these countries out because they were all Soviet bloc countries and our data come from a time of significant political and social upheaval there. Including them in the analyses presented below had no substantive effect on the results. The complete set of countries included in our sample is listed in Appendix A.

We use infant and child mortality rates, and stunting and wasting rates to measure children's welfare. The infant and child mortality rates are from the World Bank's World Development Indicators (1990). The stunting and wasting data are largely from the World Health Organization (WHO).[3] Stunting largely captures persistent shortfalls in nutrition and/or a high disease burden, while wasting captures more recent shocks to nutrition and illness (WHO, 1995, Chapter 5).

[3] These data were kindly shared by de Onis of the World Health Organization. The methodology of the WHO database is described in de Onis and Blössner (2003). We added several observations from a related UNICEF dataset (http://www.childinfo.org/). Both datasets summarize results from national surveys (usually, but not always, covering a representative sample of each nation). For each survey, analysts compute the share of children whose height for their

While genes are important at explaining variations within a well-fed population, they have little to do with variation across populations with high and low levels of nutrition (WHO, 1995, Chapter 5).

Our measures of actual and predicted trade shares are the actual and predicted (geographical) trade shares reported by Frankel and Romer (1999). They use 1985 trade, population and income data from the Penn World Table. We, also, include the percentage of land in a tropical area (from Gallup and Sachs, 1999). We sometimes, but not always, include GDP per capita, immunization rates for measles, and government expenditures on public health as a share of GDP. We are interested in comparing how the relationship between trade and children's health changes when we condition on these variables. These measures come from the World Development Indicators (1990).[4] When used each measure is from 1990.

Finally, measurement error is a serious concern for all of our data. Accurately measuring social indicators such as infant mortality across countries is notoriously difficult (Krueger and Lindahl, 2001). We discuss how measurement error may affect our results.

3.4. Identification

The validity of our identification strategy depends on our instrument—geographical trade share—satisfying three conditions: (1) it must be correlated with actual trade share; (2) it must not be affected itself by children's welfare; (3) it must be uncorrelated with other factors that affect children's welfare.

Condition (1) is easily satisfied in that our predicted trade share strongly correlates with actual trade. Table 2 contains the results of a regression of actual trade share on geographical trade share (our instrument), the percentage of land in the geographical tropics, and region indicator variables. The F-statistic for geographical trade share is 86, which by conventional standards is a very strong first stage (Staiger and Stock, 1997).

We can rule out condition (2) by virtue of the construction of geographical trade share. Children's health cannot affect a country's geographical characteristics.

Condition (3) cannot be tested completely. We can examine whether our instrument is correlated with factors that we can observe that are plausibly correlated with factors that we cannot observe. In results that are not reported, we find geographical trade share is not significantly related to health-related covariates such as the proportion of a country's population at risk of falciparum malaria transmission (as measured by McArthur and Sachs, 2001).

A rule-of-thumb about an instrumental variable is that it should affect a given dependent variable only through its effect on the endogenous variable of interest. We tested this constraint

age and sex is two or more standard deviations below healthy US norms (that is, the share stunted). A similar analysis examines low height for height (BMI), the share wasted. By construction, about 2.5% of the US population is stunted and a similar share wasted; thus, rates above 2.5% are largely driven by malnutrition and illness. Stunting and wasting start near the US norm at birth but rapidly increase in poor nations. A subset of the observations in the WHO database use slightly different age ranges than the modal 0–59 months. We assume a linear decline from zero excess stunting at birth to the steady state that holds ages 2–7 years to correct for slight differences in sample ages across surveys (for example, starting at age 12 months or ending at 47 or 71 months).

[4] When we condition on income, we miss any effect trade might have on children's welfare through its effect on income growth. When we do not condition on income, we risk attributing effects of income on children's welfare to trade. However, if the Frankel and Romer strategy of identifying the causal relation between openness and income is correct, then, our estimates that do not condition on income are also correct. Conditioning on income, then, captures the effect of openness to trade that are beyond any benefits from higher income.

