Health and Wellbeing Around the World: The Impacts of Trade

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Abstract

In recent decades, health outcomes such as life expectancy and disability from illnesses are increasingly recognized as important determinants of wellbeing. This paper estimates the impact of trade on the health and wellbeing of nations using a wellbeing measure that weights consumption by the health-adjusted life expectancy of a country. Exploiting trade expansions driven by the rise of air transportation over time, I show that trade increased life expectancy by 1.9 life years worldwide since 1990 and deceased disease burdens especially for communicable, maternal, neonatal, and nutritional diseases. The health impacts were concentrated in Asia and Africa, where 56%-68% of the wellbeing increase from trade was driven by the health impacts of trade. Worldwide, trade expansions accounted for 14% of the wellbeing increase since 1990 and the health impacts of trade accounted for nearly half (6.5%) of the increase.

Keywords: trade, health, life expectancy, disease burdens, consumption, wellbeing

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1 Introduction

The past half century has witnessed falling barriers to trade and rising integration of the world economy. Between 1965 and 2019, world trade volumes expanded by an average of 14% each year, with emerging markets in Asia and Africa now accounting for 40% of world trade compared to 19% in 1965. Opening up to trade has enabled developing countries to improve productivity leveraging comparative advantages, leading to sustained economic growth and poverty reduction around the world (International Monetary Fund 2001; World Trade Organization 2014; World Bank 2020).

Starting the 1990s, global initiatives began emphasizing a broader range of societal goals that went beyond the narrow focus on economic development. Notably, the United Nations aimed to increase public health investments tackling child and maternal mortality as well as mortality from epidemic diseases in the Millennium Development Goals (United Nations, 2000), and more recently pushed for investments against non-communicable diseases in the Sustainable Development Goals (United Nations, 2015). To achieve these goals, the initiatives emphasized the role of the multilateral trading system as an important avenue for accessing the goods and technology vital for improving health and living conditions on a global scale (Fidler et al. 2009; World Health Organization 2015; World Trade Organization 2018).

To what extent has trade successfully impacted the wellbeing of countries beyond economic growth captured in the GDP? This paper estimates the causal impact of trade on health and wellbeing using a wellbeing measure that weights consumption by the health-adjusted life expectancy in a country. To obtain causal estimates of trade, the main challenge is that multiple omitted factors, especially those related to domestic economic reforms, could correlate with a country's openness to trade while having independent impacts on health and consumption. A second concern is reverse causality. To the extent that changes in population health could in turn impact comparative advantages and the patterns of trade, the reverse causality would bias OLS estimates of trade in this setting.

To overcome the endogeneity biases, I instrument for trade exploiting the rise of air transportation over time interacted with the distance for trade over the air route relative to the sea route (Feyrer 2019; Blanchard and Olney 2017; Jacks and Novy 2018; Kleinman et al. 2020; Li 2021; Tabellini and Magistretti 2022; Aksoy et al. 2022). Intuitively, due to the geography of land masses across the globe, the advent of air transportation would differentially reduce trade costs between countries separated by long distances over the sea route relative to the great circle distance by air. The geography between countries thus implies heterogeneous impacts of transportation technology across importer-exporter pairs that are plausibly exogenous to country-specific factors of trade such as economic growth and liberalization. Moreover, because the instrument exploits the time-varying distances for trade, one can control for numerous, time-invariant resistance to trade (geography, colonial relationships, common language, etc.) using country pair fixed effects.

Applying the instrument, I show that trade expansions had significant impacts on life expectancy and child mortality around the world. Between 1965 and 2019, trade expansion increased life expectancy by 3.4 years, or by 21% of the life expectancy increase (57 to 73 years) over this period. The effect on mortality was initially small and insignificant before 1990 but grew larger after 1990, where trade decreased under-5 mortality by 1 percentage point, or by 25% of the mortality reduction in 1990-2019. Across geography, the life expectancy gains were larger in Asia and Africa whereas the mortality effect was highly concentrated in Africa, where under-5 mortality decreased by as much as 3.4 percentage points with trade since 1990.

For a more detailed understanding of the health impacts, I turn to disease-specific disability-adjusted life years (DALY) in the 2019 Global Burden of Diseases (GBD) study. DALY calculates the total health loss of a disease adding up the life years lost to mortality from the disease with the healthy life years lost to disability. I find that trade substantially decreased DALYs of communicable diseases, maternal, neonatal, and nutritional diseases, as well as DALYs from interpersonal violence and self-harm. The largest impacts were found in Africa, where trade expansion decreased DALYs by a total of 233.5 life years per 1,000 individuals since 1990, or by 60% of the DALY reduction in the region. In Asia, despite the life expectancy gains, trade had more mixed impacts on DALYs, reducing communicable diseases but worsening cardiovascular diseases and metabolic risk factors such as high cholesterol and hypertension. Moreover, behavioral risk factors such as smoking and risky diet also worsened with trade in Asia.

Building on the estimates, I next quantify the contribution of trade to the wellbeing increases around the world in 1990-2019. While conventional wellbeing measures focus on national incomes such as the GDP, health improvements matter for wellbeing as healthier populations enjoy additional life years of consumption due to greater longevity and suffer less from disease-driven disabilities per life year. I characterize the health distribution in a country using health-adjusted life expectancy (HALE), constructed from age-specific disability status and mortality rates in the GBD. I then multiply HALE by the per-period utility derived from the country's consumption distribution in micro surveys to construct a summary measure of wellbeing.

Following Jones and Klenow (2016), I compare wellbeing across country and over time using a consumption-equivalent metric equal to the proportion of US consumption that yields individuals indifferent between own country's health-consumption distribution and that of the US in 2019. Increases in the metric approaching one imply convergence to the US standard of living in terms of health and consumption. Over time, wellbeing in the median country of the world increased from 3.3% of the US in 1990 to 19% in 2019. Trade expansion accounted for 14.1% of the wellbeing increase, and 46% of the trade impact on wellbeing was attributable to the health gains from trade. In Africa and Asia, trade expansion accounted for 19%-22% of the wellbeing increase, of which 56%-68% was attributable to the health gains from trade. In Europe and South America, trade accounted for 11% of the wellbeing increase, of which roughly one-third was improvements in health. In North America, the health loss from trade decreased wellbeing by 12% despite increases in consumption, and the net impact on wellbeing was small to neutral in the region.

These results highlight the significant role of health in the wellbeing increases over the past three decades. Omitting the health improvements since 1990, in particular, would lower wellbeing to 7.9% of the US in 2019 as opposed to 19% including health. Of the trade impact on wellbeing, the health gains from trade were in the same order of magnitude compared to the consumption gains from trade, and health was in fact the dominant factor behind trade-induced wellbeing increases among Asian and African countries. Thus, living a longer, healthier life contributes substantially to the rising living standards and the wellbeing increases from trade in the developing world.

This paper relates to a growing literature that recognizes the limitation of GDP as an all-around measure of wellbeing. Additional components of wellbeing, such as longevity, leisure, and inequality, have been suggested by economists (Fleurbaey 2009; Stiglitz et al. 2009; Jean-Paul et al. 2018) and incorporated into utility-based wellbeing metrics (Becker et al. 2005; Cordoba and Verdier 2008; Fleurbaey and Gaulier 2009; Jones and Klenow 2016). While these metrics have yielded new insights on living standards around the world, beyond measurement, few papers have examined the role of economic forces as contributors to wellbeing across regions and over time. Exploiting trade expansions facilitated by transportation technology, this paper shows that greater integration into the world economy has been a major driver of wellbeing growth over the past three decades. Remarkably, the health gains from trade contributed more to the wellbeing increases than consumption gains in Asia and Africa, where life expectancy and disease burdens improved significantly with trade.

This paper also relates to the literature linking globalization to health behavior changes and increased risks of lifestyle diseases such as obesity. While correlational studies show mixed support for the linkage (Vogli et al. 2014; Miljkovic et al. 2015; Oberlander et al. 2017), studies exploiting trade liberalization events and trade shocks have found large increases in obesity rates resulting from trade (Baggio and Chong 2020; Giuntella et al.

2020).[1] Adopting a geography instrument for trade, this paper presents evidence from across the globe that trade impacts health primarily by reducing communicable, maternal, neonatal, and nutritional diseases, but indeed worsened cardiovascular diseases and associated metabolic risk factors to a small extent in some parts of the world. Increases in unhealthful consumption such as smoking and risky diet also contributed to the negative health effects, but evidence of large changes in physical activity was not strong.

The paper proceeds as follows. Section 2 introduces data and presents descriptive trends on the growth of trade and life expectancy since 1965. Section 3 motivates the empirical strategy and constructs instruments for trade exploiting time-varying geography. I estimate the impact of trade on life expectancy and mortality in Section 4 and on disease-specific health burdens in Section 5. In Section 6, I quantify the contribution of trade to the wellbeing increases in 1990-2019. Section 7 concludes.

2 Data

Bilateral Trade. Data on bilateral trade flows come from the United Nations Comtrade database, which includes annual manufacturing trade flows between importer-exporter pairs since 1962. To account for reporting inconsistencies and other data quality issues, I obtain harmonized data from the Atlas of Economic Complexity compiled by the Harvard Growth Lab. The Atlas estimates an index of reliability to adjust for country-specific reporting practices and corrects import values for freight and insurance costs to match with exporter-reported values.[2] I measure bilateral trade flows as the average of imports and exports between country pairs. A country's total trade value is the sum of bilateral trade flows across trading partners. I convert all trade values to 2000 US dollars using CPI.

[1] Specifically, Baggio and Chong (2020) uses a difference-in-differences design to show that countries signing a free trade agreement with the US experienced a 4.4% increase in obesity rates. Giuntella et al. (2020) uses a shift-share instrument to show that the supply of US food exports to Mexico could explain 10% of the rise in obesity rates among Mexican women.

[2] The data and additional information on the harmonization process are provided at https://atlas.cid.harvard.edu/data-downloads

Sea and Air Distances. Data on the sea distance between countries come from the CERDI-SeaDistance database (Bertoli et al., 2016). The distance is calculated based on the shortest maritime route that links two countries' primary ports. For landlocked countries, the nearest foreign port accessible by land is used as the primary port for calculating the sea distances. The air distance between countries is obtained from the CEPII Gravity Dataset (Conte et al., 2021), calculated as the great circle distance between two countries' most populated cities. From the same dataset I also obtain the linguistic and colonial relationship between countries, which I include as controls in some of the specifications.

Health Outcomes. Data on life expectancy and crude mortality rates across countries come from the World Bank's Health, Nutrition, and Population database.[3] Crude mortality rate is defined as the number of deaths occurring during a year per 1,000 individuals in midyear. To capture mortality differences within a population by age, I supplement crude mortality with the probability of mortality transition between birth and age 5 (under-5 mortality) and between age 15 and 59 (adult mortality) obtained from the 2019 Global Burden of Diseases (GBD) study (GBD Collaborative Network, 2019). These mortality statistics are available across countries since 1965.

Data on disease-specific health losses come from disability-adjusted life years (DALY) constructed in the GBD since 1990. The DALY of cancer, for instance, is the sum of healthy life years lost to disability from cancer and life years lost to mortality from cancer. Normalized per 1,000 individuals, DALY summarizes the total health burden of a disease accounting for its prevalence, severity, and mortality in the population. At the most granular level, GBD calculates DALYs for a total of 169 basic, level-3 diseases. The level-3 DALYs are then aggregated to construct DALYs for 22 level-2 diseases, 3 level-1 diseases, and an all-cause DALY. I focus on level-2 and above in the analysis. Examples of level-2 diseases include communicable diseases (respiratory, enteric, tropical, sexual), maternal and neonatal disorders, non-communicable diseases (cancer, cardiovascular, neurological,

[3] The data can be accessed at https://datatopics.worldbank.org/health/

digestive, among others), as well as harms from injuries.

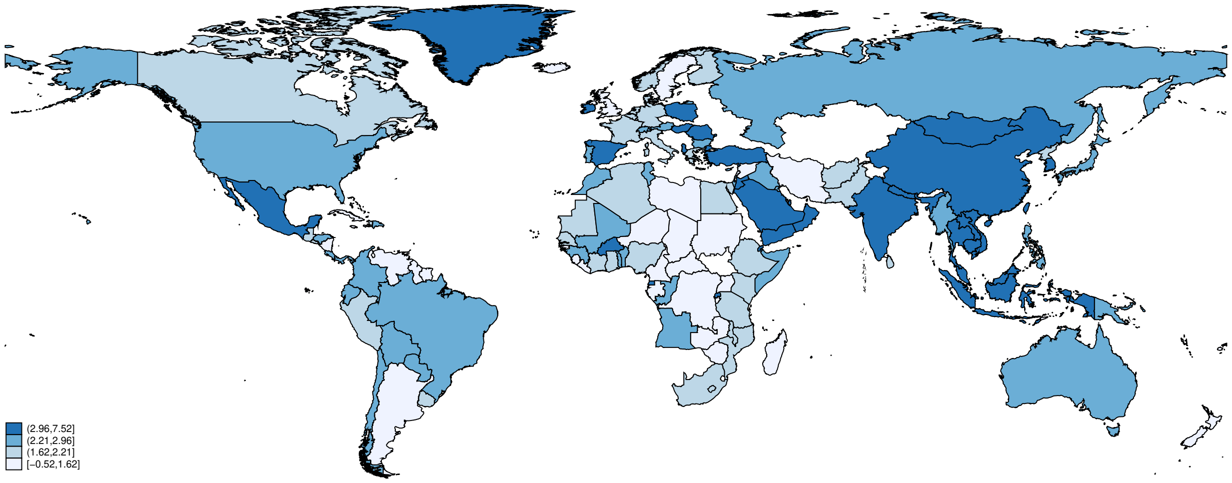
In the GBD, DALYs are similarly calculated for risk factors associated with a disease. For non-communicable diseases, in particular, risk factors include behavioral risks (smoking, drinking, risky diet, physical inactivity) and metabolic risks such as hypertension, high cholesterol, high BMI, among others. In the empirical analysis, I examine DALYs of risk factors to understand changes in health behavior and metabolic conditions as potential drivers of diseases.

Descriptive Trends. Panel (a) of Figure 1 shows the expansion of trade across countries between 1965 and 2019, measured as $log(trade_{i2019}) - log(trade_{i1965})$ for country i with positive trade values in both years. Trade increased nearly threefold in South and Southeast Asia, and more than doubled in Eastern Europe, South America, and the coastal parts of Africa. Appendix Figure A1 plots the expansion of trade in each continent. Both Asia and North America saw sustained growth of trade throughout the sample period. Trade exhibited a sustained upward trend since the mid-1980s in South America and took off more recently in Europe and Africa in the 2000s.

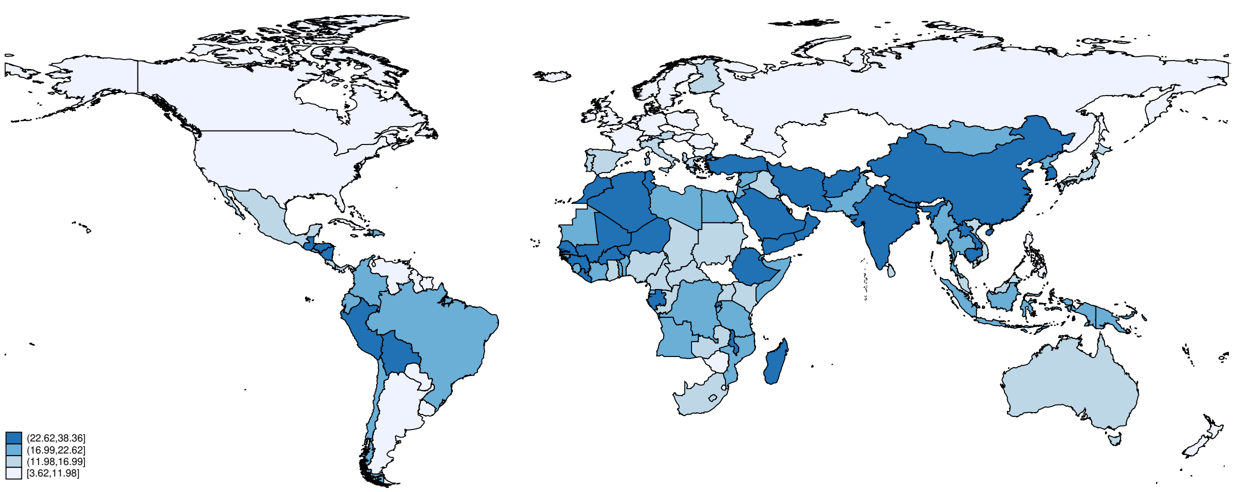
Panel (b) shows the change in life expectancy over the same period. In contrast to the large expansion of trade across the globe, the increase in life expectancy was highly concentrated among less developed countries in Asia, Africa, and South America. In these regions, life expectancy increased by over 20 years compared to an average increase of 10 years in Europe and North America. Appendix Figure A2 plots the mortality trends by continent. In Asia and Africa, crude mortality rate decreased substantially by 8-14 individuals per 1,000 since 1965. The mortality statistic was largely unchanged in Europe and decreased by a minor 2 individuals per 1,000 in North America.

Figure 1: Trade expansion and life expectancy gains around the world, 1965-2019

(a) Trade Expansion



(b) Life Expectancy Gains



Notes: Figure plots the expansion of trade across countries between 1965 and 2019 in panel (a) and the increase in life expectancy over the same period in panel (b). Trade expansion is measured as $log(trade_{i2019})-log(trade_{i1965})$ for country i with positive trade values in 1965 and 2019. Countries with missing life expectancy data in 1965 are not plotted. The color scales correspond to the four inter-quartile ranges across countries.

3 Empirical Strategy

3.1 Basic Setting

I estimate the impact of trade on health using the following specification

$$y_{it} = \beta_0 + \beta_1 \cdot log(trade_{it}) + \alpha_i + \gamma_t + \epsilon_{it}, \tag{1}$$

where health outcome y_{it} is regressed on the log trade value $log(trade_{it})$ in country i and year t. α_i and γ_t are country and year fixed effects, respectively. The key parameter of interest is β_1, which estimates the change in health outcome in response to a given expansion of trade.

Interpreting OLS estimates of β_1, however, runs into several challenges. Primarily, common third factors, such as GDP growth, could drive both a country's openness to trade and the health of its population (Cutler et al. 2006; Hall and Jones 2007). In developing countries, trade liberalization can affect distortions in the domestic economy and induce regulatory changes that mitigate or exacerbate the distortions (Atkin and Donaldson 2022; Tian 2022; Li et al. 2023). To the extent that the quality of a country's institutions has independent effects on health (Fisman and Wang 2015; Jia and Nie 2017), OLS estimates of equation 1 would be biased due to omitted variables correlated with trade.

A second concern is reverse causality, whereby changes in population health could in turn impact a country's comparative advantages and the patterns of trade. Population aging, for instance, would increase the relative supply of age-appreciating skills and shift comparative advantage towards human capital-intensive industries (Romalis 2004; Cai and Stoyanov 2016). Disease burdens, such as those predicted from demographics and aging trends, could impact the export specialization of firms (Costinot et al., 2019). The reverse causality running from health to trade would then bias OLS estimates of equation 1.

To overcome the biases, I construct instrumental variables for trade exploiting time-varying distances driven by transportation technology. Because trade decreases sharply over longer distances (Disdier and Head, 2008), technologies that reduce the shipping distance between countries (Feyrer 2019; Pascali 2017) or the time cost of travel (Pauly and Stipanicic, 2022) should differentially increase trade for country pairs more distant absent the technology. The arrival of air transportation, in particular, should increase trade between countries separated by long distances over the sea route relative to the great circle distance by air. I exploit this variation to predict bilateral trade flows and construct instruments for trade.

3.2 Predicting Trade from Time-Varying Geography

I motivate the geography instrument for trade using the gravity equation (Anderson and Van Wincoop, 2003), which models the bilateral trade between country i and j at time t as

$$trade_{ijt} = \frac{y_{it} y_{jt}}{y_{wt}} \left(\frac{\tau_{ijt}}{P_{it} P_{jt}} \right)^{1-\sigma}, \tag{2}$$

where y_{it} and y_{jt} are the income of the trading partners with y_{wt} the world average. τ_{ijt} is the bilateral resistance between country i and j, which may include distance, linguistic commonality, colonial relationship, among others. Multilateral resistance facing each country is captured in P_{it} and P_{jt}. The gravity equation motivates log trade as a linear function of country characteristics (income and resistance) and bilateral resistance as follows

$$log(trade_{ijt}) = log(y_{it}) + log(y_{jt}) - log(y_{wt}) + (1-\sigma)\Big(log(\tau_{ijt}) + log(P_{it}) + log(P_{jt})\Big). \tag{3}$$

The impact of transportation technology for international trade enters through the bilateral resistance τ_{ijt}. To capture the heterogeneous implications of air transportation across the geographic distances between countries, Feyrer (2019) models the bilateral resistance term as follows

$$log(\tau_{ijt}) = \beta_{sea,t}\,log(seadist_{ij}) + \beta_{air,t}\,log(airdist_{ij}) + \beta\,X_{ij}\,, \tag{4}$$

where $\beta_{sea,t}$ and $\beta_{air,t}$ are time-varying coefficients reflecting the weights of sea and air distances for trade over the sample period. The rise of air transportation would imply greater values of $\beta_{air,t}$ and hence greater elasticity of trade with respect to air distances over time. X_{ij} controls for additional resistances such as the linguistic and colonial relationship between countries.