Table 2
Predicting actual trade as a share of GDP

	Actual trade share
Geographical trade share	1.62 (0.18)***
Tropics (% land in tropics)	0.04 (0.15)
Latin America and Caribbean	−0.08 (0.13)
Middle East	−0.08 (0.09)
Africa	−0.06 (0.16)
Southern Asia	0.14 (0.29)
Eastern Asia	0.21 (0.14)
Constant	0.32 (0.05)***
Observations	130
R^2	0.49

Notes: Robust standard errors in parentheses; actual trade share and geographical trade share are from Frankel and Romer (1999). OECD is base category for region dummies.
*** Significant at 1%.

by regressing each measure of health on actual trade share, geographical trade share, the percentage of land in the geographical tropics, and region dummies. We find that geographical trade share does not have a statistically significant effect on mortality, wasting or life expectancy when actual trade share is included as an independent variable (these results are available upon request), but predicts log(stunting) independently of actual trade share.[5]

At the same time, our measure of openness to trade may capture openness to other forms of exchange such as direct foreign investment and movements of people. In results not shown, we find that direct foreign investment as a share of GDP is positively and statistically significantly related to trade as predicted by the gravity model. This suggests that our measures of trade (actual and geographical) likely represent both trade and—more generally—openness to the international economy. In addition, it is likely that other measures such as tourist flow are also correlated with our geographic-based measure of openness.

Thus, our identification strategy appears plausible, at least for mortality, wasting and life expectancy. Our instrument has a strong first-stage effect, it is not significantly correlated with other observable covariates that are plausibly related to factors that we cannot observe (proximity to tropics and malaria risk), and it does not independently affect our dependent variables. At the same time, the gravity model's prediction of trade also predicts direct foreign investment, which suggests that our results may have to do with "openness" broadly conceived, not just openness to foreign trade in goods and service.

4. Results

4.1. Infant mortality

Table 3 contains the main results of the paper. Column 1 presents the results of the second stage of a two-stage least squares regression (2SLS) of log(infant mortality) on actual trade share instrumented for by geographical trade share, the percentage of land in the tropics, and region

[5] In a regression of log(stunting) on actual trade share, geographical trade share, the percentage of the population living in the tropics and region indicators, the estimated coefficient for actual trade share is −.35 and the estimated coefficient for geographical trade share is −1.27. Both coefficients are statistically significant at the 5% level of confidence.

Table 3
Trade has favorable affect on health measures

	(1) log(Infant mortality rate)	(2) log(Child mortality rate)	(3) log(Stunting)	(4) log(Life expectancy)
2SLS: actual trade share is instrumented for by geographical trade share				
Actual trade share	−0.597 (0.175)***	−0.626 (0.202)***	−1.113 (0.325)***	0.091 (0.030)***
Tropics (% land in tropics)	0.204 (0.239)	0.381 (0.252)	0.379 (0.282)	−0.088 (0.033)***
Latin America and Caribbean	1.190 (0.230)***	1.077 (0.239)***	1.434 (0.420)***	−0.032 (0.029)
Middle East	1.386 (0.194)***	1.407 (0.206)***	1.971 (0.357)***	−0.105 (0.021)***
Africa	2.216 (0.257)***	2.290 (0.270)***	2.043 (0.432)***	−0.328 (0.037)***
Southern Asia	1.622 (0.398)***	2.156 (0.183)***	2.564 (0.342)***	−0.158 (0.047)***
Eastern Asia	1.378 (0.278)***	1.314 (0.303)***	1.929 (0.453)***	−0.119 (0.035)***
Constant	2.539 (0.169)***	2.762 (0.179)***	1.831 (0.353)***	4.263 (0.024)***
Observations	130	128	101	129
R^2	0.75	0.77	0.48	0.77

Notes: Robust standard errors in parentheses; actual trade share and geographical trade share are from Frankel and Romer (1999). OECD is base category for region dummies.
*** Significant at 1%.

indicators. The estimated coefficient for geographical trade share is −.597 and is statistically significant at the 1% level of confidence.[6]

According to this finding, a 20-percentage point change in trade as a share of GDP (a large change) corresponds to about a .10 decrease in log(infant mortality) rate. With a mean rate of around 50 infant deaths per 1000 live births, 10% lower infant mortality saves 5 lives per 1000 births. While important, that change is only about 10% of the cross-sectional standard deviation of infant mortality and only about 3 years' of trend improvement in infant mortality. Thus, these estimates are consistent with trade being a determinant, but not a first-order determinant, of infant mortality.

4.2. Child mortality

We repeated the analysis described above using log(child mortality) as the measure of children's health (these results are not reported). In the same 2SLS specification as above, the estimated coefficient for trade share is −.63 and is statistically significant at the 1% level of confidence.