The bilateral resistance $log(\tau_{ijt})$ together with equation 3 implies that bilateral trade $log(trade_{ijt})$ could be predicted based on time-varying distances as follows

$$log(trade_{ijt}) = \beta_{sea,q}\,log(seadist_{ij}) + \beta_{air,q}\,log(airdist_{ij}) + \beta\,X_{ij} + \phi_{it} + \psi_{jt} + \epsilon_{ijt}\,, \tag{5}$$

$$log(trade_{ijt}) = \beta_{sea,q}\,log(seadist_{ij}) + \beta_{air,q}\,log(airdist_{ij}) + \rho_{ij} + \phi_{it} + \psi_{jt} + \epsilon_{ijt}\,, \tag{6}$$

where country-year effects ϕ_{it} and ψ_{jt} absorb time-varying factors of trade specific to each partner country. In the preferred specification (equation 6), I control for pair fixed effects ρ_{ij} rather than X_{ij} to fully absorb time-invariant resistances to trade. With these controls, $\beta_{sea,q}$ and $\beta_{air,q}$ capture the impacts on trade across the distances between countries as transportation technology shifted towards air freight over time. Due to the large number of country-by-year effects in ϕ_{it} and ψ_{jt}, I estimate the distance coefficients $\beta_{sea,q}$ and $\beta_{air,q}$ every 5 years in q rather than annually in t in the prediction.

The total trade value of country i can be constructed as follows

$$\widehat{trade}_{it} = \sum_{j \neq i} \omega_j \exp\Big\{\underbrace{\hat{\beta}_{sea,q}\,log(seadist_{ij}) + \hat{\beta}_{air,q}\,log(airdist_{ij})}_{log(\widehat{trade}_{ijt})}\Big\}, \tag{7}$$

where bilateral trade $log(\widehat{trade}_{ijt})$ is predicted solely from time-varying distances without including the country-by-year effects. This ensures that predicted bilateral trade nets out the effects of domestic policies, economic growth, and other country-specific factors of trade which may have independent impacts on health. Predicted bilateral trade is then summed across partner j to construct an instrument for trade in country i, $\widehat{trade}_{it}$. Following Feyrer (2019), I weight bilateral trade by country j's population in 1960. In robustness checks, I show that results are similar when bilateral trade is weighted equally across countries in the instrument.

Figure 2 plots estimates of $\beta_{sea,q}$ and $\beta_{air,q}$ from equation 5 in panel (a). Over time, the elasticity of trade to air distances increased from -0.6 from the early 1960s to -1.2 in 2015-2019, whereas the elasticity to sea distances remained roughly constant at around -0.3. The rising importance of air travel thus implies greater trade expansions between countries with shorter distances by air than over seas. Panel (b) plots estimates from equation 6 normalizing the pre-1965 coefficients to zero due to the presence of pair fixed effects. These estimates confirm the secular rise in the elasticity with respect to air distances in 1965-2019, whereas the elasticity with respect to sea distances was roughly constant over the same period.

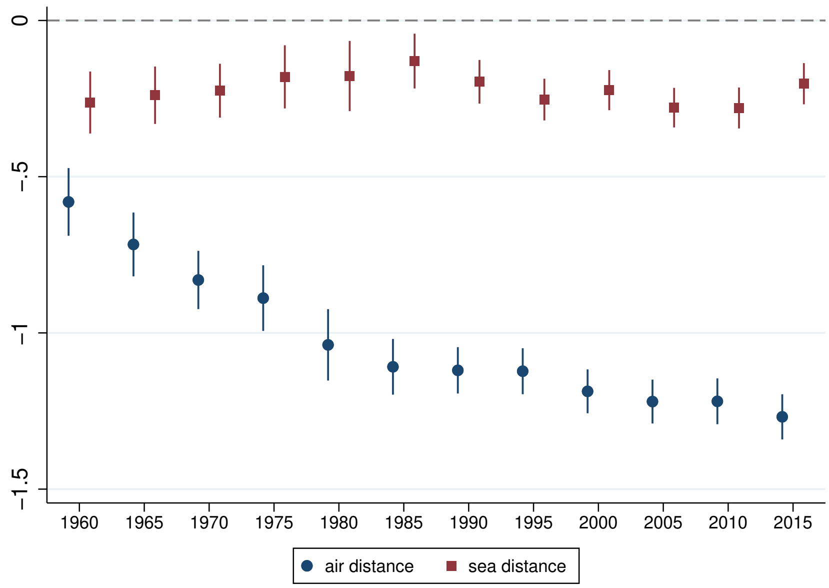
To illustrate the predictive power of the instrument, I plot $log(\widehat{trade}_{it})$ against actual trade values in Appendix Figure A3. Panels (a)-(b) show results for an instrument where the distance coefficients are estimated with bilateral controls in equation 5. The instrument is positively correlated with actual trade values, and the relationship is approximately linear once netting out the country and year effects of trade. According to the R-squared, time-varying geography explains around 8% of the overall variation in trade and 26% of the variation upon residualization. In panels (c)-(d), similar patterns hold when the instrument builds on distance coefficients that net out country pair effects in equation 6.

3.3 Instrument Validity and the First Stage

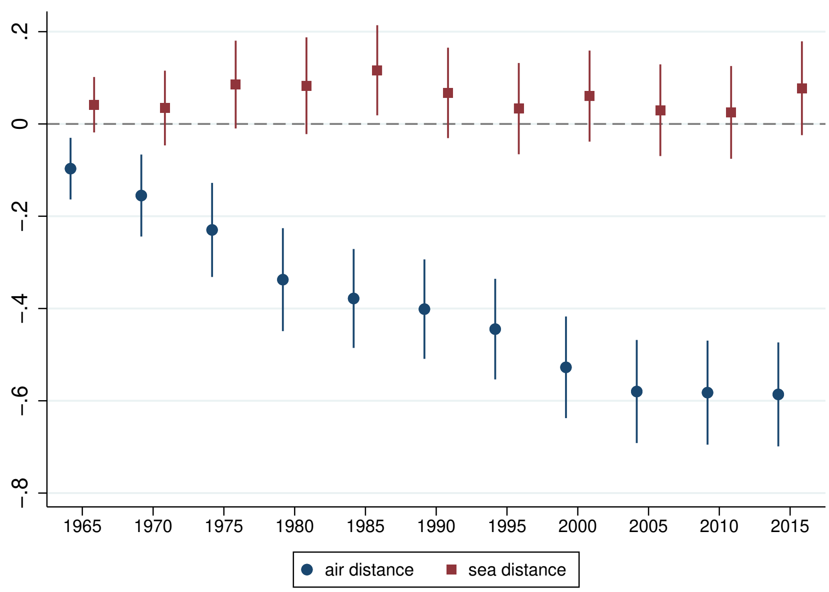
For the instrument to be valid, $log(\widehat{trade}_{it})$ should strongly predict trade (relevance) without being correlated with unobserved country characteristics that influence health

Figure 2: Prediction coefficients of sea and air distances for trade

(a) Bilateral X_{ij}



(b) Pair Effects ρ_{ij}



Notes: Figure plots estimates of $\beta_{sea,q}$ and $\beta_{air,q}$ from equation 5 in panel (a) and the estimates from equation 6 in panel (b). Coefficients prior to 1965 are normalized to zero in panel (b) due to the presence of pair fixed effects in equation 6.

(exclusion restriction). The exclusion restriction would be violated, if characteristics affecting technology adoption are correlated with a country's openness to trade and the health of its population. This would be the case if, for instance, early and late adopters of air transportation differ systematically in country characteristics that also matter for health.

The concern that country-specific, time-varying factors may correlate with the instrument is mitigated by the large number of country-by-year effects in the prediction (equation 5 and 6). These effects flexibly control for country-specific factors driving technology adoption and the patterns of trade over time. Netting out the effects, the distance coefficients $\hat{\beta}_{sea,q}$ and $\hat{\beta}_{air,q}$ exploit the secular shift towards air transportation interacted with country geography to generate exogenous variations in trade. Nonetheless, to directly assess the potential bias from omitted variables, in robustness checks, I control for long-run trending across a wide range of country characteristics in the main equation linking trade and health. I show that the estimated impacts of trade are robust to including these controls.

Table 1 estimates the first-stage equation regressing log trade values on the instrument $log(\widehat{trade}_{it})$. To construct the instrument, distance coefficients $\hat{\beta}_q$'s are estimated with country pair effects in column (1), estimated with bilateral controls in column (2), and predict trade as a five-year average between $t-4$ and t to capture the lagged effects in column (3). Column (4) controls for long-run trending across country characteristics in the main equation of trade. Specifically, in addition to the basic controls in equation 1, I interact the 1970 values of country population, employment share, human capital index, income, as well as the consumption, import, and export share of GDP with year effects to control for confounding economic and demographic trends that may correlate with the long-run expansion of trade.[4]

Across specifications, the instruments remain a strong predictor of trade with the

[4] I obtain the variables from the Penn World Table 10.0. For most countries, the first year these variables are available is 1970.

Table 1: First-stage prediction of trade

	(1)	(2)	(3)	(4)
$log(\widehat{trade_{it}})$	0.59***	0.69***	0.60***	0.91***
	(0.061)	(0.054)	(0.071)	(0.098)
pair FE	Y		Y	Y
bilateral controls		Y		
5-year average			Y	
X_i-year FE				Y
F-stat	92.60	165.01	71.28	85.47
N	9,771	9,771	9,801	7,282

Notes: Table estimates the first-stage equation where the instrument is predicted trade based on the time-varying impacts of sea and air distances. To construct the instrument, distance coefficients are estimated with country pair fixed effects in column (1), estimated with bilateral controls in column (2), and predict trade as a five-year average between $t-4$ and t to capture the lagged effects in column (3). Column (4) uses the same instrument as column (1) but additionally controls for long-run trending across population, employment, human capital, income, as well as the consumption, import, and export share of GDP across countries, interacting the 1970 values of these variables with year fixed effects in the regression. Robust standard errors clustered at the level of countries in the parentheses.

F-statistics well exceeding the conventional threshold at 10. Importantly, the predictive power of the instrument does not weaken when additional controls allowing for long-run trending across economic and demographic factors are included in the regression (column 4). Moreover, in Appendix Table B1, I show that results are similar when bilateral trade is weighted equally across countries in the instrument.

The second-stage equation is given by

$$y_{it} = \beta_0 + \beta_1 \cdot log(\widehat{trade}_{it}) + \alpha_i + \gamma_t + \epsilon_{it}, \tag{8}$$

where $log(\widehat{trade}_{it})$ is trade value predicted from the first stage. I show the two-stage-least-squares (TSLS) estimates of β_1 and further address instrument validity and robustness in the results below.

4 Results on Mortality

4.1 Estimating the Impacts of Trade

I first examine the impacts of trade on life expectancy and crude mortality using data from World Bank's Health, Nutrition, and Population database. Table 2 summarizes TSLS estimates where the instrument for trade builds on distance coefficients estimated with country pair effects in equation 6. Column (1) includes the full sample from 1965 to 2019 and estimates a 1.44 increase in life expectancy for a 100% increase of trade. With a 234% increase of world trade over this period, the life expectancy gain from trade was $1.44 \cdot 2.34 = 3.37$ life years. Compared to the 15.31 increase in life expectancy worldwide (from 57.06 in 1965 to 72.37 in 2019), the expansion of trade accounted for 22% of the increase.

Columns (2) and (3) split the sample by year 1990 and estimate separate effects of trade before and after 1990, the first year when detailed, disease-specific measures of health became available for a large number of countries in the GBD. While I estimate significant impacts of trade in both periods, the magnitude of the health gains was larger in the post-1990 period, where expansion increased life expectancy by $1.37 \cdot 1.39 = 1.90$ life years, or by 24% of the life expectancy increase after 1990. Before 1990, the life expectancy gain from trade was smaller at $0.80 \cdot 1.08 = 0.86$ life years, accounting for roughly 10% of the life expectancy increase over this period.

Columns (4)-(6) estimate the impact of trade on crude mortality rate per 1,000 individuals. According to estimates in column (4), trade expansion reduced crude mortality by $1.38 \cdot 2.33 = 3.22$ individuals per 1,000 since 1965, or by 50% of the mortality reduction over this period. Across periods, the mortality effect was primarily driven by expansions after 1990, where trade decreased crude mortality by $0.94 \cdot 1.39 = 1.31$ individuals per 1,000, or by 54% of the mortality reduction over this period. Before 1990, the mortality effect was smaller and only marginally significant.

Table 2: TSLS estimates of trade on life expectancy and mortality

	(1)	(2)	(3)	(4)	(5)	(6)
	life expectancy			mortality (per 1,000 individuals)		
$log(trade)$	1.44**	0.80***	1.37***	-1.38***	-0.67*	-0.94***
	(0.59)	(0.29)	(0.26)	(0.48)	(0.34)	(0.20)
period	full	pre-1990	post	full	pre-1990	post
F-stat	64.66	61.51	148.13	68.88	64.24	130.17
y_0	57.06	55.20	64.48	14.06	14.97	10.04
Δy	15.31	8.74	7.89	-6.44	-4.87	-2.42
$\Delta log(trade)$	2.34	1.08	1.39	2.33	1.07	1.39
N	9,187	3,767	5,420	9,304	3,811	5,493

Notes: Table shows the TSLS estimates of trade on life expectancy and the crude mortality rate per 1,000 individuals, applying an instrument for trade where the distance coefficients are estimated with country pair effects in equation 6. Column (1) estimates the impact on life expectancy for the full sample period in 1965-2019. Columns (2)-(3) show separate estimates before 1990 and after. Columns (4)-(6) show the results for crude mortality. Robust standard errors clustered at the level of countries in the parentheses.

Supplementing the results on crude mortality, Appendix Table B2 examines the impact of trade on the probability of mortality transition between birth and age 5 (under-5 mortality) and between age 15 and 59 (adult mortality). While I do not find significant impacts of trade on adult mortality, under-5 mortality decreased substantially with trade by $1.38 \cdot 0.7\% = 0.97\%$ since 1990, or by 24% of the mortality reduction over this period. This result points to reductions in neonatal and early-life mortality risks as important drivers of the life expectancy gains from trade. Before 1990, despite large declines in both under-5 and adult mortality over time, the impact of trade on mortality probability was estimated to be small and indistinguishable from zero.

4.2 Robustness

I next examine the robustness of results to alternative constructions of the instrument and additional controls in the main equation linking trade and health. Appendix Table B3 shows the results for life expectancy and crude mortality. In column (1), I apply an instrument where the distance coefficients are estimated with bilateral controls instead of country pair effects. Column (2) applies an instrument where trade is measured as a five-year average between $t-4$ and t. In both cases, the estimated impacts of trade on life expectancy are comparable to the main results in Table 2.

In column (3), I assess the validity of the instrument controlling for long-term trending across country characteristics in the main equation linking trade and health. Specifically, I interact the 1970 values of country population, employment share, human capital index, income, as well as the consumption, import, and export share of GDP with year fixed effects to allow for demographic and economic trends that may confound the predicted increase of trade based on geography. Despite the wide range of controls, the estimates do not materially differ from the main results, lending support to the validity of the geography instrument. Similar robustness results hold for crude mortality in columns (4)-(6) and for mortality probability in Appendix Table B4.

Appendix Table B5 conducts additional robustness checks on the instrument. In column (1), using an unweighted sum across partner countries as the instrument yields fairly similar estimates of trade on life expectancy. In column (2), dropping country-by-year effects from the prediction of trade in equation 6 also has little impact on the estimates. Similar results hold for crude mortality in columns (3)-(4). Overall, estimates from robustness checks confirm that trade substantially improved life expectancy and mortality in the three decades after 1990 but had more modest impacts before.

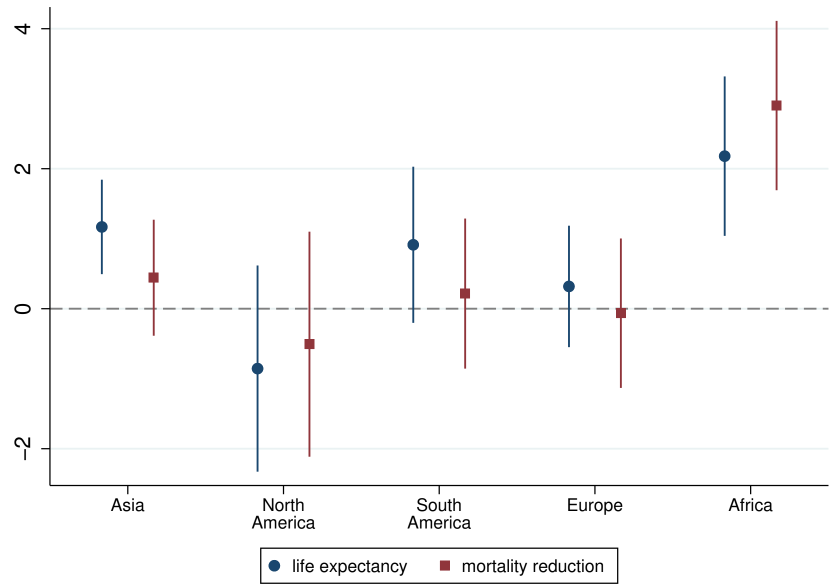
4.3 Heterogeneity

Focusing on the post-1990 period, I estimate heterogeneous impacts of trade by continent and plot the coefficients in Figure 3. In panel (a), both Asia and Africa saw significant life expectancy gains from trade whereas mortality reductions were primarily concentrated in Africa. In terms of magnitude, trade accounted for 26%-31% of the life expectancy increase in Asia and Africa and over 60% of the mortality reduction in Africa (Appendix Table B6). Panel (b) plots the life expectancy trends as implied by the expansion of trade. Since 1990, trade increased life expectancy from 55.9 to 58.6 in Africa and from 65.0 to 67.4 in Asia. In Africa, almost all of the health gains from trade were concentrated during the rapid expansion of the 2000s. By comparison, trade had very small impacts on life expectancy in Europe and slightly decreased life expectancy in North America.

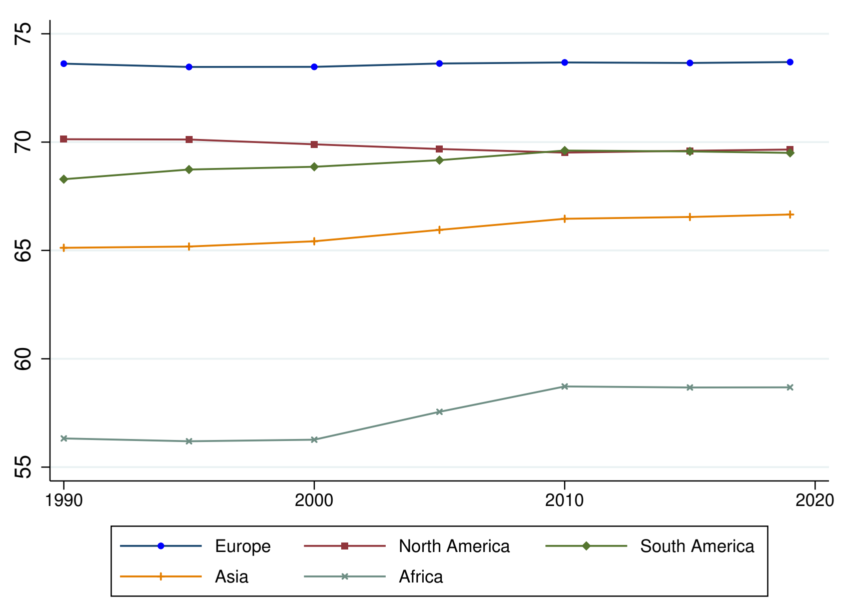
Appendix Figure A4 shows the heterogeneous impacts on mortality probability. Similar to the results on crude mortality, trade had the largest impact on under-5 mortality in Africa, reducing it by $2.7\% \cdot 1.25 = 3.4\%$ in the region, or by 46% of the mortality reduction since 1990 (Appendix Table B7). By contrast, the reduction in adult mortality was small and statistically insignificant across regions. While these estimates show large improvements in life expectancy and survival from trade, they cannot uncover the heterogeneous impacts of trade across diseases and risk factors in the population, which I turn to next.

Figure 3: Heterogeneous impacts of trade on life expectancy: by continent

(a) Coefficients of trade



(b) Life expectancy gains from trade



Notes: Figure plots estimates of trade on life expectancy and mortality reduction by continent in panel (a). Applying the estimates, panel (b) plots life expectancy trends as implied by trade expansions in each continent. 95% confidence intervals from robust standard errors clustered at the level of countries are shown in panel (a).

5 Results on Disease Burdens

5.1 Disability-Adjusted Life Years

I measure disease-specific health burdens using disability-adjusted life years (DALY), calculated as the sum of healthy life years lost to disability from a disease and the life years lost to mortality. In the GBD, disease-level DALYs are aggregated into DALYs of three major disease groups and an all-cause DALY summing over all diseases. I examine these aggregate measures of DALY first.

Table 3: TSLS estimates of trade on DALYs

	(1)	(2)	(3)	(4)
	All-Cause	Communicable, maternal, neonatal, nutritional	Non-Communicable	Injuries
$log(trade)$	-45.01***	-34.41***	2.12	-12.72***
	(11.35)	(9.64)	(2.87)	(2.65)
F-stat	43.73	43.73	43.73	43.73
y_0	522.96	261.51	210.13	51.32
Δy	-180.38	-166.55	3.37	-17.20
$\Delta log(trade)$	1.38	1.38	1.38	1.38
N	5,794	5,794	5,794	5,794

Notes: Table shows the TSLS estimates of trade on disability-adjust life years (DALY) per 1,000 individuals, applying an instrument for trade where the distance coefficients are estimated with country pair effects in equation 6. DALYs of specific diseases are aggregated into three major disease groups examined in columns (2)-(4). An all-cause DALY summing over all diseases is examined in column (1). Robust standard errors clustered at the level of countries in the parentheses.

Table 3 summarizes TSLS estimates applying an instrument where the distance coefficients are estimated with country pair effects in equation 6. In column (1), trade had large and significant impacts on all-cause DALY. According to the estimate, trade expansion since 1990 decreased DALY by a total of $45.01 \cdot 1.38 = 62.1$ life years per 1,000 individuals, or by 30% of the DALY reduction over this period. Across disease groups, trade had the largest impact on communicable, maternal, neonatal, and nutritional diseases (column 2), where expansion decreased DALYs by $34.41 \cdot 1.38 = 47.5$ life years. This effect accounted for $\frac{47.5}{62.1} = 76\%$ of all trade-induced DALY reductions since 1990. Trade further decreased the DALY from injuries by a modest $12.72 \cdot 1.38 = 17.6$ life years whereas the impact on non-communicable diseases was small and statistically insignificant (columns 3-4).

Appendix Figure A5 estimates heterogeneous impacts of trade by continent. In Africa, trade decreased all-cause DALY substantially by $187.06 \cdot 1.25 = 233.5$ life years per 1,000 individuals, with much of the reduction deriving from expansions in the 2000s. Improvements in communicable, maternal, neonatal, and nutritional diseases accounted for 76% of all trade-induced DALY reductions in Africa (Appendix Table B8). Outside Africa, however, trade had mixed impacts across disease groups and the overall impact on all-cause DALY was small and insignificant.

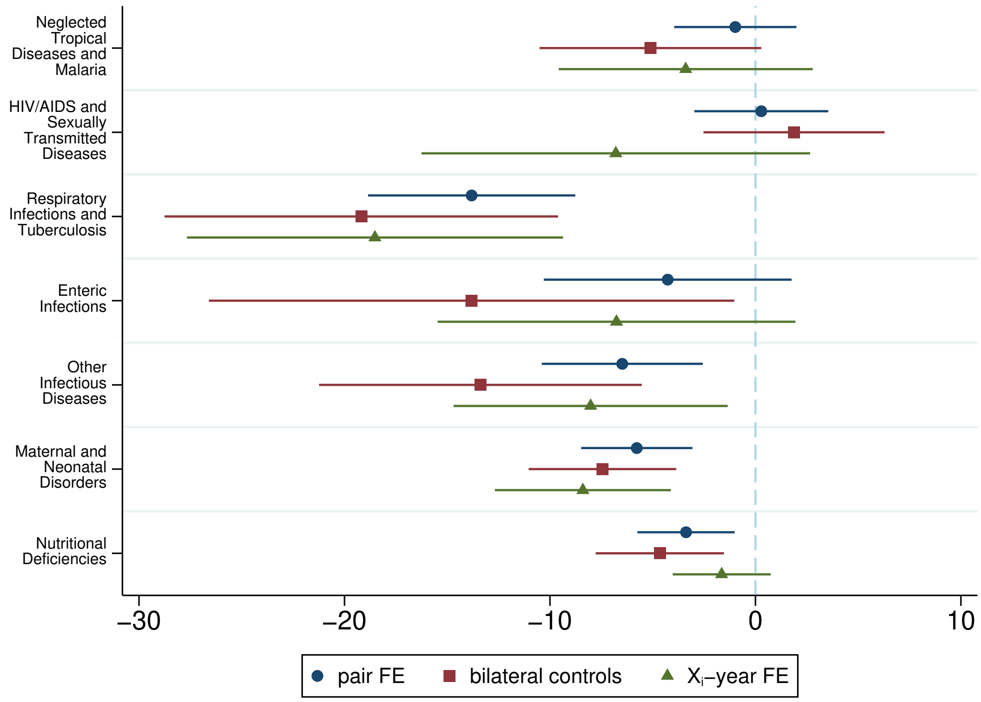
5.2 Disease-Specific DALYs

I next estimate the impacts of trade across specific diseases in Figure 4. For each disease, I show the main estimate applying an instrument where the distance coefficients are estimated with country pair effects in equation 6. For robustness, I also show estimates where the distance coefficients are estimated with bilateral controls in equation 5 and when covariate-by-year effects capturing long-run trending are added to the main equation of trade.

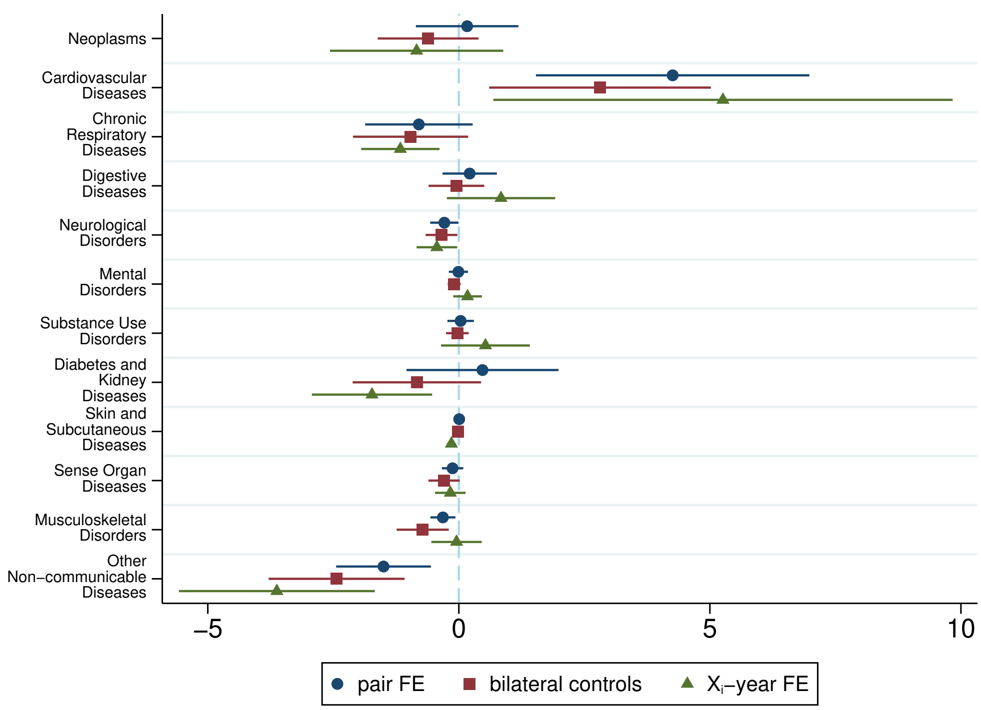
In panel (a), trade had significant impacts improving communicable diseases such as respiratory infections and tuberculosis, enteric infections, and other infectious diseases. Respiratory infections and tuberculosis showed the largest improvement with trade, for which DALY decreased by $13.81 \cdot 1.38 = 19.1$ life years since 1990 according to the main estimate. By comparison, the trade impact on sexually transmitted diseases and neglected tropical diseases was small and indistinguishable from zero. Apart from communicable diseases, trade further decreased the DALY of maternal and neonatal disorders by roughly 8-12 life years and decreased the DALY of nutritional deficiencies by 2-6 life years.

Figure 4: Impacts of trade on disease-specific DALY

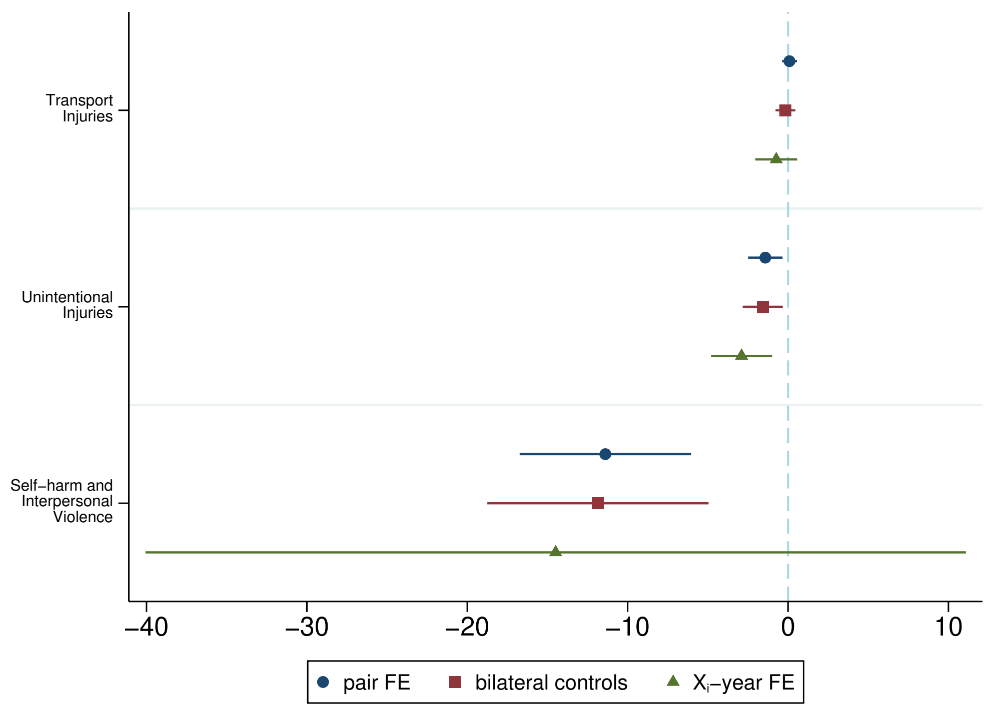
(a) Communicable, Maternal, Neonatal, Malnutrition



(b) Non-Communicable



(c) Injuries



Notes: Figure plots estimates of trade on the DALY of specific diseases within groups. For each disease, I show the robustness of results to alternative constructions of the instrument (country pair effects versus bilateral controls in the gravity equation) and to controlling for covariate-by-year effects in the main equation of trade. 95% confidence intervals from robust standard errors clustered at the level of countries are shown with the estimates.

Compared to the large reductions in communicable diseases, the trade impact on non-communicable diseases was overall small in panel (b). DALYs of chronic respiratory diseases, neurological disorders, and musculoskeletal diseases, in particular, showed significant but fairly minor reductions (less than one year) with trade. An obvious outlier was cardiovascular diseases, for which DALY increased by $4.26 \cdot 1.38 = 5.9$ life years with trade. While modest in magnitude, the increased burden of cardiovascular diseases outsized and offset the health gains from alternative non-communicable diseases, and the heterogeneity would be difficult to unmask using more aggregate measures of DALY.

In panel (c), trade had significant impacts reducing the health loss from interpersonal violence and self-harm, for which DALY decreased by $11.39 \cdot 1.38 = 15.7$ life years since 1990. The magnitude of this effect was comparable to the reduction in respiratory infections and tuberculosis estimated in panel (a). Trade further decreased the DALY of unintentional injuries to a small extent, whereas the impact on transport injuries was not significant.

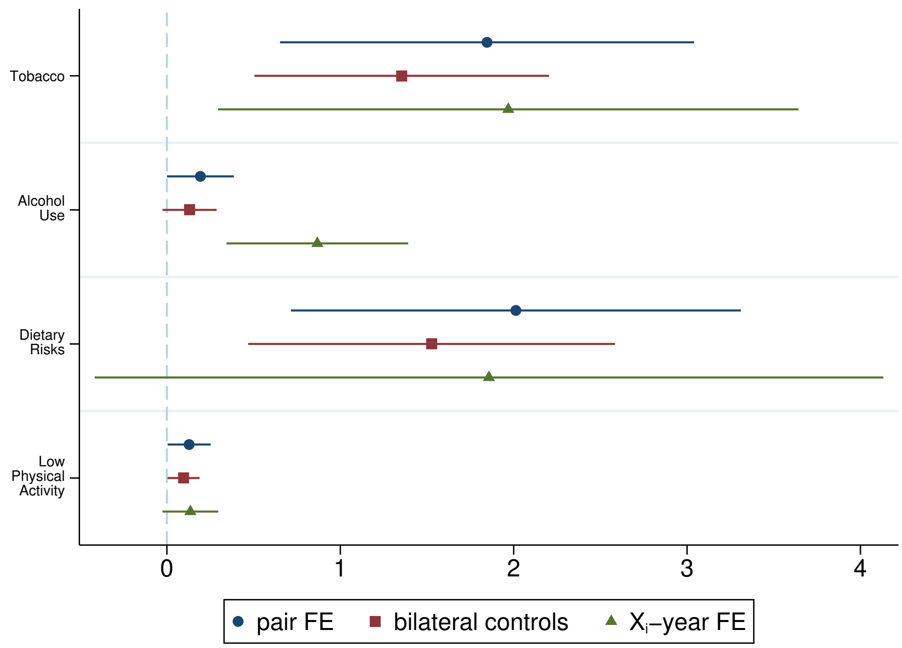
5.3 Behavioral and Health Risk Factors of Cardiovascular Diseases

I next explore the health behavior and health risk factors that may contribute to the increase in cardiovascular diseases. To do so, I estimate the impact of trade on the DALYs of risk factors associated with cardiovascular diseases. In the GBD, behavioral risk factors contributing to cardiovascular diseases include consumption risks (smoking, drinking, risky diet) and physical inactivity. The health risk factors consist of metabolic conditions such as high fasting plasma glucose, high LDL cholesterol, high systolic blood pressure, and high BMI. Figure 5 shows the estimates.

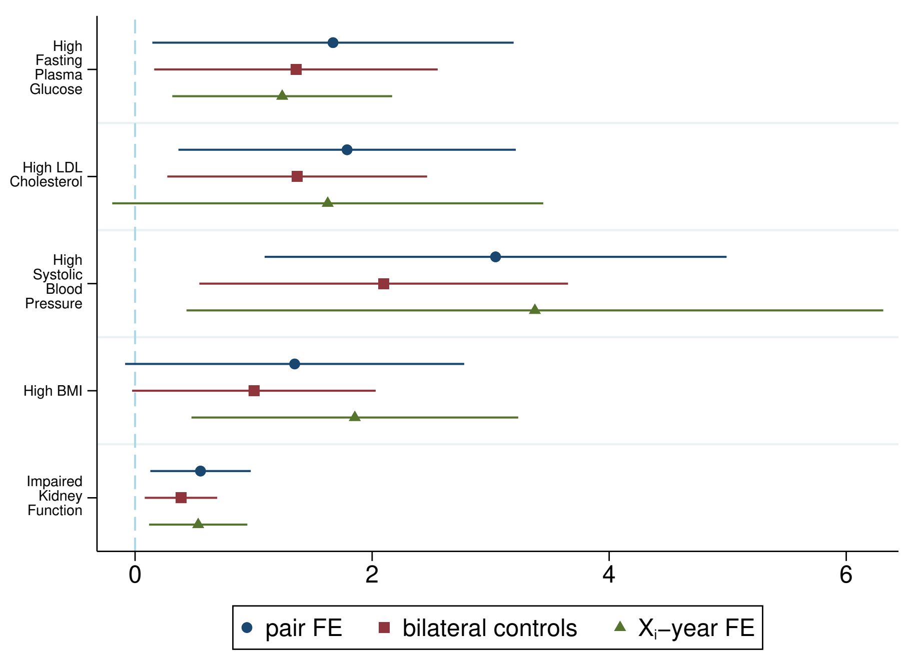
In panel (a), trade had significant impacts on consumption risks such as smoking and risky diet. For both risks, DALY increased by roughly $1.90 \cdot 1.38 = 2.6$ life years since 1990. Risk factors such as alcohol use and physical inactivity showed much smaller increases with trade and are less important contributors to the rise of cardiovascular

Figure 5: Impacts of trade on the risk factors of cardiovascular diseases

(a) Behavioral Risk Factors



(b) Health Risk Factors



Notes: Figure plots estimates of trade on the risk factors of cardiovascular diseases. For each risk factor, I show the robustness of results to alternative constructions of the instrument (country pair effects versus bilateral controls in the gravity equation) and to controlling for covariate-by-year effects in the main equation of trade. 95% confidence intervals from robust standard errors clustered at the level of countries are shown with the estimates.

diseases. Turning to health risk factors in panel (b), trade significantly worsened metabolic conditions such as high systolic blood pressure, high LDL cholesterol, and high fasting plasma glucose, for which DALYs increased by an average $2.17 \cdot 1.38 = 3.0$ life years with trade. Similar patterns across consumption and metabolic risks also apply when examining risk factors of non-communicable diseases more generally (Appendix Figure A6).

Appendix Figure A7 shows heterogeneous impacts by continent. In panel (a), consumption risks such as smoking and risky diet increased mainly in Asia, decreased in Europe, and were largely unaffected by trade in other parts of the world. Asia also saw significant increases in metabolic conditions such as high systolic blood pressure and high LDL cholesterol in panel (b). Thus, while improving life expectancy, trade may have worsened non-communicable diseases in Asia due to changes in consumption patterns and metabolic conditions. This differs from the health impacts in Africa where neither the behavioral nor metabolic risk factors showed significant increases with trade.

In summary, trade substantially decreased the DALY of communicable diseases, maternal and neonatal disorders, and injuries from violence and self-harm. The impact on non-communicable diseases was overall small and statistically indistinguishable from zero. Cardiovascular diseases, however, worsened significantly with trade due to increases in consumption and metabolic risks in Asia. Next, I incorporate health outcomes in a wellbeing metric of nations and quantify the contribution of trade to the wellbeing increases in 1990-2019.

6 Trade and the Convergence of Wellbeing

6.1 Measuring Wellbeing

I develop a measure of wellbeing adopting the expected utility framework in Jones and Klenow (2016). Behind the veil of ignorance, the expected lifetime utility of an individual born in country i and time t is given by

$$U_{it} = \underbrace{\left[\sum_a \beta^a S_{it}(a) H_{it}(a)\right]}_{HALE_{it}} \cdot \underbrace{\left(\bar{u} + \log c_{it} - \frac{1}{2}\sigma_{it}^2\right)}_{\mathbb{E}_c[u(\mathcal{C}_{it})]}, \tag{9}$$

where $S_{it}(a)$ is the survival probability till age a, obtained from country i's life table in time t. $H_{it}(a) = 1 - D_{it}(a)$ captures health in age a where $D_{it}(a) \in [0, 1]$ is disability-induced health loss. By construction, $H_{it}(a)$ equals one for a healthy life year free from disability but decreases with disease incidences and severity in $D_{it}(a)$. Summing over ages, $\sum_a \beta^a S_{it}(a) H_{it}(a)$ is the health-adjusted life expectancy ($HALE_{it}$), which summarizes the health profile of country i based on age-specific disability status and mortality rates in time t.

The individual has period utility $u(\mathcal{C}_{it}) = \bar{u} + \log \mathcal{C}_{it}$, where the intercept $\bar{u}$ captures the utility gain from living in full health each period. Consumption $\mathcal{C}_{it}$ is drawn randomly from the cross-sectional distribution in country i and time t. As in Jones and Klenow (2016), I assume that $\mathcal{C}_{it}$ follows a log-normal distribution, so that expected period utility equals $\mathbb{E}_c[u(\mathcal{C}_{it})] = \bar{u} + \log c_{it} - \frac{1}{2}\sigma_{it}^2$, where c_{it} is the mean consumption value measured in country i's micro data and σ_{it} the standard deviation.[5]

To compare wellbeing across countries and over time, I employ a consumption-equivalent metric that benchmarks expected utility U_{it} to that of the US in 2019. Suppose in a thought experiment that individuals born in country i and time t were instead faced with the health-consumption distribution of the US in 2019. The consumption-equivalent metric is the proportion of US consumption that keeps individuals indifferent between own country's living standards and that of the US in 2019. Formally, let $U_{it}(\lambda) = \mathbb{E}_c \sum_a \beta^\alpha S_{it}(a) H_{it}(a)\, u(\lambda \mathcal{C}_{it})$ indicate expected utility when consumption in each period is multiplied by a factor λ. The adjustment keeping individuals indifferent in

[5] The utility specification assumes that the same log-normal distribution applies to consumption in all ages. At some loss of nuance, this approach allows wellbeing comparisons across the broadest set of countries given available data.

expected utility satisfies the following condition

$$U_{US2019}(\lambda_{it}) = U_{it}(1), \tag{10}$$

where λ_{it} captures the consumption equivalent of the wellbeing difference between country i in time t and the US in 2019. By construction, countries whose U_{it} is greater than U_{US2019} would require consumption greater than the US level (hence $\lambda_{it} > 1$) to equate expected utility. For countries with wellbeing less than U_{US2019} (hence $\lambda_{it} < 1$), λ_{it} closer to one indicates greater convergence to the US wellbeing in 2019.