4.3. Malnutrition

Column 3 of Table 3 presents the 2SLS results on stunting (low height for age and sex). Similar to the effects on infant and child mortality, stunting ages 0–5 is lower in nations that trade more. The estimated coefficient for trade share is −1.11 and is statistically significant at the 1% level of confidence. According to these estimates, a 20-percentage point increase in trade as a share of GDP reduces predicted stunting by about .25 log points, which corresponds to about a third of a standard deviation or roughly 7-percentage points.[7]

Results on wasting (low weight for height) are consistently near zero and never statistically significant (results available on request). This latter result is expected as the cross-sectional relationship captures long-term effects; thus, it should affect stunting (a cumulative outcome) more than wasting (typically due to recent bad news).

4.4. Life expectancy

Column 4 of Table 3 presents the 2SLS results on log(life expectancy). The estimated coefficient for trade share is −.091 and is statistically significant at the 1% level of confidence. According to these estimates, a 20-percentage point increase in trade as a share of GDP increases life expectancy by almost 2 log points, which is roughly a half year longer life, or a tenth of the standard deviation across nations.[8]

5. Causal channels

We examined several potential causal mechanisms through which trade might affect children's welfare: income, immunization rates, urbanization, and the share of GDP spent on public health. All of these measures are from World Development Indicators (1990).

[6] Our findings are very similar when we use actual trade share but do not instrument for it with geographical trade share (results not shown). The estimated coefficient for trade share is −.51 and is statistically significant at the 1% level of confidence.

[7] In the OLS specification, the estimated coefficient for trade share is −.78 ($P < .01$).

[8] In the OLS specification, the estimated coefficient for trade share is .097 ($P < .01$).

To determine if each measure is a plausible causal channel, we first regressed each on the geographical trade share, the percentage of land in the tropics, and region indicator variables. Columns 1–5 of Table 4 present the results of these regressions. Geographic trade share predicted higher GDP per capita (as in Frankel and Romer, 1999), higher immunization rates, and higher expenditures on public health. Our measure of openness did not have a statistically significant effect on urbanization. We should note, also, that geographic trade share predicted higher immunization rates and higher expenditures on public health even when we conditioned on log(GDP per capita) as well. Thus, there is no evidence here that openness starves the public health portion of the public sector.

We, next, examined whether conditioning on these variables affected the estimated effect of trade on our measures of children's health. Referring to columns 1–4 in Table 5a, conditioning on log(GDP per capita) reduced the estimated effect of trade share on log(infant mortality rate) from −.60 to −.21 (with almost identical effects on log(child mortality rate)), reduced the estimated effect of trade share on log(stunting) from −1.113 to −.888, and reduced the estimated effect of trade share on log(life expectancy) from .091 to .035. In all specifications, the coefficient for trade share remained statistically significant at least the 10% level of confidence. Also, the estimated effect of log(GDP per capita) was favorable and statistically significant in all specifications.

Taken on their face, these results suggest that a meaningful share—but not all—of the benefits of trade operates through higher income. At the same time, since income might be endogenous, if omitted factors harm both health and income then the coefficient on income can be biased up. However, income is likely also measured with substantial error, and such measurement error typically leads the coefficient on income to be biased down. Thus, we do not want to take these results too literally.

We, next, condition on the measles immunization rate. This single measure of public health is presumably a proxy for the overall state of the public health system, as measles immunization rates are well correlated with other immunization rates. As such, this measure helps capture any improvements in GDP that are captured by the public health system as well as how efficiently the public health system focuses on child health.

Conditioning on the rate of immunization for measles (Table 5b) reduced the estimated effect of trade share on log(infant mortality) from −.60 to −.43 (with almost identical effects on child mortality) and reduced the effect of trade share on log(life expectancy) from .091 to .057. In contrast, conditioning on immunizations had virtually no impact on the effect of trade share on log(stunting). In all specifications, the coefficient for trade share remained statistically significant at least the 10% level of confidence. Also, the estimated effect of the immunization rate was favorable in all specifications and generally statistically significant. (The estimated coefficients for trade share in the specifications that did not condition on immunization differ slightly from those reported in Table 3. The reason is that the samples of countries are slightly different because we do not observe immunization rates for all countries in the base sample. The comparison of coefficients described here corresponds to regressions that used identical samples of countries).

It is possible that government health expenditures rise with trade both due to rising incomes and due to any changes in priority of health care. Conditioning on government health expenditures as a percentage of GDP (Table 5c) reduced the estimated effect of trade share on log(infant mortality) from −.66 to −.60, reduced the estimated effect of trade share on log(child mortality) from −.73 to −.64, reduced the estimated effect of trade share on log(stunting) from −1.56 to −1.09, and reduced the effect of trade share on log(life expectancy) from .103 to

Table 4
Does trade predict the potential causal channels?