Solving for λ_{it}, the consumption equivalent can be written as

$$\log\frac{\lambda_{it}}{\tilde{y}_{it}} = \underbrace{\left(\frac{HALE_{it}}{HALE_{US2019}} - 1\right)\left(\bar{u} + \log c_{it} - \frac{1}{2}\sigma_{it}^2\right)}_{\text{health}} + \underbrace{\log\frac{c_{it}}{y_{it}}\Big/\frac{c_{US2019}}{y_{US2019}}}_{\text{consumption}} - \underbrace{\frac{1}{2}(\sigma_{it}^2 - \sigma_{US2019}^2)}_{\text{inequality}}, \tag{11}$$

where I normalize λ_{it} using $\tilde{y}_{it} = y_{it}/y_{US2019}$, the per capita GDP relative to the US value in 2019. Adjusted for income, cross-country differences in wellbeing could be decomposed in terms of differences in health-adjusted life expectancy $HALE_{it}$, consumption share of GDP $\frac{c_{it}}{y_{it}}$, and inequality σ_{it}. The health component is weighted by the period utility indicating the value of a healthy life year in country i. It follows that countries where health is more valued also demand greater consumption equivalents for a given difference in health, resulting in greater weights of health in the wellbeing of these countries.

In what follows, I measure wellbeing $\Lambda_{it} \equiv \frac{\lambda_{it}}{\tilde{y}_{it}}$ for 157 countries and quantify the contribution of trade to the wellbeing increases in 1990-2019. I obtain consumption data for these countries from the Penn World Table 10.0 (Feenstra et al., 2015), inequality data from the World Income Inequality Database (UNU-WIDER, 2021), and data on health-adjusted life expectancy (HALE) from the Global Burden of Diseases study (GBD Collaborative Network, 2019). Appendix C describes the data and the sample of countries. Upon measuring the wellbeing increases, I calculate the percent attributable to trade drawing on the estimated impacts of trade on health and consumption. I turn to these estimates next.

6.2 Impacts on HALE and Consumption

Table 4 shows TSLS estimates of trade on HALE, log per capita consumption, and inequality. Trade had substantial impacts on HALE in column (1), with expansions since 1990 (142%) increasing HALE by $1.30 \cdot 1.42 = 1.85$ healthy life years, or by 31% of the global HALE increase (5.94 healthy life years) over this period. The estimate is largely unchanged when long-run trending across country characteristics is added to the main equation of trade (column 2).

Furthermore, trade expansions increased per capita consumption by $0.23 \cdot 1.42 = 33\%$ in columns (3)-(4). This effect accounted for 46% of the global consumption increase (71%) in 1990-2019. Compared to the growth in consumption levels, consumption inequality decreased by a modest 0.04 of a standard deviation over the same period, and the impact of trade on inequality was estimated to be small and indistinguishable from zero (columns 5-6).

Figure 6 plots heterogeneous impacts across geography. Trade had larger impacts on HALE in Asia and Africa, where expansion increased HALE by 2.1-2.5 life years since 1990 (Appendix Table B9). The impact on consumption was positive in all continents but larger in Asia ($0.28 \cdot 2.36 = 66\%$), Europe (36%), and South America (33%). Africa and North America saw smaller consumption gains from trade (16%). Trade further decreased consumption inequality by 0.11-0.12 standard deviations in South America and Africa but had small and insignificant impacts elsewhere. These results are robust to alternative constructions of the instrument and to controlling for covariate-by-year effects in the main equation of trade (Appendix Figure A8).

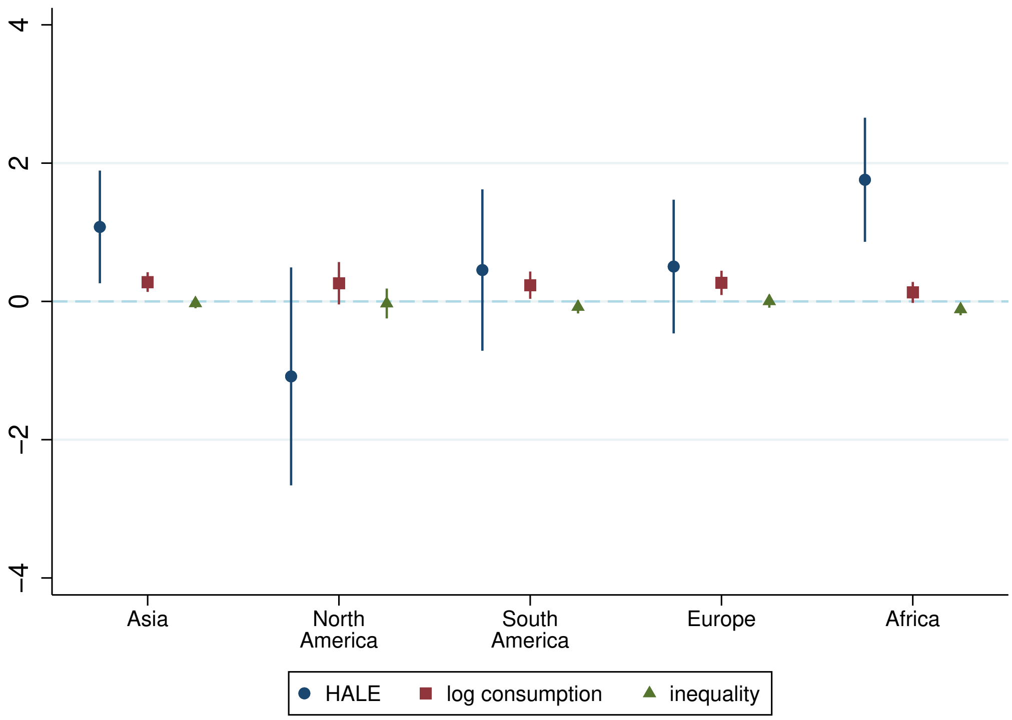
I then apply the estimates to quantify the contribution of trade to the wellbeing increases in 1990-2019. Let subscript $t = 0$ denote the baseline year 1990 and $t = 1$

Table 4: TSLS estimates of trade on HALE and consumption

	(1)	(2)	(3)	(4)	(5)	(6)
	HALE		log consumption		inequality	
$log(trade)$	1.30***	1.29***	0.23***	0.24***	-0.012	0.004
	(0.37)	(0.36)	(0.070)	(0.065)	(0.027)	(0.024)
F-stat	24.35	59.64	24.35	25.72	60.37	77.50
y_0	57.88	57.88	8.20	8.20	0.75	0.75
Δy	5.94	5.94	0.71	0.71	-0.042	-0.042
$\Delta log(trade)$	1.42	1.42	1.42	1.42	1.21	1.21
N	5,057	5,057	5,057	5,057	2,095	2,095
pair FE	Y	Y	Y	Y	Y	Y
X_i-year FE		Y		Y		Y

Notes: Table shows the TSLS estimates of trade on health-adjusted life expectancy (HALE) in columns (1)-(2), log per capita consumption in columns (3)-(4), and inequality measured by the standard deviation of log consumption in columns (5)-(6). All estimates are based on the main instrument where the distance coefficients are estimated with country pair effects in equation 6. Specifications in even-numbered columns control for long-run trending in population size and the import and export shares of GDP, interacting the 1970 values of the variables with year effects. Due to potentially endogenous correlations with consumption, I do not further control for trends in per capita GDP, the consumption share of GDP, employment share, or the human capital index. Robust standard errors clustered at the level of countries in the parentheses.

Figure 6: Impacts of trade on HALE and consumption, by continent



Notes: Figure plots heterogeneous impacts of trade on HALE, log per capita consumption, and consumption inequality by continent. 95% confidence intervals based on robust standard errors clustered at the level of countries are shown with the estimates.

the year 2019. Given expansion $\Delta \log trade_i = \log \frac{trade_{i1}}{trade_{i0}}$, the wellbeing increase from trade is $\Delta\tilde{\Lambda}_i = \Lambda\left(X_{i0} + \hat{\beta}_i \Delta \log trade_i\right) - \Lambda\left(X_{i0}\right)$, where $\hat{\beta}_i = \left(\hat{\beta}_i^{HALE}, \hat{\beta}_i^{c}, \hat{\beta}_i^{\sigma}\right)$ is the estimated coefficient of trade on health, consumption, and inequality, and $X_{i0} = (HALE_{i0}, c_{i0}, \sigma_{i0})$ is country i's health-consumption distribution in 1990.

Of the raw wellbeing increase $\Delta\Lambda_i = \Lambda\left(X_{i1}\right) - \Lambda\left(X_{i0}\right)$, the percent attributable to trade is

$$Percent\_Trade_i = \Delta\tilde{\Lambda}_i \Big/ \Delta\Lambda_i \,, \tag{12}$$

and the percent attributable to the health impacts of trade is given by

$$Percent\_Health_i = \frac{\Lambda\left(X_{i0} + \hat{\beta}_i \Delta \log trade_i\right) - \Lambda\left(X_{i0} + \hat{\beta}_i \Delta \log trade_i \,;\, \hat{\beta}_i^{HALE} = 0\right)}{\Delta\Lambda_i}, \tag{13}$$

where $\Lambda\left(X_{i0} + \hat{\beta}_i \Delta \log trade_i \,;\, \hat{\beta}_i^{HALE} = 0\right)$ is the counterfactual wellbeing from trade shutting down the health impacts of trade.

To preserve statistical power, instead of estimating β_i for each country, I apply coefficients across continents from Figure 6 to quantify country-specific wellbeing increases from trade. I then summarize the contribution of trade by continent in 1990-2019, which I turn to next.

6.3 Wellbeing and Trade

Table 5 summarizes wellbeing and the contribution of trade by continent. I focus on results for the median country and show the inter-quartile ranges (25th to 75th percentile) in the square brackets. Worldwide, wellbeing in the median country increased from 3.3% of the US in 1990 to 19% in 2019, and increased in the 75th percentile from 16% to 66%. European countries had the highest wellbeing in both 1990 and 2019, with median wellbeing reaching 166% of the US in 2019. However, wellbeing still lagged substantially behind the US in most Asian and African countries, where median wellbeing was only 1.2%-12% of the US in 2019.

Table 5: Wellbeing and the contribution of trade, 1990-2019

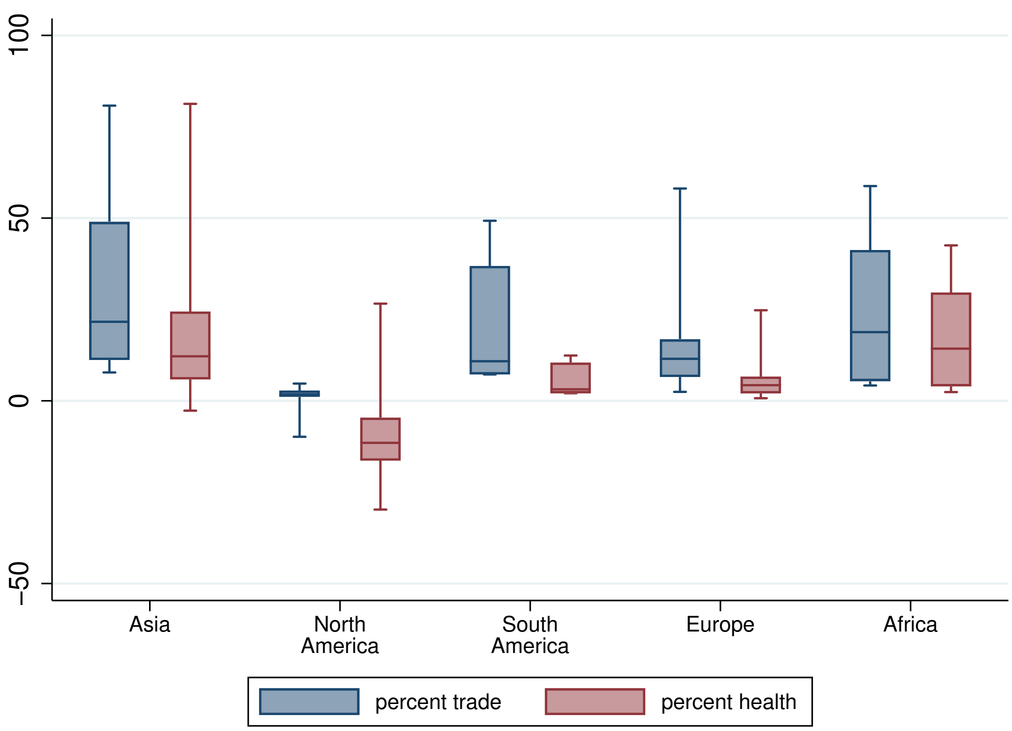
				Omitting Health Gains		Percent Trade	Percent Health
	Λ_0	Λ_1	$\tilde{\Lambda}_1$	Λ_1^{noh}	$\tilde{\Lambda}_1^{noh}$	$(\tilde{\Lambda}_1 - \Lambda_0)/(\Lambda_1 - \Lambda_0)$	$(\tilde{\Lambda}_1 - \tilde{\Lambda}_1^{noh})/(\Lambda_1 - \Lambda_0)$
World	0.033	0.19	0.070	0.079	0.057	14.13%	6.53%
	[0.004, 0.16]	[0.017, 0.66]	[0.007, 0.23]	[0.007, 0.27]	[0.005, 0.21]	[5.66%, 30.18%]	[2.64%, 16.46%]
Asia	0.025	0.12	0.060	0.047	0.040	21.62%	12.18%
	[0.009, 0.11]	[0.029, 0.40]	[0.020, 0.19]	[0.019, 0.22]	[0.014, 0.14]	[11.17%, 48.94%]	[5.86%, 24.42%]
North America	0.086	0.19	0.086	0.19	0.086	1.77%	-11.51%
	[0.058, 0.21]	[0.051, 0.38]	[0.063, 0.22]	[0.085, 0.26]	[0.075, 0.27]	[1.11%, 2.81%]	[-16.38%, -4.62%]
South America	0.056	0.22	0.095	0.097	0.083	10.83%	3.15%
	[0.016, 0.084]	[0.14, 0.48]	[0.027, 0.14]	[0.051, 0.22]	[0.024, 0.12]	[7.22%, 36.90%]	[2.06%, 10.45%]
Europe	0.32	1.66	0.52	0.59	0.46	11.49%	4.28%
	[0.082, 0.60]	[0.61, 2.51]	[0.18, 0.70]	[0.20, 1.04]	[0.14, 0.67]	[6.52%, 16.81%]	[2.04%, 6.62%]
Africa	0.002	0.012	0.003	0.003	0.002	18.80%	14.27%
	[0.001, 0.013]	[0.004, 0.036]	[0.001, 0.019]	[0.001, 0.019]	[0.001, 0.015]	[5.40%, 41.26%]	[3.97%, 29.64%]

Notes: Table summarizes the wellbeing increases from trade and from the health impacts of trade across continents in 1990-2019. I focus on results for the median country and show inter-quartile ranges (25th to 75th percentile) in the square brackets.

Column $\tilde{\Lambda}_1$ shows wellbeing in 2019 as implied by the expansion of trade since 1990. Applying the estimated impacts of trade on health and consumption, expansions of world trade would have increased wellbeing in the median country to 7% in 2019, with an inter-quartile range from 0.7% to 23%. Relative to the wellbeing increase from 1990 to 2019, the percent attributable to trade was 14.1% in the median country, with an inter-quartile range from 5.7% to 30.2%.

Figure 7 illustrates the contribution of trade by continent. In Asia and Africa, the wellbeing increase from trade was roughly 20% in the median country and increased to 41%-49% in the 75th percentile. The wellbeing increase from trade was similarly large in the upper percentiles in South America (37%) but overall small in Europe (7%-17% across the inter-quartile range) and North America (1%-3%).

Figure 7: Wellbeing increases from trade and from the health impacts of trade



Notes: Figure plots the wellbeing increases from trade and from the health impacts of trade across continents in 1990-2019. The box edges indicate the inter-quartile range (25th to 75th percentile) in each continent and the middle line indicates the median.

Column Λ^{noh} re-calculates wellbeing in 2019 holding HALE at the 1990 value in each country. Omitting the health improvements substantially understates the wellbeing increase over time, with λ^{noh} indicating a 7.9% wellbeing in 2019 as opposed to the 19% including health. In column $\tilde{\Lambda}^{noh}$, shutting down the health impacts ($\hat{\beta}_i^{HALE} = 0$) leads to lower counterfactual wellbeing from trade at 5.7% in 2019 as opposed to the 7% including health. The 1.3% difference was attributable to the health impacts of trade and accounted for 6.5% of the wellbeing increase in the median country, with an inter-quartile range from 2.6% to 16.5%.

Across continents, as much as 13% of the wellbeing increase in Asia and Africa was attributable to the health impacts of trade. Relative to the 20% wellbeing increase from trade, the health impacts contributed to 68% of the trade impact on wellbeing in Africa and 56% in Asia, suggesting substantial health gains from trade along with consumption gains in these regions. In South America and Europe, around one-third of the trade impact on wellbeing was attributable to the health gains from trade. In North America, the negative health impacts decreased wellbeing by roughly 12%, resulting in much smaller wellbeing increases from trade in the region.

6.4 Robustness

Alternative Estimates of Trade. I first examine the robustness of wellbeing results to alternative estimates of trade. Appendix Figure A9 applies estimates that control for covariate-by-year effects in the main equation of trade. According to the estimates, trade accounted for 21% of the wellbeing increase in Asia and Africa, of which 56%-75% was attributable to the health impacts of trade. In South America and Europe, trade accounted for 12% of the wellbeing increase, of which 31%-35% was attributable to the health impact of trade. In North America, the health loss from trade decreased wellbeing by 11%. These findings are comparable to the main results in Figure 7. Similar patterns also hold across alternative constructions of the instrument, such as dropping country pair effects in the gravity equation of trade (Appendix Figure A10), dropping country-year effects (Appendix Figure A11), predicting trade over a lagged five-year period (Appendix Figure A12), or using an unweighted sum across partner countries as the instrument (Appendix Figure A13).

Alternative Values per Life Year. I next consider alternative values of a healthy life year captured in the intercept $\bar{u}$ in the period utility. In the main analysis, I assume $\bar{u} = 5$ following Jones and Klenow (2016). This corresponds to a value of a healthy life year equal to $436,846 in 2000 US dollars. In Appendix Figure A14, I re-calculate the wellbeing increases from trade varying $\bar{u}$ from 3 to 6. Across this range, trade contributed to 13%-16% of the wellbeing increase in the median country, comparable to the 14% increase in Table 5. At higher $\bar{u}$, the contribution from the health gains from trade increases relative to the consumption gains, consistent with greater importance of health for wellbeing as $\bar{u}$ increases. In Asia and Africa, in particular, the health gains accounted for 53%-67% of the trade impact on wellbeing when $\bar{u} = 3$. With $\bar{u} = 6$, the percent from health increased to 58%-77%.

7 Conclusion

Over the past half century, greater integration into the world economy has brought about rapid economic growth and poverty reduction in developing countries. Since the 1990s, the international trade network further contributed to global partnerships promoting the right to health and health services in less advanced economies. As health gained prominence as an important target for development, understanding the health impacts of trade has become critical for policies to improve living standards along a balanced growth path of economic gains and health.

Exploiting trade expansions driven by the rise of air transportation over time, this paper shows that trade had substantial impacts on mortality and life expectancy in the post-1990 era, where over 60% of the mortality reduction in Africa and over 30% of the life expectancy gains in Asia were attributable to the expansion of trade. Trade further decreased disease burdens in Africa especially for communicable, maternal, neonatal, and nutritional diseases. In Asia, despite large gains in life expectancy, trade had mixed impacts across diseases, reducing communicable diseases but worsening cardiovascular diseases with increased metabolic conditions and consumption risks such as smoking and unhealthy diet.

Building on the estimates, I quantify the contribution of trade to the wellbeing increases in 1990-2019 using a wellbeing metric that decomposes changes in wellbeing into changes in the health and consumption distribution within countries. I find that trade contributed to 20% of the wellbeing increase in Asia and Africa, of which 56%-68% was attributable to the health gains from trade. In Europe and South America, around one-third of the wellbeing increase from trade was attributable to the health gains from trade, whereas in North America, the negative health impacts decreased wellbeing by 12%. Worldwide, trade contributed to 14% of the wellbeing increase in 1990-2019, and nearly half of the contribution (6.5%) was attributable to the health impacts of trade.

These results show that trade was a significant driver of the wellbeing increases over the past three decades. Moreover, the health gains from trade contributed substantially to wellbeing alongside consumption gains, and health was in fact the dominant factor behind trade-induced wellbeing increases in Asia and Africa. However, trade also led to health losses in North America that were quantitatively meaningful but overlooked in traditional measures of wellbeing focusing on income. The results thus call for a more nuanced understanding of the impacts of trade to further the progress along multiple dimensions of wellbeing.

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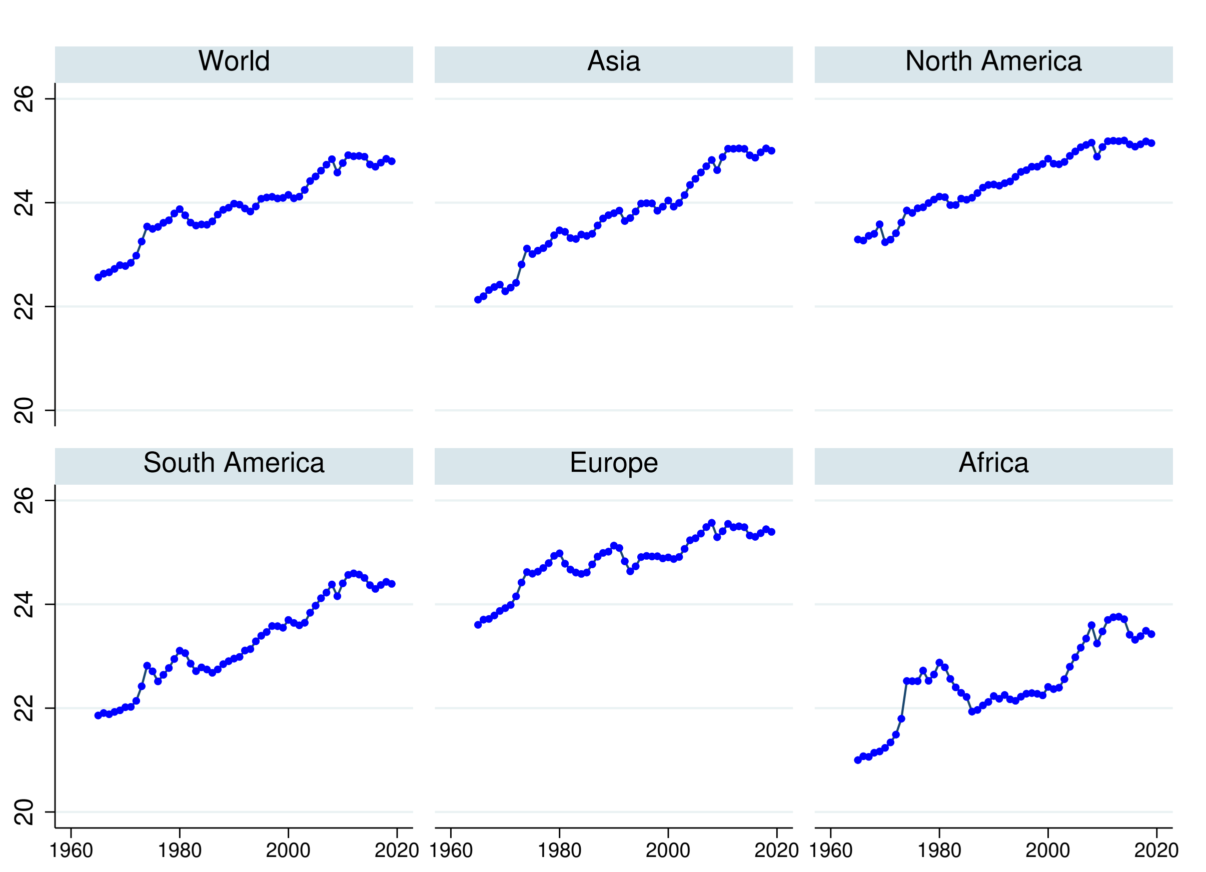
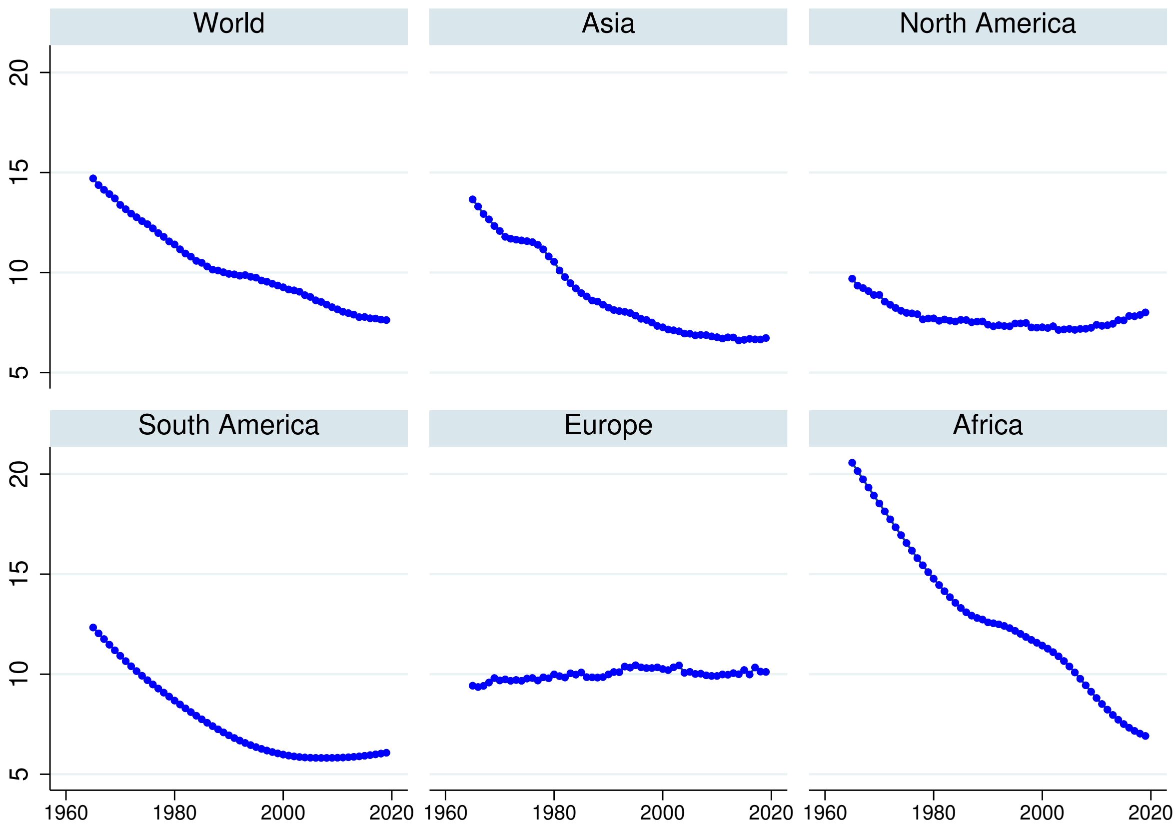
A Appendix Figures

Figure A1: Expansion of trade by continent, 1965-2019



Notes: Figure plots the expansion of trade worldwide in 1965-2019. Each dot represents the log trade value in a given year for an average country in the world or a continent.

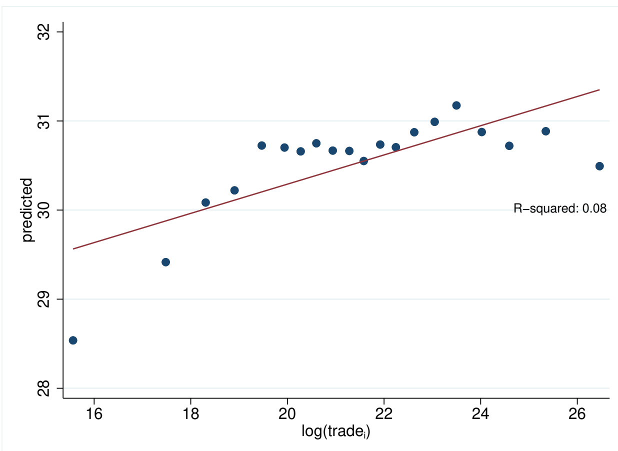
Figure A2: Crude mortality by continent, 1965-2019



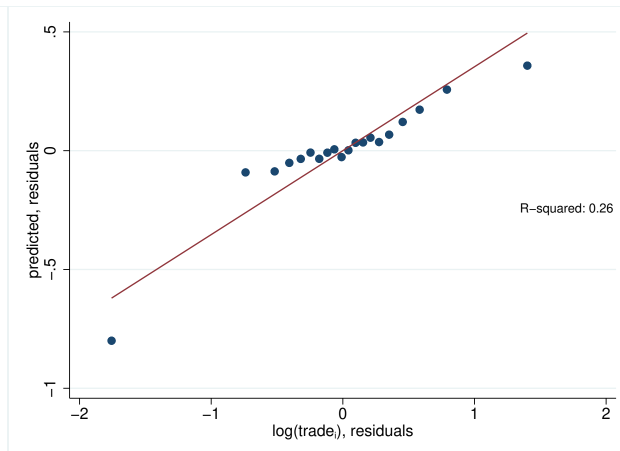
Notes: Figure plots the trend in crude mortality rate (per 1,000 individuals) around the world in 1965-2019. Each dot represents the mortality rate in a given year for an average country in the world or a continent.

Figure A3: Predicting trade from the distance coefficients

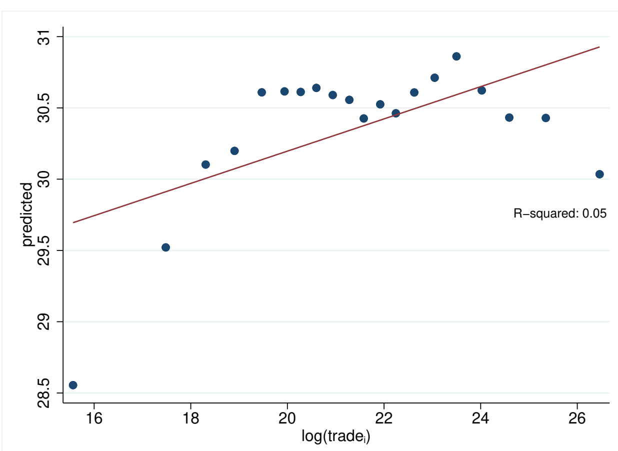
(a) Bilateral X_{ij}



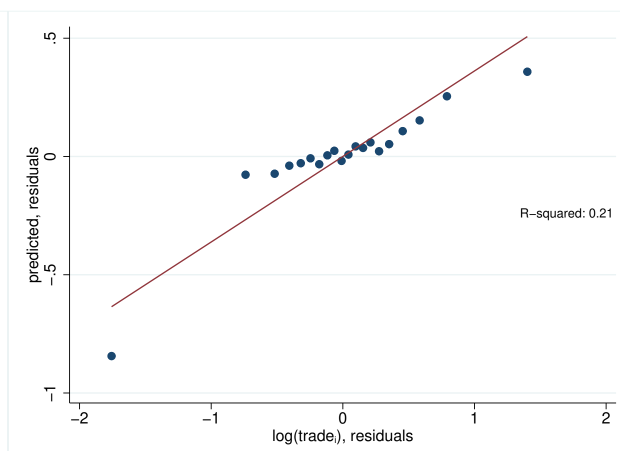
(b) Bilateral X_{ij}, residuals



(c) Pair effects ρ_{ij}

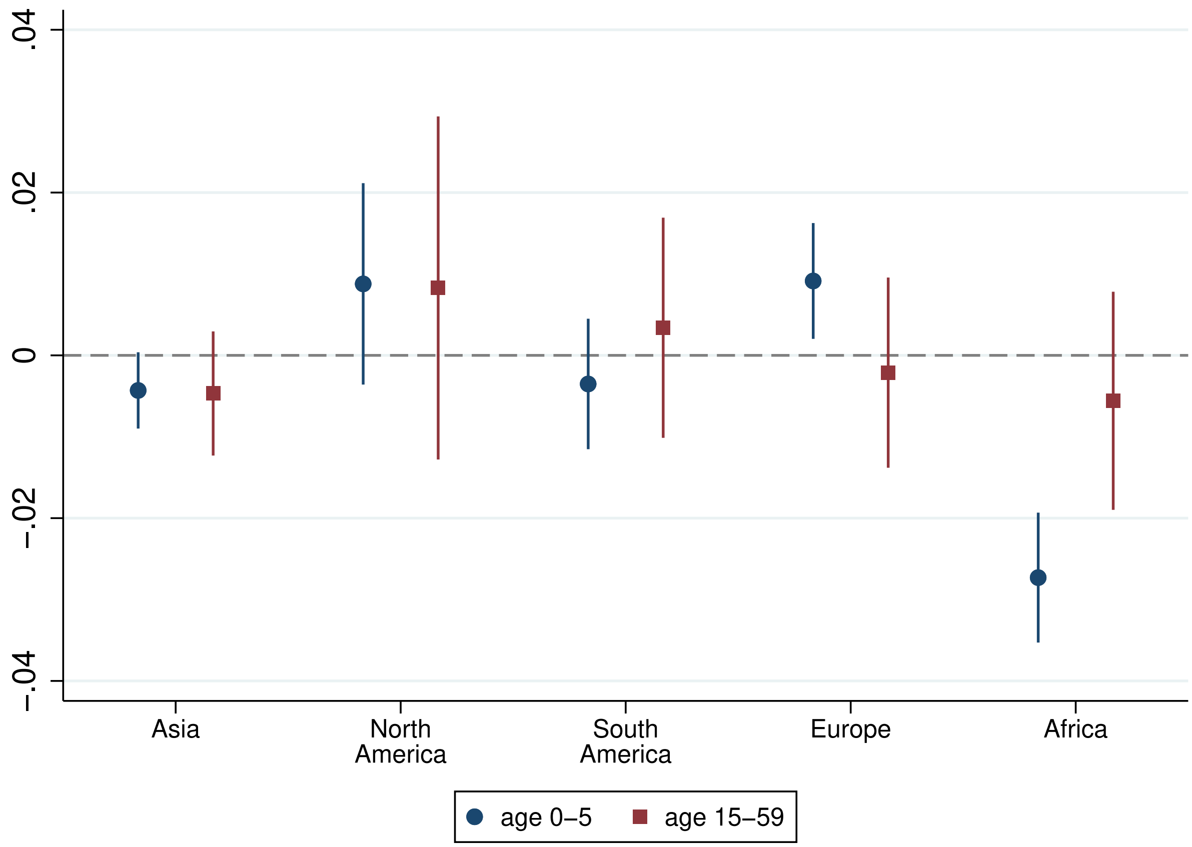


(d) Pair effects ρ_{ij}, residuals



Notes: Figure plots the instrument $log(\widehat{trade_{it}})$ against actual trade values in each panel. I construct the instrument from distance coefficients estimated with bilateral controls (equation 5) in panels (a)-(b), and from distance coefficients that control for country pair effects (equation 6) in panels (c)-(d). In panels (b) and (d), both the instrument and trade are residualized to net out the country and year effects of trade. R-squared statistics indicating the variation in trade explained by the instrument are shown in each panel.

Figure A4: Heterogeneous impacts of trade on mortality probability, by continent

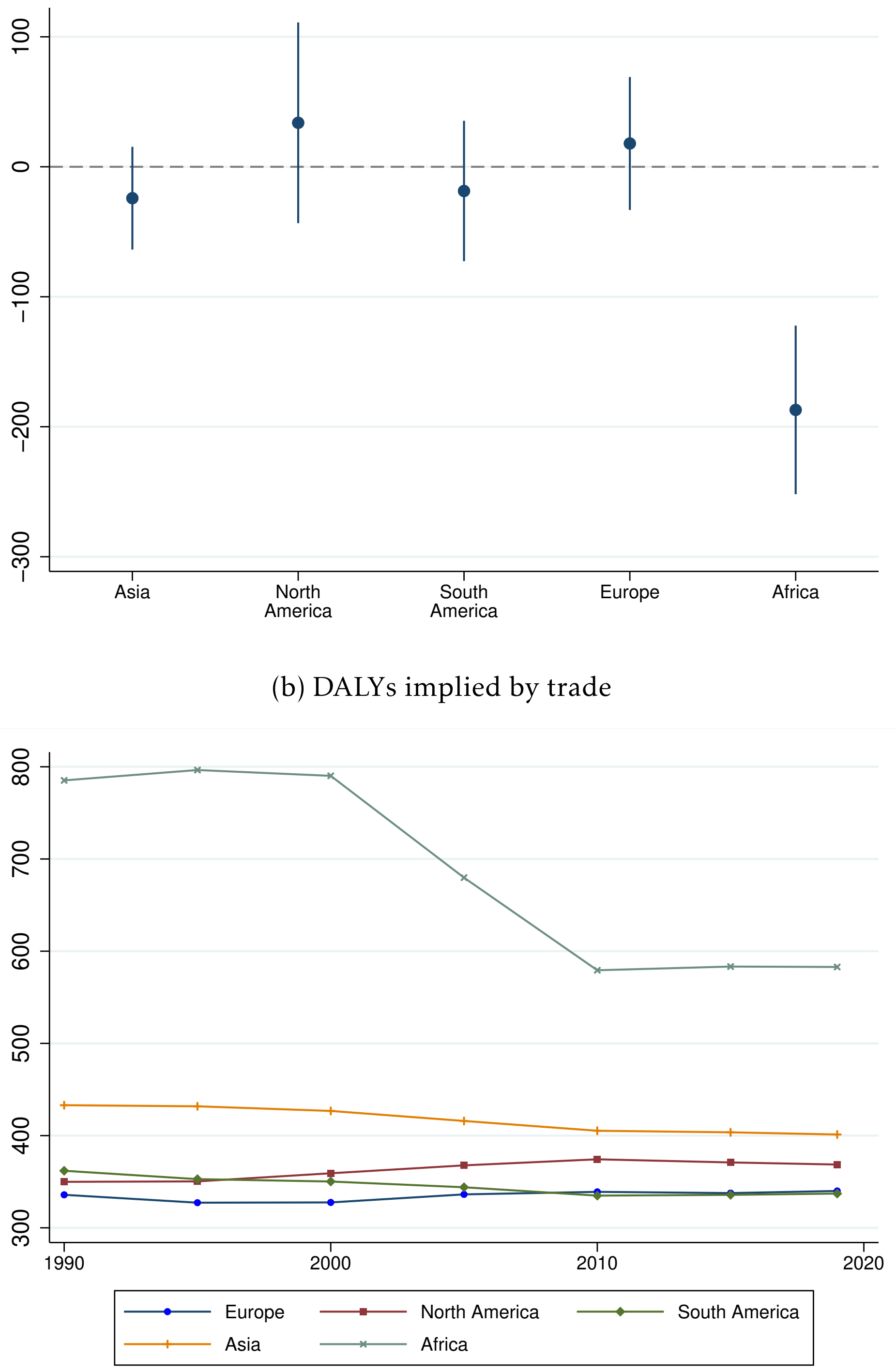


Notes: Figure plots heterogeneous impacts of trade on under-5 mortality (age 0-5) and adult mortality (age 15-59) by continent. 95% confidence intervals from robust standard errors clustered at the level of countries are shown with the point estimates.

Figure A5: Impacts of trade on all-cause DALY, by continent

(a) Coefficients of trade

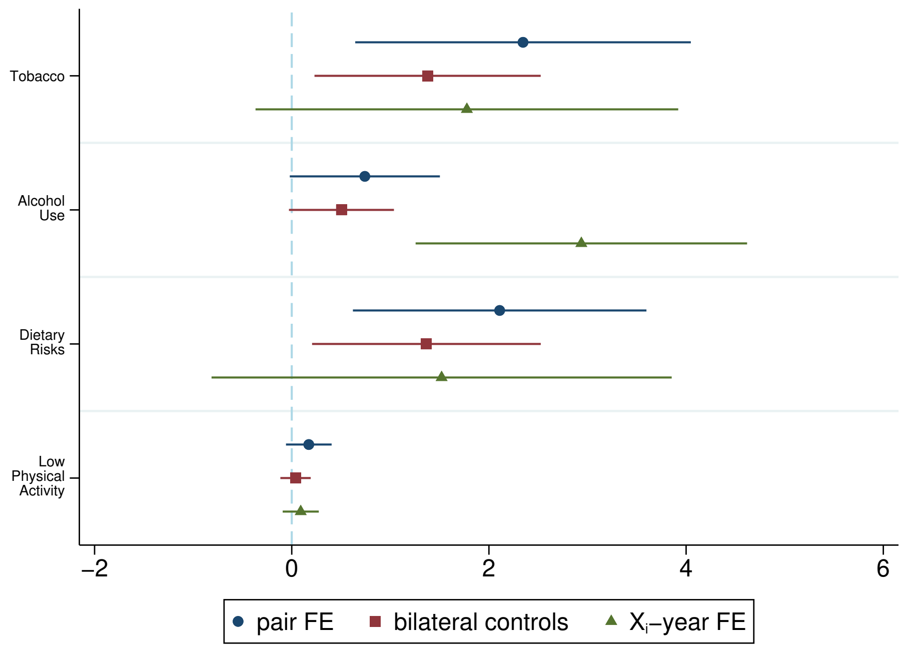
(b) DALYs implied by trade



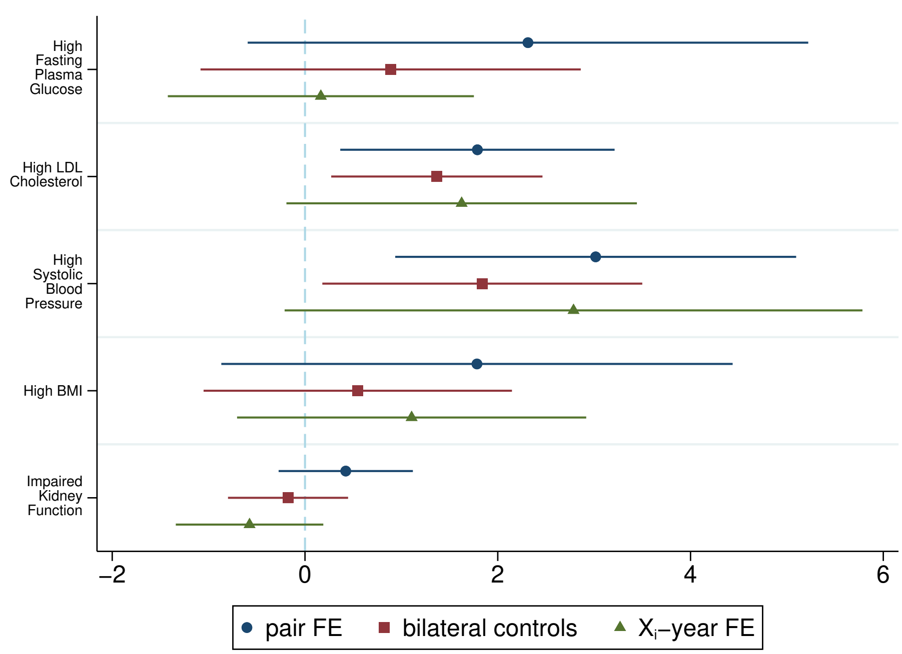
Notes: Figure plots heterogeneous impacts of trade on all-cause DALY by continent in panel (a). Applying the estimates, panel (b) plots DALY trends as implied by trade expansions in each continent. 95% confidence intervals from robust standard errors clustered at the level of countries are shown in panel (a).