	(1) log(GDP per capita)	(2) Immunization rate for measles	(3) Immunization rate for measles	(4) Public expenditure on health/GDP	(5) Public expenditure on health/GDP
Geographical trade share	1.348 (0.506)***	20.713 (5.496)***	14.900 (4.937)***	1.668 (0.541)***	1.383 (0.555)**
log(GDP per capita)			4.445 (1.445)***		0.171 (0.148)
Latin America and Caribbean	−2.170 (0.223)***	−3.461 (4.157)	6.597 (4.526)	−2.907 (0.377)***	−2.499 (0.504)***
Middle East	−2.123 (0.358)***	2.375 (3.647)	11.981 (4.806)**	−3.784 (0.392)***	−3.364 (0.573)***
Africa	−3.648 (0.205)***	−16.293 (4.219)***	−0.059 (6.240)	−3.816 (0.291)***	−3.181 (0.654)***
Southern Asia	−2.863 (0.834)***	−21.384 (4.768)***	−4.418 (7.446)	−4.450 (0.265)***	−3.941 (0.556)***
Eastern Asia	−2.707 (0.315)***	−4.723 (6.039)	7.248 (5.591)	−3.437 (0.489)***	−2.952 (0.629)***
Constant	9.510 (0.164)***	76.890 (3.335)***	34.390 (14.044)**	5.295 (0.275)***	3.655 (1.498)**
Observations	130	122	122	113	113
R^2	0.66	0.25	0.31	0.59	0.60

Notes: Robust standard errors in parentheses; actual trade share and geographical trade share are from Frankel and Romer (1999). OECD is base category for region dummies.
** Significant at 5%.
*** Significant at 1%.

Table 5
The mediating role of causal channels

	(1) log(Infant mortality rate)	(2) log(Child mortality rate)	(3) log(Stunting)	(4) log(Life expectancy)
2SLS: actual trade share instrumented for by geographical trade share				
(a) Conditioning on GDP per capita				
Actual trade share	−0.213 (0.115)*	−0.245 (0.119)**	−0.888 (0.362)**	0.035 (0.021)*
Constant	6.699 (0.429)***	7.220 (0.480)***	3.397 (1.030)***	3.665 (0.075)***
Observations	130	128	101	129
R^2	0.89	0.90	0.55	0.86
(b) Conditioning on measles immunization rate				
Actual trade share	−0.427 (0.167)**	−0.468 (0.191)**	−0.881 (0.274)***	0.057 (0.028)**
Constant	3.367 (0.269)***	3.714 (0.290)***	2.009 (0.396)***	4.101 (0.050)***
Observations	122	122	96	121
R^2	0.78	0.79	0.58	0.81
(c) Conditioning on public expenditure on health				
Actual trade share	−0.603 (0.194)***	−0.643 (0.222)***	−1.092 (0.422)**	0.086 (0.035)**
Constant	2.988 (0.376)***	3.214 (0.395)***	2.251 (0.503)***	4.188 (0.042)***
Observations	113	112	87	112
R^2	0.75	0.77	0.50	0.79

Notes: Robust standard errors in parentheses; actual trade share and geographical trade share are from Frankel and Romer (1999). OECD is base category for region dummies. Other controls are as in Table 2: region dummies and share of land in the tropics.

* Significant at 10%.
** Significant at 5%.
*** Significant at 1%.