Figure A6: Impacts of trade on the risk factors of non-communicable diseases

(a) Behavioral Risk Factors



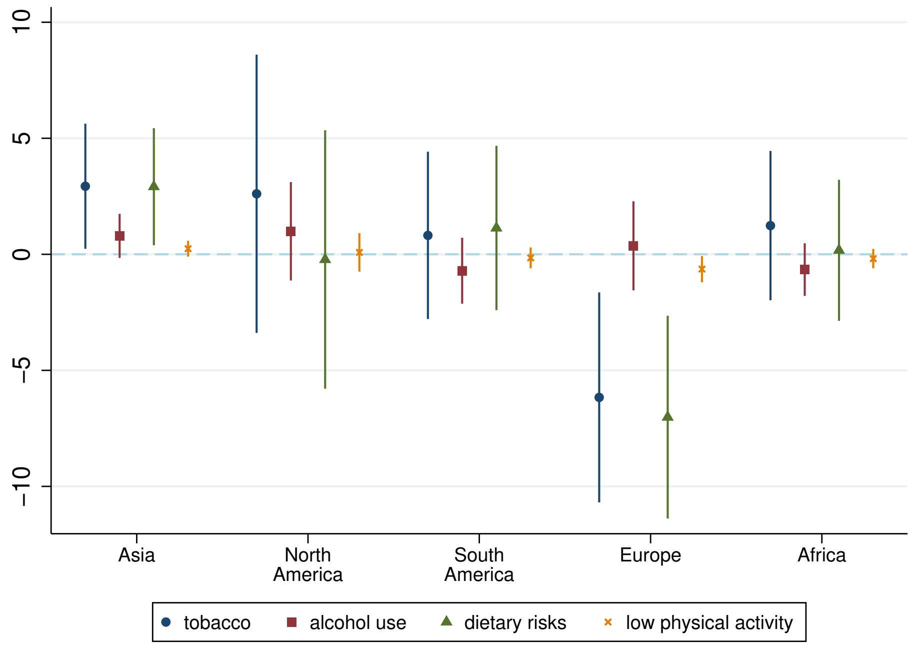
(b) Health Risk Factors



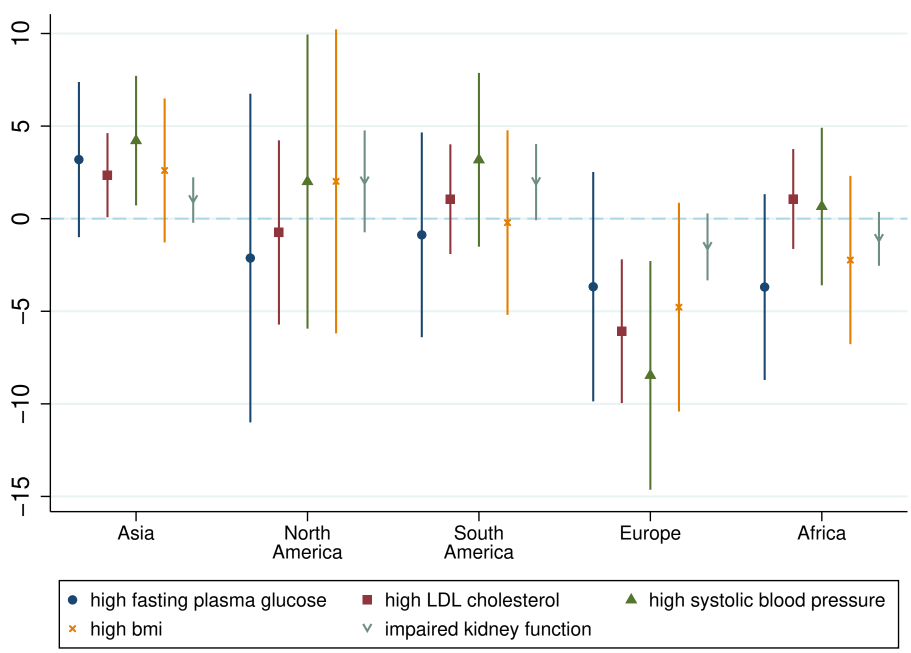
Notes: Figure plots estimates of trade on the risk factors of non-communicable diseases. For each risk factor, I show the robustness of results to alternative constructions of the instrument (country pair effects versus bilateral controls in the gravity equation) and to controlling for covariate-by-year effects in the main equation of trade. 95% confidence intervals from robust standard errors clustered at the level of countries are shown with the estimates.

Figure A7: Impacts of trade on the risk factors of non-communicable diseases, by continent

(a) Health Behavior



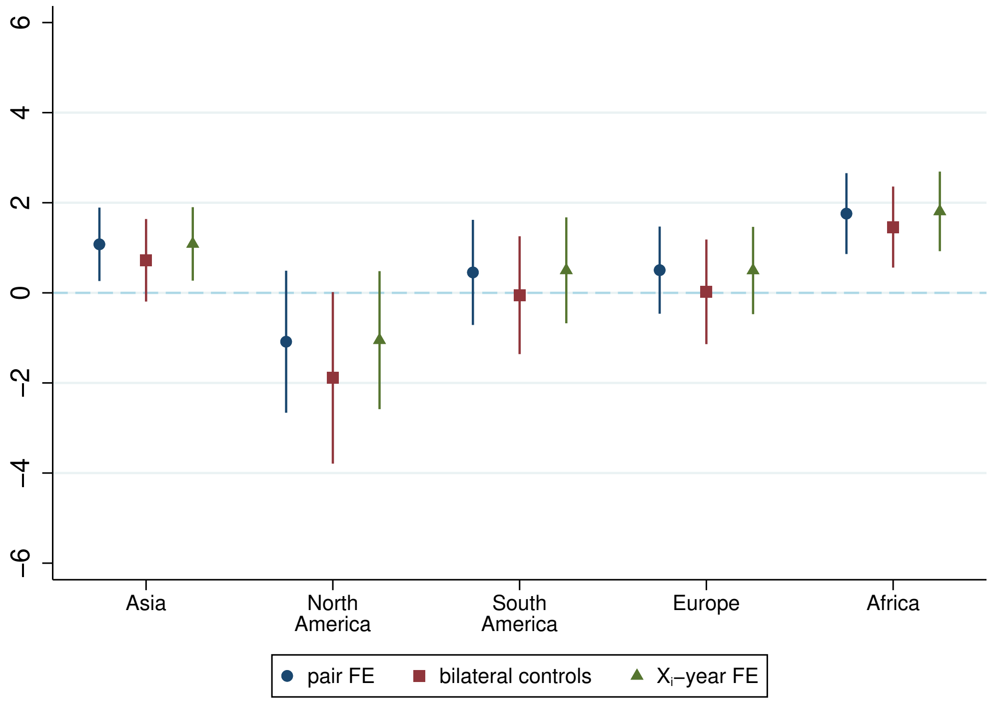
(b) Metabolic Conditions



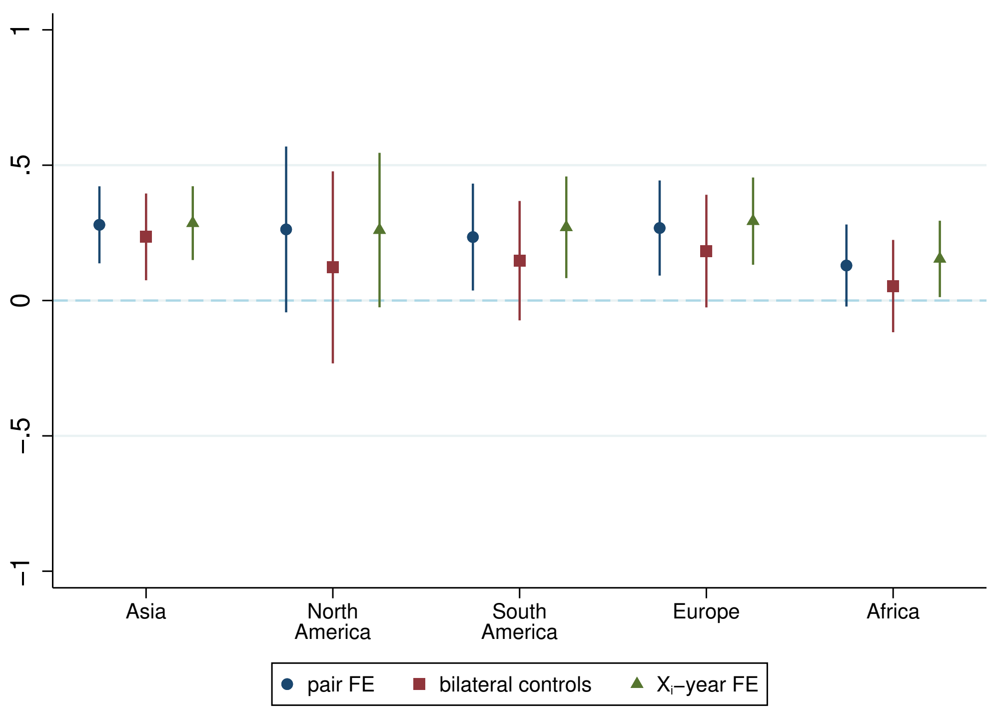
Notes: Figure plots heterogeneous impacts of trade on the risk factors of non-communicable diseases by continent. 95% confidence intervals from robust standard errors clustered at the level of countries are shown with the estimates.

Figure A8: Impacts of trade on HALE and consumption, robustness

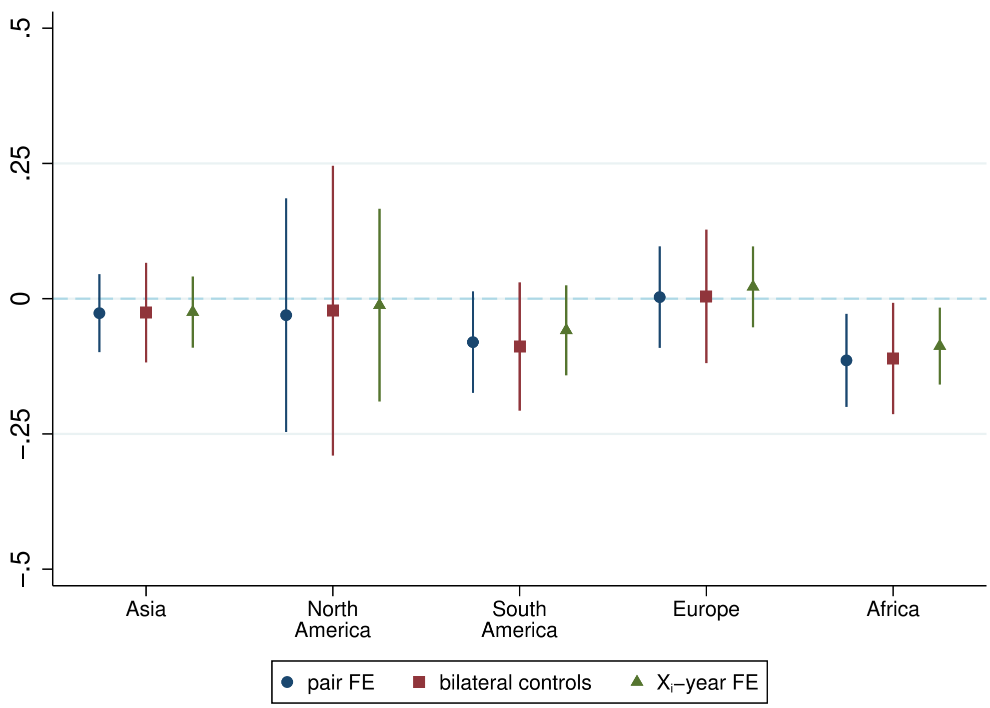
(a) HALE



(b) Log Consumption

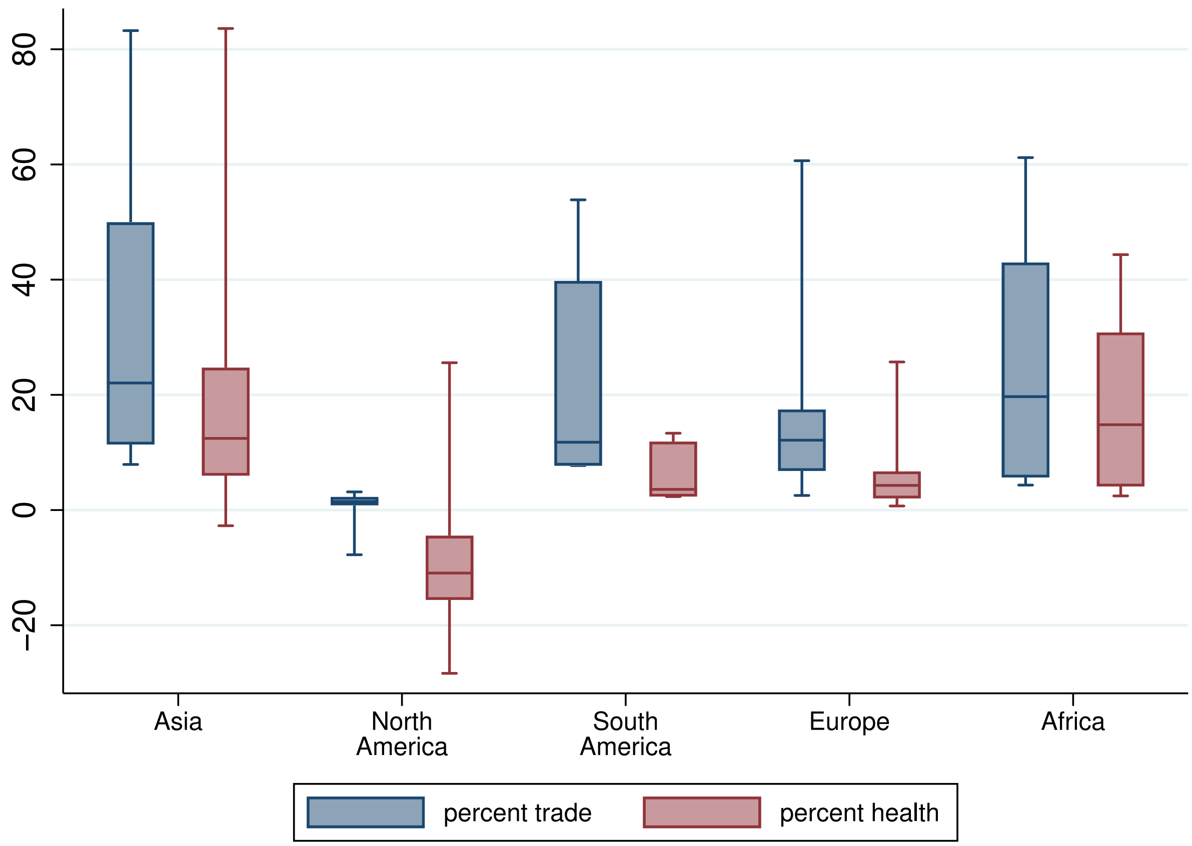


(c) Inequality



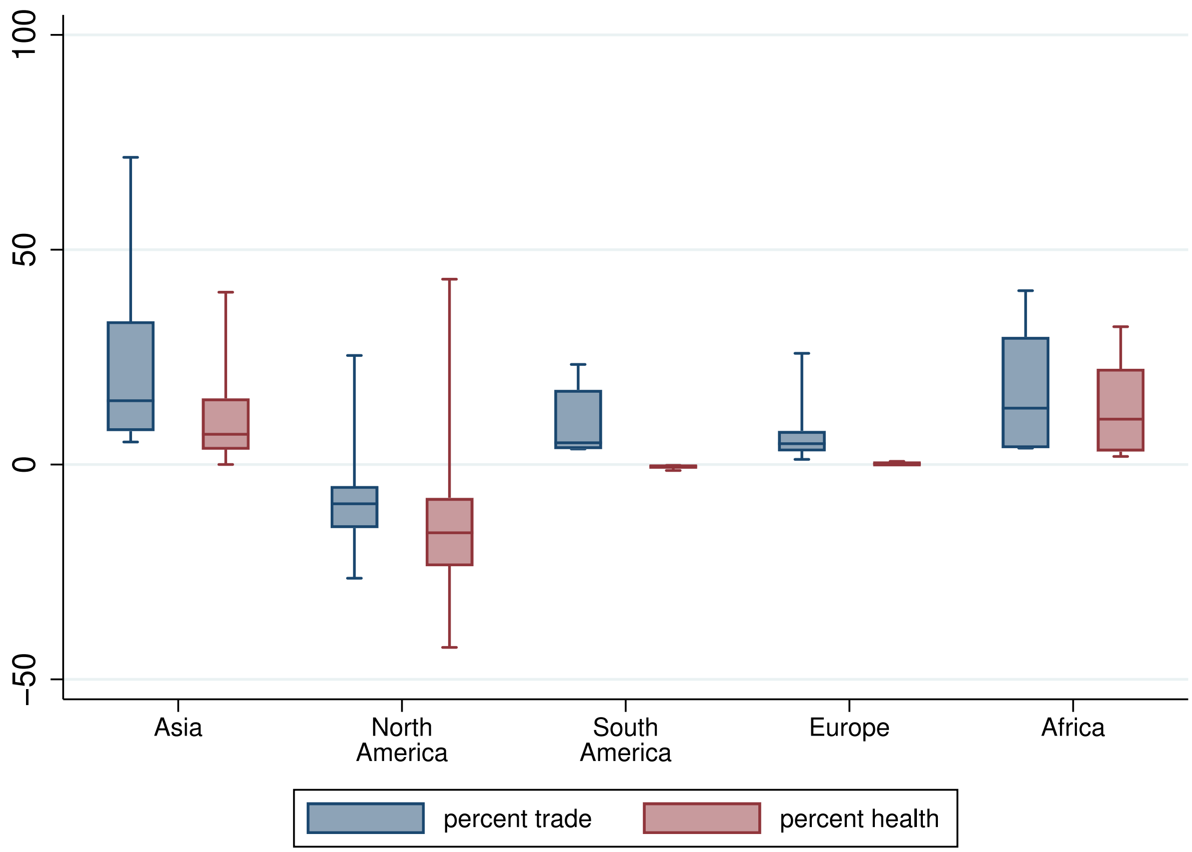
Notes: Figure plots heterogeneous impacts of trade on HALE in panel (a), log per capita consumption in panel (b), and inequality measured as the standard deviation of log consumption in panel (c). For each outcome, I show the robustness of results to alternative constructions of the instrument (country pair effects versus bilateral controls in the gravity equation) and to controlling for covariate-by-year effects in the main equation of trade. 95% confidence intervals based on robust standard errors clustered at the level of countries are plotted along the estimates.