Table 6
The mediating role of all causal channels

	log(Infant mortality rate)			
	(1)	(2)	(3)	(4)
(a) 2SLS: actual trade share instrumented for by geographical trade share				
Actual trade share	−0.657 (0.210)***	−0.242 (0.138)*	−0.188 (0.135)	−0.125 (0.129)
log(GDP per capita)		−0.429 (0.056)***	−0.427 (0.054)***	−0.418 (0.054)***
Public expenditure on health			−0.056 (0.037)	−0.041 (0.038)
Immunization rate for measles				−0.006 (0.002)***
Constant	2.528 (0.187)***	6.504 (0.533)***	6.771 (0.572)***	7.059 (0.556)***
Observations	109	109	109	109
R^2	0.75	0.89	0.89	0.90
	log(Child mortality rate)			
	(1)	(2)	(3)	(4)
(b) 2SLS: actual trade share instrumented for by geographical trade share				
Actual trade share	−0.742 (0.233)***	−0.291 (0.148)*	−0.236 (0.145)	−0.168 (0.137)
log(GDP per capita)		−0.465 (0.058)***	−0.464 (0.056)***	−0.454 (0.055)***
Public expenditure on health			−0.058 (0.039)	−0.042 (0.039)
Immunization rate for measles				−0.007 (0.002)***
Constant	2.784 (0.198)***	7.099 (0.549)***	7.376 (0.579)***	7.686 (0.567)***
Observations	109	109	109	109
R^2	0.76	0.89	0.90	0.91
	log(Stunting)			
	(1)	(2)	(3)	(4)
(c) 2SLS: actual trade share instrumented for by geographical trade share				
Actual trade share	−1.001 (0.374)***	−0.730 (0.359)**	−0.622 (0.358)*	−0.628 (0.349)*
log(GDP per capita)		−0.219 (0.098)**	−0.229 (0.096)**	−0.230 (0.097)**
Public expenditure on health			−0.078 (0.049)	−0.079 (0.052)
Immunization rate for measles				0.0001 (0.003)
Constant	1.774 (0.368)***	3.770 (0.992)***	4.207 (1.023)***	4.186 (0.982)***
Observations	84	84	84	84
R^2	0.55	0.64	0.66	0.66
	log(Life expectancy)			
	(1)	(2)	(3)	(4)
(d) 2SLS: actual trade share instrumented for by geographical trade share				
Actual trade share	0.096 (0.037)**	0.038 (0.025)	0.027 (0.025)	0.012 (0.023)
log(GDP per capita)		0.059 (0.009)***	0.059 (0.009)***	0.057 (0.008)***
Public expenditure on health			0.011 (0.004)**	0.007 (0.004)*
Immunization rate for measles				0.002 (0.000)***
Constant	4.265 (0.027)***	3.718 (0.085)***	3.666 (0.087)***	3.596 (0.081)***
Observations	108	108	108	108
R^2	0.78	0.87	0.87	0.89

Notes: Robust standard errors in parentheses; actual trade share and geographical trade share are from Frankel and Romer (1999). OECD is base category for region dummies. Other controls are as in Table 2: region dummies and share of land in the tropics.

* Significant at 10%.
** Significant at 5%.
*** Significant at 1%.

.086. In all specifications, the coefficient for trade share remained statistically significant at least the 10% level of confidence. Also, the estimated effect of public health expenditures was favorable in all specifications though generally not statistically significant. (The estimated coefficients for trade share in the specifications that did not condition on public health expenditures differ slightly from those reported in Table 4 because of changes in the sample. The comparison of coefficients described here corresponds to regressions that used identical samples of countries).

We also examined the effect of public health expenditures and immunization rates on the relationship between trade and children's health while conditioning on per capita GDP. These results are reported in Table 6a–d. Adding public expenditure on health to a specification that already conditioned on GDP per capita reduced the estimated effect of trade on log(infant mortality) from −.24 to −.18, and adding the immunization rate to that specification reduced the estimated effect to −.125. In each of these latter specifications, the estimated effect of trade of log(infant mortality) was not significant. Similar patterns were observed with respect to child mortality.

Adding public health expenditures to a specification that already conditioned on log(GDP per capita) reduced the estimated effect of trade on log(stunting) from −.73 to −.62, and adding the immunization rate to that specification had no additional impact. In each of these latter specifications, the estimated effect of trade of log(stunting) remained significant at the 10% level.

Finally, adding public health expenditures to a specification that already conditioned on log(GDP per capita) reduced the estimated effect of trade on log(life expectancy) from .038 to .027, and adding the immunization rate to that specification reduced the estimated effect to .012. The effect of trade on log(life expectancy) was not significant in any specification that conditioned on log(GDP per capita).

6. Robustness checks

Our results were not affected by omitting Singapore and/or Hong Kong (two observations with very high trade shares both with and without adjusting for geographic factors), by capping a country's trade as a share of GDP at .80, or by removing the OECD nations from the sample. Also, our sample did not include Cuba, a country that is unlikely to be representative since it has a large predicted trade share due to its physical proximity to the United States, low actual trade due to a US embargo, and relatively low rates of infant mortality. Including trade squared (and squared predicted trade as an additional instrument) as a covariate did not affect our results either, nor did including the measure of institutional quality used by Acemoglu et al. (2001), or controlling for the percentage of the population living in the tropics.

In results available in the longer working-paper version of this article, we used longitudinal data to estimate how changes in trade affect children's health. In this version of the gravity model, changes in nearby nation's GDP drives changes in predicted trade. The results were consistent with the small favorable effects we estimate using the more convincing cross-sectional variation in predicted trade. At the same time, in some specifications' changes in predicted trade predicted changes in children's health even conditioning on actual trade. Thus, it is possible that regional shocks affected trade, income, and health of a set of nations, even though our data were from before the HIV/AIDS pandemic had macroeconomic effects. In that longer version, we also examined the relationship between openness to trade and education. In general, results were not statistically significantly different from zero, although many were imprecise.

7. Summary and discussion

Our first main result is that openness to trade predicts slightly reduced rates of infant mortality, child mortality and stunting (low height for age, a measure of sustained malnutrition). Given the well-known problems comparing data across nations, it is encouraging to have completely different data sources provide consistent answers. Our second main result is that, in contrast, the estimated effects of trade on wasting (low weight for height) are always close to zero; this effect is predicted because wasting (unlike stunting) responds largely to short-run changes in nutrition while we are estimating a cross-section that emphasizes long-term nutrition. Finally, openness to trade predicts higher income, immunization rates, and expenditures on public health. Some, but not all, of the benefits of openness on child health appear to operate through these causal channels.

In brief, we do not find evidence that trade has the dire consequences sometimes ascribed to it by critics of globalization. At the same time, we find no support for proponents of trade as an almost-sufficient condition for development, broadly conceived. As such, our results on openness and child health are consistent with the Frankel and Romer (1999) results on openness and economic growth.

It is also likely that our results measure openness to the international economy more broadly than just the effects of trade. Our instrument for trade—geographical trade share—also predicts foreign direct investment. It is likely that flows of people and ideas are also predicted in part by factors such as having a coastline that are included in our gravity model.

An important caution for studies such as this is that policies that the geographic factors that make trade more costly might have different effects on children than do trade policies that restrict trade (Frankel and Romer, 1999; Rodrik and Rodríguez, 2001). For example, trade-restricting policies might restrict imports of skill-intensive goods, increasing the returns to skill in a poor nation. Such higher returns to skill increase incentives for investing in children. In such a setting, the effects of opening up trade may be to reduce incentives for education. The opposite case is also possible. For example, Feenstra and Hanson (1997) provide a theoretical example and evidence from Mexico that opening up trade can increase returns to skill in poor nations.

A final caution involves our emphasis on measures of infant mortality and under-nutrition. In the last few years, even fairly poor nations have suffered from an epidemic of obesity and the resulting maladies. As international data arrive, it is important to analyze how openness affects obesity, diabetes, heart attacks, and related health problems.

Appendix A

The following countries are in the largest sample, with some attrition for missing values in some regressions:

Algeria	Haiti	Seychelles
Angola	Honduras	Sierra Leone
Argentina	Hong Kong	Singapore
Australia	Iceland	Solomon Islands
Austria	India	South Africa
Bahamas	Indonesia	Spain
Bahrain	Iran	Sri Lanka
Bangladesh	Ireland	St. Lucia
Barbados	Israel	St. Vincent and the Grenadines
Belgium	Italy	Sudan

Belize	Jamaica	Suriname
Benin	Japan	Swaziland
Bolivia	Jordan	Sweden
Botswana	Kenya	Switzerland
Brazil	South Korea	Syria
Burkina Faso	Lao PDR	Tanzania
Burundi	Lesotho	Thailand
Cameroon	Liberia	Togo
Canada	Madagascar	Tonga
Cape Verde	Malawi	Trinidad and Tobago
Central Africa	Malaysia	Tunisia
Chad	Mali	Turkey
Chile	Malta	Uganda
China	Mauritania	United Arab Emirates
Colombia	Mauritius	United Kingdom
Comoros	Mexico	United States
Costa Rica	Mongolia	Uruguay
Cote d'Ivoire	Morocco	Vanuatu
Cyprus	Mozambique	Venezuela
Denmark	Namibia	Yemen
Djibouti	Nepal	Zambia
Dominica	The Netherlands	Zimbabwe
Dominican Republic	New Zealand	
Egypt	Nicaragua	
El Salvador	Niger	
Ethiopia	Nigeria	
Fiji	Norway	
Finland	Oman	
France	Pakistan	
Gabon	Panama	
Gambia	Papua New Guinea	
Germany	Paraguay	
Ghana	Peru	
Greece	Philippines	
Grenada	Portugal	
Guatemala	Puerto Rico	
Guinea	Rwanda	
Guinea-Bissau	Saudi Arabia	
Guyana	Senegal	

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