Figure A9: Wellbeing increases from trade and from the health impacts of trade: controlling for covariate-by-year effects



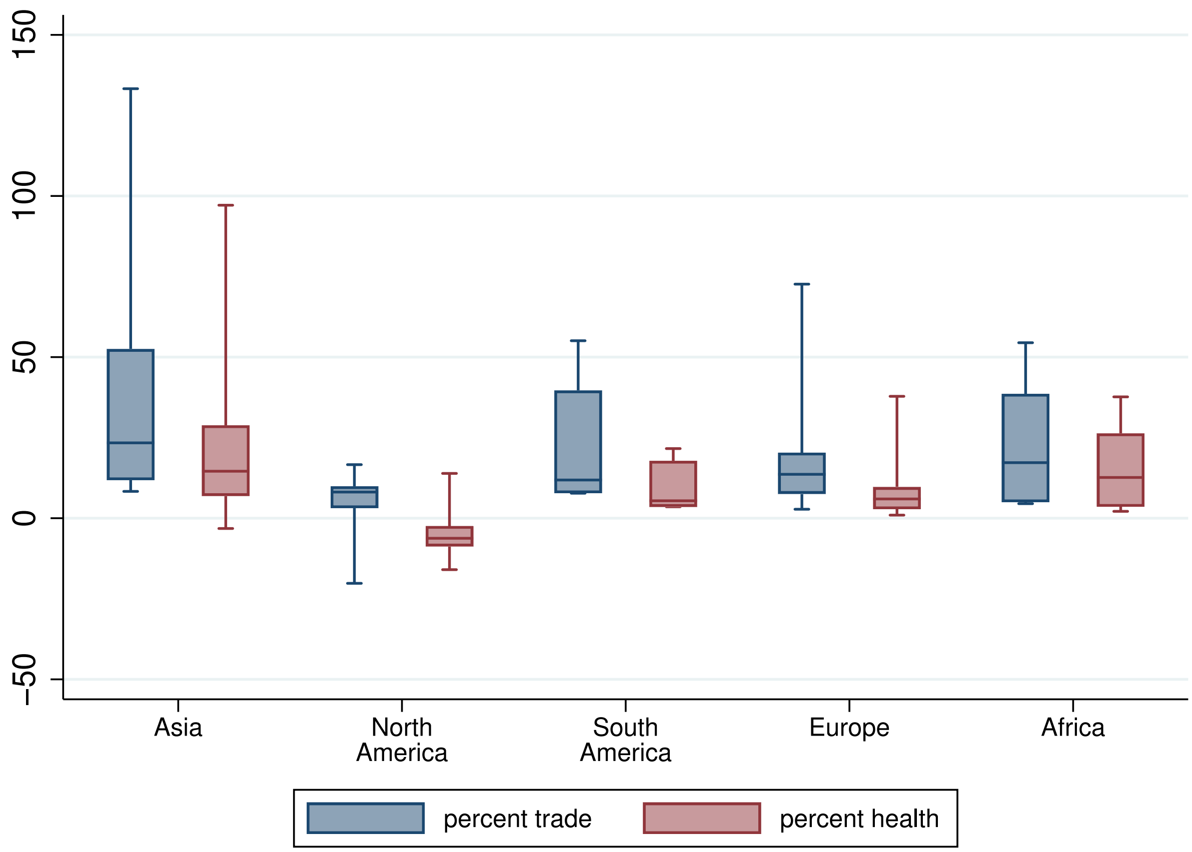
Notes: Figure plots the wellbeing increase from trade and from the health impacts of trade across continents in 1990-2019. I estimate the trade impacts controlling for long-term trending across country characteristics in the main equation of trade. The box edges indicate the inter-quartile range (25th to 75th percentile) in each continent and the middle line indicates the median.

Figure A10: Wellbeing increases from trade and from the health impacts of trade: bilateral controls in the gravity equation



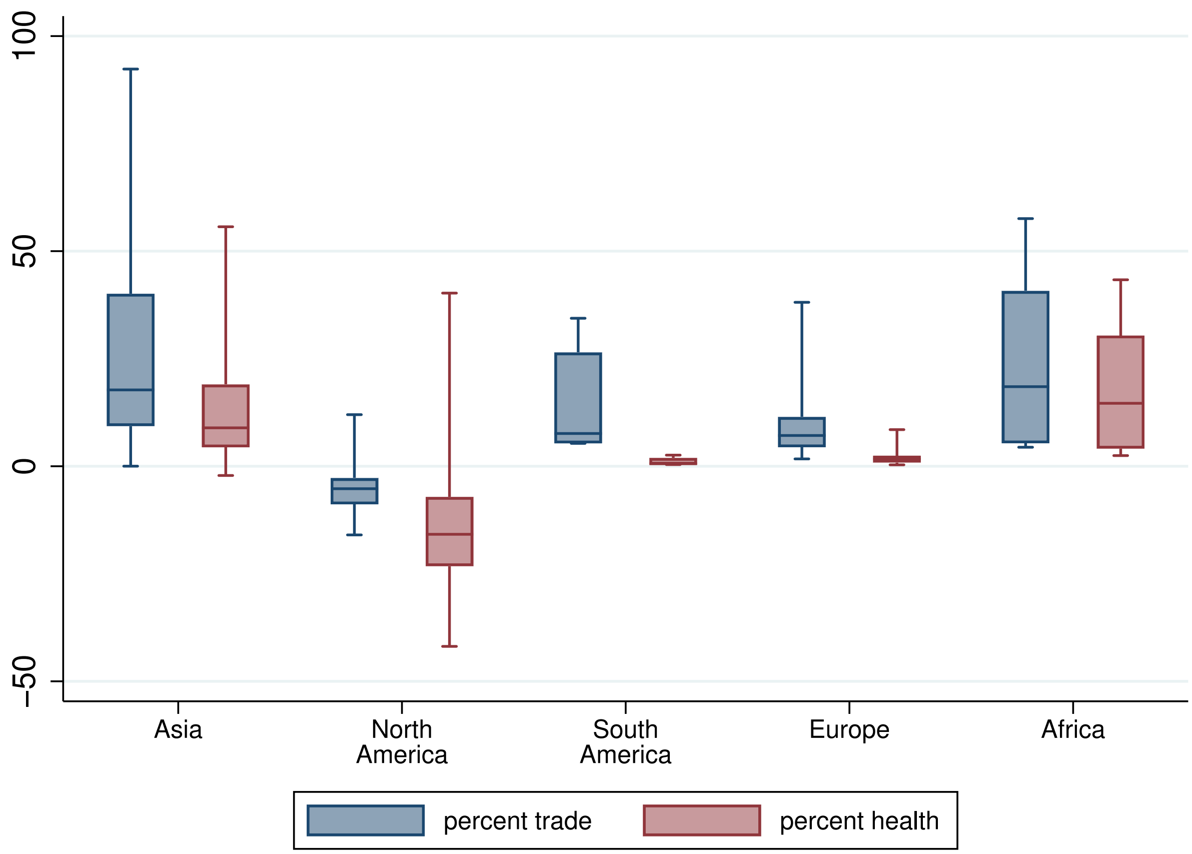
Notes: Figure plots the wellbeing increase from trade and from the health impacts of trade across continents in 1990-2019. To estimate the impacts of trade, I apply an instrument where the distance coefficients are estimated with bilateral controls in equation 5. The box edges indicate the inter-quartile range (25th to 75th percentile) in each continent and the middle line indicates the median.

Figure A11: Wellbeing increases from trade and from the health impacts of trade: omitting country-by-year effects in the gravity equation



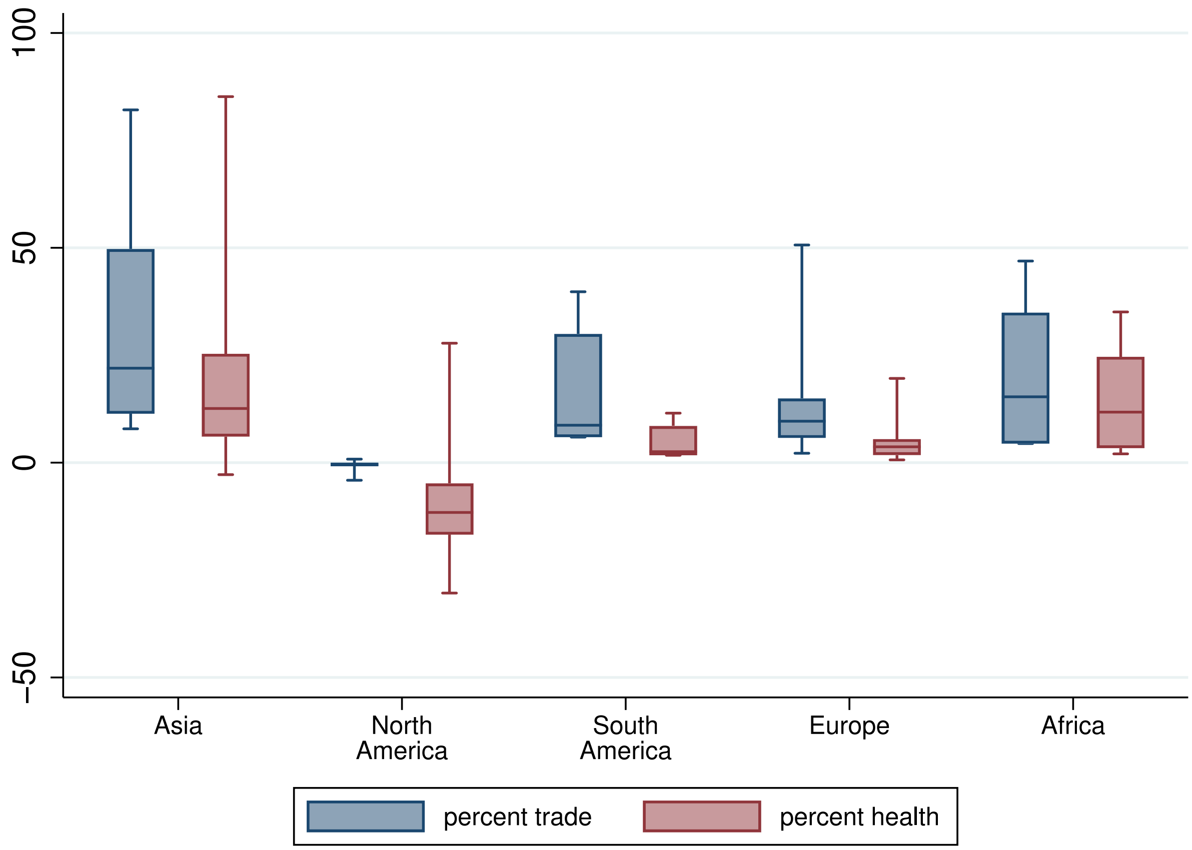
Notes: Figure plots the wellbeing increase from trade and from the health impacts of trade across continents in 1990-2019. To estimate the impacts of trade, I apply an instrument where the distance coefficients are estimated with country pair effects but without country-by-year effects in equation 6. The box edges indicate the inter-quartile range (25th to 75th percentile) in each continent and the middle line indicates the median.

Figure A12: Wellbeing increases from trade and from the health impacts of trade: predicting trade as a five-year average between $t-4$ and t



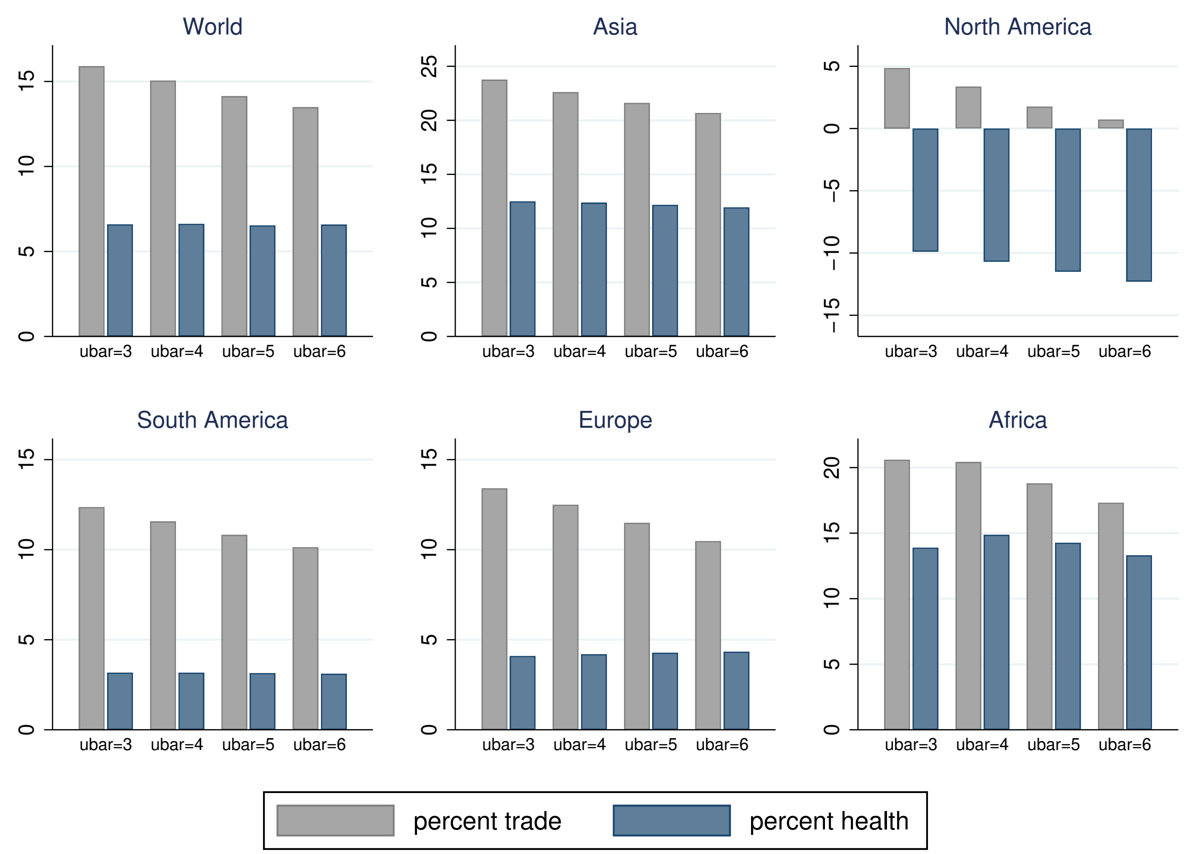
Notes: Figure plots the wellbeing increase from trade and from the health impacts of trade across continents in 1990-2019. To allow for lagged effects of trade, I measure trade as a lagged five-year average between $t-4$ and t and construct an instrument for lagged trade using the gravity specification in equation 6. The box edges indicate the inter-quartile range (25th to 75th percentile) in each continent and the middle line indicates the median.

Figure A13: Wellbeing increases from trade and from the health impacts of trade: unweighted sum across partner countries as instrument



Notes: Figure plots the wellbeing increase from trade and from the health impacts of trade across continents in 1990-2019. Different from equation 7, the instrument for trade is constructed using an unweighted sum across trading partners. The box edges indicate the inter-quartile range (25th to 75th percentile) in each continent and the middle line indicates the median.

Figure A14: Wellbeing increases from trade and from the health impacts of trade: alternative values of a healthy life year ($\bar{u}$)



Notes: Figure plots the wellbeing increase from trade and from the health impacts of trade for different values of a healthy life year captured by the intercept $\bar{u}$ in period utility. The main analysis assumes $\bar{u} = 5$ and a corresponding value of a healthy life year equal to $436,846 in 2000 US dollars. Alternative contributions of trade are plotted for $\bar{u}$ ranging from 3 to 6.

B Appendix Tables

Table B1: First-stage prediction of trade: unweighted instrument

	(1)	(2)	(3)	(4)
$log(\widehat{trade}_{it})$	1.03***	0.60***	1.00***	1.14***
	(0.09)	(0.074)	(0.096)	(0.11)
pair FE	Y		Y	Y
X_{ij}		Y		
5-year average			Y	
X_i-year FE				Y
F-stat	121.38	66.18	109.82	100.96
N	9,771	9,771	9,801	7,282

Notes: Table estimates the first-stage equation where the instrument is predicted trade based on the time-varying impacts of sea and air distances. Predicted bilateral trade values are added across trading partners using equal weights in the instrument. The distance coefficients predicting trade are estimated with country pair fixed effects in column (1), estimated with bilateral controls in column (2), and predict trade as a five-year average between $t-4$ and t to capture the lagged effects in column (3). Column (4) uses the same instrument as column (1) but additionally controls for differential trends across population, employment, human capital, income, as well as the consumption, import, and export share of GDP across countries, interacting the 1970 values of these variables with year fixed effects in the regression. Robust standard errors clustered at the level of countries in the parentheses.

Table B2: TSLS estimates of trade on mortality probability

	(1)	(2)	(3)	(4)	(5)	(6)
	age 0-5			age 15-59		
$log(trade)$	-0.006	-0.001	-0.007***	-0.003	0.001	-0.006
	(0.004)	(0.002)	(0.002)	(0.005)	(0.002)	(0.004)
period	full	pre-1990	post	full	pre-1990	post
F-stat	92.60	82.44	43.73	92.60	82.44	43.73
y_0	0.12	0.14	0.066	0.26	0.27	0.22
Δy	-0.095	-0.07	-0.041	-0.10	-0.06	-0.06
$\Delta log(trade)$	2.46	1.23	1.38	2.46	1.23	1.38
N	9,771	3,977	5,794	9,771	3,977	5,794

Notes: Table shows the TSLS estimates of trade on the probability of mortality transition between birth and 5 (under-5 mortality) and between age 15 and 59 (adult mortality), using an instrument for trade constructed from the distance coefficients in equation 6. Column (1) estimates the impact on under-5 mortality for the full sample period in 1965-2019. Columns (2)-(3) show separate estimates before 1990 and after. Columns (4)-(6) show the results for adult mortality. Robust standard errors clustered at the level of countries in the parentheses.

Table B3: TSLS estimates of trade on life expectancy and mortality, robustness

	(1)	(2)	(3)	(4)	(5)	(6)
	life expectancy			mortality (per 1,000 individuals)		
			Panel A: pre 1990			
$log(trade)$	0.70***	0.96***	0.99**	-0.50*	-0.79	-1.05*
	(0.26)	(0.36)	(0.50)	(0.30)	(0.41)	(0.60)
F-stat	97.77	24.70	73.68	105.15	24.80	73.47
N	3,767	3,781	3,058	3,811	3,825	3,059
			Panel B: post 1990			
$log(trade)$	1.39***	1.59***	1.31**	-1.43***	-1.00***	-1.11**
	(0.35)	(0.47)	(0.57)	(0.44)	(0.35)	(0.52)
F-stat	103.44	113.21	59.54	76.39	74.88	59.54
N	5,420	5,420	4,168	5,493	5,493	4,168
pair FE		Y	Y		Y	Y
X_{ij}	Y			Y		
5-year average		Y			Y	
X_i-year FE			Y			Y

Notes: Table conducts robustness checks on the TSLS estimates of trade on life expectancy and mortality. Columns (1) and (4) apply an instrument constructed without pair fixed effects from equation 5. Columns (2) and (5) measure trade using a lagged 5-year average. Columns (3) and (6) show estimates when the main equation also controls for differential trends across a wide range of country characteristics including population, human capital, employment, income, and the consumption, import, and export share of GDP. Separate estimates are shown for the period before 1990 and after. Robust standard errors clustered at the level of countries in the parentheses.

Table B4: TSLS estimates of trade on mortality probability, robustness

	(1)	(2)	(3)	(4)	(5)	(6)
	age 0-5			age 15-59		
	Panel A: pre 1990					
$log(trade)$	-0.001	-0.002	-0.007	0.001	0.001	-0.006
	(0.002)	(0.003)	(0.004)	(0.002)	(0.003)	(0.004)
F-stat	155.58	43.85	71.90	155.58	43.85	71.90
N	3,977	4,007	3,084	3,977	4,007	3,084
	Panel B: post 1990					
$log(trade)$	-0.012***	-0.007***	-0.012***	-0.004	-0.008*	-0.021***
	(0.004)	(0.003)	(0.003)	(0.004)	(0.004)	(0.007)
F-stat	42.31	39.60	59.64	42.31	39.60	59.64
N	5,794	5,794	4,198	5,794	5,794	4,198
pair FE		Y	Y		Y	Y
X_{ij}	Y			Y		
5-year average		Y			Y	
X_i-year FE			Y			Y

Notes: Table conducts robustness checks on the TSLS estimates of trade on the mortality probability between birth and age 5 (under-5 mortality) and between age 15 and 59 (adult mortality). Columns (1) and (4) apply an instrument constructed without pair fixed effects from equation 5. Columns (2) and (5) measure trade using a lagged 5-year average. Columns (3) and (6) show estimates when the main equation also controls for differential trends across a wide range of country characteristics including population, human capital, employment, income, and the consumption, import, and export share of GDP. Separate estimates are shown for the period before 1990 and after. Robust standard errors clustered at the level of countries in the parentheses.

Table B5: TSLS estimates of trade on life expectancy and mortality, alternative instrument weights and controls

	(1)	(2)	(3)	(4)
	life expectancy		mortality (per 1,000 individuals)	
	Panel A: pre 1990			
$log(trade)$	0.90***	0.80***	-0.64**	-0.66*
	(0.26)	(0.29)	(0.28)	(0.34)
F-stat	89.40	61.68	94.12	64.46
N	3,767	3,767	3,811	3,811
	Panel B: post 1990			
$log(trade)$	1.48***	1.33***	-1.57***	-0.90***
	(0.37)	(0.27)	(0.36)	(0.20)
F-stat	73.19	163.91	68.61	148.23
N	5,420	5,420	5,493	5,493
unweighted	Y		Y	
no country-year FE		Y		Y

Notes: Table conducts robustness checks on the TSLS estimates of trade on life expectancy and mortality. Columns (1) and (3) apply an unweighted instrument where bilateral trade flows are summed across trading partners without weighting. Columns (2) and (4) apply an instrument where the distance coefficients are estimated with country pair effects but without country-by-year effects in equation 6. Separate estimates are shown for the period before 1990 and after. Robust standard errors clustered at the level of countries in the parentheses.

Table B6: Heterogeneous impacts of trade on life expectancy and mortality, by continent

	(1)	(2)	(3)	(4)	(5)	(6)
	life expectancy			mortality (per 1,000 individuals)		
	$\hat{\beta}_{TSLS}$	Δy	$\Delta \hat{y}$	$\hat{\beta}_{TSLS}$	Δy	$\Delta \hat{y}$
Asia	1.17***	7.86	2.41	-0.44	-1.58	-0.93
	(0.34)			(0.42)		
North America	-0.86	4.68	-0.65	0.51	0.32	0.28
	(0.75)			(0.82)		
South America	0.91	7.64	1.21	-0.22	-0.87	-0.29
	(0.57)			(0.55)		
Europe	0.32	5.72	0.43	0.064	0.12	0.083
	(0.44)			(0.54)		
Africa	2.18***	10.27	2.72	-2.90***	-5.82	-3.62
	(0.58)			(0.62)		

Notes: Table summarizes the impact of trade on life expectancy and mortality in each continent. Δy is the raw difference in outcome between 1990 and 2019. $\Delta \hat{y}$ calculates the trade-induced changes multiplying the estimated coefficient of trade, $\hat{\beta}_{TSLS}$, by the trade expansion in each continent. Robust standard errors clustered at the level of countries in the parentheses.

Table B7: Heterogeneous impacts of trade on mortality probability, by continent

	(1)	(2)	(3)	(4)	(5)	(6)
	age 0-5			age 15-59		
	$\hat{\beta}_{TSLS}$	Δy	$\Delta \hat{y}$	$\hat{\beta}_{TSLS}$	Δy	$\Delta \hat{y}$
Asia	-0.004*	-0.036	-0.008	-0.005	-0.056	-0.009
	(0.002)			(0.004)		
North America	0.009	-0.017	0.005	0.008	-0.036	0.005
	(0.006)			(0.011)		
South America	-0.004	-0.033	-0.005	0.003	-0.040	0.005
	(0.004)			(0.007)		
Europe	0.009**	-0.009	0.012	-0.002	-0.046	-0.003
	(0.004)			(0.006)		
Africa	-0.027***	-0.074	-0.034	-0.006	-0.073	-0.007
	(0.004)			(0.007)		

Notes: Table summarizes the impact of trade on the probability of mortality transition between birth and age 5 (under-5 mortality) and between age 15 and 59 (adult mortality) in each continent. Δy is the raw difference in outcome between 1990 and 2019. $\Delta \hat{y}$ calculates the trade-induced changes multiplying the estimated coefficient of trade, $\hat{\beta}_{TSLS}$, by the trade expansion in each continent. Robust standard errors clustered at the level of countries in the parentheses.

Table B8: Impacts of trade on all-cause DALY and by disease categories, by continent

	(1)	(2)	(3)	(4)	(5)	(6)
		DALY		Communicable, maternal, neonatal, nutritional	Non-Communicable	Injuries
	$\hat{\beta}_{TSLS}$	Δy	$\Delta \hat{y}$	$\Delta \hat{y}$	$\Delta \hat{y}$	$\Delta \hat{y}$
Asia	-24.16	-122.67	-47.22	-38.59	12.30	-20.93
	(20.17)					
North America	33.84	-27.77	18.76	16.59	4.52	-2.34
	(39.41)					
South America	-18.61	-98.31	-24.74	-9.67	2.33	-17.41
	(27.56)					
Europe	17.93	-22.56	23.39	57.65	-15.35	-18.90
	(26.09)					
Africa	-187.06***	-392.84	-233.48	-178.46	-23.71	-31.30
	(33.09)					

Notes: Table estimates the impact of trade on aggregate measures of DALY in each continent. In column (2), Δy is the raw difference in all-cause DALY between 1990 and 2019. In column (3), $\Delta \hat{y}$ calculates the trade-induced changes multiplying the estimated coefficient of trade, $\hat{\beta}_{TSLS}$, by the trade expansion in each continent. Trade-induced changes across major disease groups are shown in columns (4)-(6). Robust standard errors clustered at the level of countries in the parentheses.

Table B9: Impacts of trade on HALE and consumption, by continent

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	HALE			consumption			inequality		
	$\hat{\beta}_{TSLS}$	Δy	$\Delta\hat{y}$	$\hat{\beta}_{TSLS}$	Δy	$\Delta\hat{y}$	$\hat{\beta}_{TSLS}$	Δy	$\Delta\hat{y}$
Asia	1.08**	6.39	2.54	0.28***	0.97	0.66	-0.027	-0.019	-0.040
	(0.42)			(0.073)			(0.037)		
North America	-1.08	2.77	-0.66	0.26*	0.60	0.16	-0.030	-0.11	-0.018
	(0.80)			(0.16)			(0.11)		
South America	0.45	4.77	0.60	0.23**	0.69	0.31	-0.080*	-0.079	-0.11
	(0.60)			(0.10)			(0.048)		
Europe	0.50	4.53	0.68	0.27***	0.78	0.36	0.003	0.035	0.004
	(0.49)			(0.090)			(0.048)		
Africa	1.76***	7.86	2.11	0.13*	0.54	0.16	-0.11**	-0.092	-0.12
	(0.46)			(0.077)			(0.044)		

Notes: Table estimates the impact of trade on HALE, log per capita consumption, and inequality in each continent. Δy is the raw difference in outcome in 1990-2019, and $\Delta\hat{y}$ is the trade-induced changes multiplying the estimated coefficient of trade, $\hat{\beta}_{TSLS}$, by the trade expansion in each continent. Robust standard errors clustered at the level of countries in the parentheses.

C Cross-Country Data for Wellbeing Calculations

Consumption. Data on per capita consumption comes from the Penn World Table (PWT) version 10.0 (Feenstra et al., 2015), which provides national account variables on real GDP, consumption, population, and price levels across countries from around 1970. Focusing on the post-1990 period, I obtain per capita consumption and GDP from PWT for a total of 173 countries in the United Nations Comtrade database. Of these countries, 16 were missing information on consumption inequality (detailed below) and were dropped from the analysis. For each of the remaining 157 countries in the final sample, Appendix Table C1 shows detailed information on consumption, health, and wellbeing in 1990 and in 2019. Appendix Figure C1 summarizes changes in the distribution from 1990 to 2019 by continent. In Asia and South America, consumption increased by over 60% in the median country and increased by over 100% in the upper percentiles of countries. In contrast to the rapid consumption gains in the rest of the world, African countries had the lowest consumption levels in 1990-2019 and showed the smallest consumption growth over the same period.

Inequality. I derive consumption inequality, measured as the standard deviation of log per capita consumption, from the World Income Inequality Database (WIID, UNU-WIDER 2021). The database provides consumption statistics – such as mean, Gini, and percentiles – from harmonized micro survey data in 200 countries. Following Jones and Klenow (2016), I calculate standard deviation σ_{it} from Gini coefficient g_{it} using the formula $\sigma_{it} = \sqrt{2}\Phi^{-1}\left(\frac{g_{it}+1}{2}\right)$, with $\Phi^{-1}()$ the inverse CDF of a Standard Normal. When multiple micro data are available for a given country-year, I use the highest quality data according to quality rankings computed by WIID. A total of 157 countries were included in WIID at least twice during the period from 1990 to 2019.[6] For these countries, in the case that

[6]Of the 173 countries matched with consumption information in the Penn World Table, 13 were missing from the WIDD (Antigua and Barbuda, Bahrain, Barbados, Bermuda, Brunei Darussalam, Dominica, Equatorial Guinea, Grenada, Kuwait, Oman, Saint Kitts and Nevis, Saint Vincent and the Grenadines, Saudi Arabia), and 3 have only one observation post 1990 in WIDD (Lebanon, Suriname, Trinidad and Tobago).

no micro data was available in 1990 or 2019, I use data from the country's nearest survey year after 1990 and before 2019 to measure consumption inequality σ_{i0} and σ_{i1}. As shown in panel (b) of Appendix Figure C1, consumption inequality decreased to a small extent in North America and Africa while remaining largely unchanged in the median Asian and European country.

Health. I obtain health-adjusted life expectancy (HALE) from the 2019 Global Burden of Diseases (GBD) study (GBD Collaborative Network, 2019). To construct HALE, the GBD assigns to each life year in a country a quality-of-life value derived from the country's disease-driven disabilities by age. The age-specific disability status is then combined with age-specific mortality rates to calculate HALE, or the number of life years citizens in a given country can expect to live in full health. As shown in panel (c) of Appendix Figure C1, HALE increased substantially across countries in Asia, South America, Europe, and Africa, and increased to a smaller extent in North America. In panel (d), wellbeing, measured as the consumption-equivalent relative to the US wellbeing in 2019, was highest in Europe, where the median country enjoyed a 167% wellbeing in 2019. Over time, wellbeing increased by 100%-200% across the inter-quartile range in Asia, South America, Europe, and Africa, and increased by a smaller 57%-92% across the inter-quartile range in North America.

These 16 countries were dropped from the final sample for wellbeing calculations.

Table C1: Consumption, health, and wellbeing across countries, 1990 and 2019

	$\log c_{i0}$	$\log c_{i1}$	σ_{i0}	σ_{i1}	$HALE_{i0}$	$HALE_{i1}$	Λ_{i0}	Λ_{i1}
Asia								
Armenia	7.90	9.19	0.91	0.63	62.09	66.55	3.29%	35.92%
Australia	9.70	10.27	0.61	0.59	66.05	70.30	54.83%	260.60%
Azerbaijan	7.60	7.80	0.63	0.48	57.61	59.95	1.31%	2.63%
Bangladesh	7.00	7.74	0.50	0.59	52.40	64.03	0.32%	5.16%
Bhutan	7.98	8.72	0.76	0.69	59.05	62.90	2.23%	10.06%
Cambodia	7.17	7.59	0.65	0.56	55.15	59.53	0.56%	1.94%
China	7.22	8.62	0.53	0.88	60.48	68.53	1.67%	24.71%
Fiji	8.27	8.84	0.70	0.68	58.29	59.44	2.57%	5.57%
Georgia	7.95	9.07	0.68	0.67	62.82	64.41	4.76%	19.70%
India	6.87	7.92	0.54	0.67	51.05	58.20	0.22%	1.89%
Indonesia	7.55	8.61	0.57	0.70	55.92	62.35	0.94%	8.05%
Japan	9.72	10.03	0.59	0.62	70.23	73.43	142.40%	404.17%
Kazakhstan	8.74	9.59	0.60	0.50	57.95	62.83	3.90%	25.61%
Kyrgyzstan	8.26	8.38	0.89	0.50	58.61	64.83	2.39%	11.93%
Lao People's Democratic Republic	6.71	8.32	0.63	0.67	48.17	58.77	0.11%	3.04%
Malaysia	8.47	9.48	0.90	0.76	63.30	65.63	7.31%	35.76%
Maldives	8.36	8.96	0.77	0.57	65.16	68.98	10.62%	48.96%
Mauritius	9.18	9.65	0.65	0.68	63.85	65.03	19.71%	39.62%
Mongolia	7.53	8.77	0.61	0.60	53.08	60.38	0.53%	6.61%
Myanmar	7.91	7.90	0.70	0.56	59.44	59.89	2.34%	2.76%
Nepal	6.83	7.26	0.65	0.60	54.05	59.94	0.35%	1.51%
New Zealand	9.48	10.09	0.55	0.62	64.70	69.61	33.81%	179.22%
Pakistan	7.48	8.06	0.61	0.61	53.16	56.24	0.52%	1.51%
Philippines	7.82	8.45	0.82	0.74	59.73	62.03	2.11%	6.29%
Republic of Korea	8.87	9.84	0.64	0.63	64.21	72.28	15.84%	248.80%
Seychelles	9.09	9.54	0.80	0.88	63.55	64.46	15.30%	26.84%
Singapore	9.84	10.14	0.86	0.89	70.79	73.10	149.19%	336.39%
Sri Lanka	7.68	8.96	0.59	0.74	61.55	66.51	3.04%	26.17%
Taiwan (Province of China)	9.30	10.10	0.54	0.50	66.13	70.41	38.76%	235.96%
Tajikistan	6.85	7.75	0.54	0.62	58.80	61.12	0.88%	2.95%
Thailand	8.02	9.09	0.85	0.67	62.25	68.32	4.00%	45.99%
Turkmenistan	8.15	8.42	0.66	0.76	57.41	57.65	2.00%	2.51%
Uzbekistan	8.10	8.05	0.61	0.65	59.41	57.79	2.92%	1.99%
Viet Nam	7.05	8.36	0.65	0.66	61.99	65.64	1.76%	12.61%

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Table C1: (continued from the previous page)

	$\log c_{i0}$	$\log c_{i1}$	σ_{i0}	σ_{i1}	$HALE_{i0}$	$HALE_{i1}$	Λ_{i0}	Λ_{i1}
North America								
Bahamas	9.94	9.80	1.13	0.77	62.71	64.44	21.37%	37.79%
Belize	8.46	8.50	1.20	1.03	64.57	62.01	6.85%	5.14%
Canada	9.84	10.26	0.56	0.55	67.34	70.47	86.49%	276.44%
Dominican Republic	8.18	9.24	0.98	0.82	63.98	63.98	5.84%	18.99%
Guyana	7.49	7.81	1.04	0.84	55.01	55.23	0.55%	0.88%
Haiti	7.23	7.22	1.18	0.76	50.48	53.35	0.17%	0.40%
Jamaica	7.94	8.73	0.76	0.68	66.24	66.54	8.64%	21.64%
Saint Lucia	8.76	9.15	0.79	0.98	62.37	65.14	8.72%	19.24%
United States of America	10.06	10.56	0.52	0.77	63.90	65.43	50.39%	100.00%
South America								
Argentina	8.42	9.54	0.88	0.79	63.69	66.79	7.69%	47.76%
Bolivia (Plurinational State of)	7.48	8.64	0.93	0.79	54.67	62.96	0.56%	8.81%
Brazil	8.26	9.11	1.19	1.04	57.96	64.97	1.58%	16.81%
Chile	8.50	9.47	1.02	0.92	63.99	69.14	7.73%	66.50%
Colombia	8.53	9.11	0.98	0.96	61.96	69.49	5.47%	46.68%
Costa Rica	8.65	9.40	0.82	0.91	67.03	69.38	19.69%	65.35%
Ecuador	8.19	8.75	1.03	0.85	63.92	66.60	5.56%	19.56%
El Salvador	6.78	8.72	0.84	0.71	60.21	65.44	0.87%	16.62%
Guatemala	8.17	8.59	0.90	0.64	56.91	62.07	1.57%	7.74%
Honduras	7.63	8.20	1.12	1.00	60.21	62.93	1.47%	4.79%
Mexico	8.99	9.37	0.88	0.73	62.17	65.19	9.75%	29.87%
Nicaragua	7.71	8.17	0.96	0.87	62.83	65.10	3.02%	7.93%
Panama	8.41	9.61	1.08	0.94	66.77	69.13	11.46%	75.62%
Paraguay	8.02	8.92	0.76	0.87	65.68	66.37	8.41%	21.85%
Peru	7.83	8.88	0.82	0.80	60.59	69.76	2.51%	44.82%
Uruguay	8.86	9.48	0.77	0.74	64.47	67.44	15.13%	54.14%
Venezuela (Bolivarian Republic of)	8.44	8.73	0.79	0.89	63.24	65.32	7.65%	14.38%
Europe								
Albania	8.22	9.01	0.49	0.61	65.38	68.77	11.47%	48.40%
Austria	9.69	10.23	0.57	0.56	66.41	70.60	60.03%	273.03%
Belarus	8.72	9.46	0.39	0.46	60.86	65.03	7.70%	37.36%
Belgium	9.61	10.15	0.45	0.50	66.32	69.72	57.90%	213.41%
Bosnia and Herzegovina	8.58	9.03	0.54	0.60	65.70	66.75	16.97%	32.25%

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Table C1: (continued from the previous page)

	$\log c_{i0}$	$\log c_{i1}$	σ_{i0}	σ_{i1}	$HALE_{i0}$	$HALE_{i1}$	Λ_{i0}	Λ_{i1}
Bulgaria	8.74	9.51	0.60	0.77	61.57	64.58	8.22%	29.34%
Croatia	8.96	9.65	0.44	0.54	64.22	68.21	19.17%	87.15%
Cyprus	9.77	10.01	0.55	0.60	67.74	69.90	89.12%	180.47%
Czechia	9.34	9.93	0.48	0.45	63.84	68.60	25.21%	133.03%
Denmark	9.58	10.19	0.41	0.52	65.25	69.92	44.73%	230.25%
Estonia	8.67	9.85	0.73	0.56	60.02	68.13	5.18%	104.87%
Finland	9.49	10.17	0.41	0.49	65.41	70.34	42.62%	251.49%
France	9.60	10.12	0.61	0.59	66.99	71.50	60.86%	293.52%
Germany	9.62	10.23	0.52	0.55	65.77	69.72	49.78%	224.02%
Greece	9.37	9.83	0.65	0.61	67.61	69.91	53.82%	148.29%
Hungary	8.93	9.77	0.54	0.54	60.81	66.79	8.63%	71.92%
Iceland	10.04	10.34	0.49	0.47	69.99	72.29	202.19%	481.49%
Ireland	9.39	10.04	0.68	0.56	65.82	70.35	36.27%	211.85%
Israel	9.56	10.06	0.60	0.67	67.48	71.79	64.88%	276.93%
Italy	9.65	10.02	0.50	0.65	66.43	71.24	60.14%	237.52%
Latvia	8.66	9.79	0.49	0.65	58.67	66.32	4.44%	62.08%
Lithuania	8.72	9.99	0.62	0.66	60.40	66.56	6.30%	80.07%
Luxembourg	10.15	10.43	0.49	0.65	67.18	70.99	119.10%	349.98%
Malta	9.68	10.03	0.49	0.52	69.15	71.07	113.86%	251.21%
Montenegro	9.11	9.55	0.55	0.62	64.99	66.49	24.94%	51.16%
Netherlands	9.60	10.19	0.58	0.52	67.37	70.62	67.26%	269.99%
North Macedonia	8.32	9.27	0.49	0.56	62.20	65.38	6.62%	31.53%
Norway	9.54	10.32	0.45	0.51	66.36	70.84	54.06%	327.25%
Poland	8.46	9.87	0.48	0.55	61.99	68.12	7.31%	106.51%
Portugal	9.14	9.88	0.68	0.61	64.20	70.21	20.00%	166.15%
Republic of Moldova	7.69	8.87	0.67	0.46	59.56	64.90	2.01%	20.06%
Romania	8.37	9.77	0.46	0.66	61.30	66.36	5.91%	61.07%
Russian Federation	8.82	9.68	0.47	0.69	60.47	63.73	7.54%	30.27%
Serbia	8.87	9.36	0.67	0.64	63.74	66.33	14.00%	40.20%
Slovakia	9.10	9.80	0.34	0.45	63.23	67.61	18.54%	93.66%
Slovenia	9.30	9.90	0.45	0.44	65.08	70.38	32.19%	194.64%
Spain	9.33	9.99	0.64	0.64	67.03	71.60	45.31%	252.84%
Sweden	9.65	10.27	0.44	0.55	67.75	71.39	82.45%	344.08%
Switzerland	9.93	10.30	0.68	0.61	67.17	72.02	84.30%	398.80%
Ukraine	8.55	9.09	0.54	0.47	60.58	64.66	5.83%	23.60%
United Kingdom	9.67	10.20	0.61	0.62	65.38	69.11	45.37%	180.85%

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Table C1: (continued from the previous page)

	$\log c_{i0}$	$\log c_{i1}$	σ_{i0}	σ_{i1}	$HALE_{i0}$	$HALE_{i1}$	Λ_{i0}	Λ_{i1}
Africa								
Algeria	8.34	8.84	0.65	0.50	60.68	65.41	4.59%	21.28%
Angola	7.09	8.21	1.00	0.98	46.57	56.75	0.09%	1.47%
Benin	7.13	7.59	0.71	0.90	51.05	55.05	0.25%	0.67%
Botswana	8.61	9.05	1.31	1.03	40.22	53.18	0.06%	1.41%
Burkina Faso	6.62	7.05	0.91	0.65	44.22	52.24	0.05%	0.30%
Burundi	6.57	6.53	0.61	0.71	41.80	53.29	0.03%	0.23%
Cabo Verde	7.76	8.35	1.01	0.79	61.97	65.31	2.58%	10.62%
Cameroon	7.41	7.66	0.83	0.88	48.92	52.08	0.20%	0.41%
Central African Republic	6.57	6.65	1.22	1.10	39.93	40.93	0.02%	0.02%
Chad	6.80	7.05	0.74	0.81	46.25	49.75	0.08%	0.18%
Comoros	7.67	7.74	1.09	0.85	56.05	59.10	0.74%	1.70%
Congo	7.40	7.55	0.90	0.93	49.66	53.71	0.21%	0.49%
Côte d'Ivoire	7.44	7.92	0.73	0.79	46.61	53.46	0.14%	0.70%
Democratic Republic of the Congo	6.09	6.29	0.79	0.78	48.32	52.76	0.07%	0.17%
Djibouti	7.52	8.09	0.84	0.77	53.47	58.42	0.49%	2.16%
Egypt	7.54	9.00	0.58	0.57	56.86	62.28	1.11%	12.40%
Eswatini	8.69	8.71	1.02	1.06	40.86	49.56	0.09%	0.50%
Ethiopia	6.11	7.07	0.84	0.64	44.08	58.96	0.03%	1.04%
Gabon	8.77	8.77	0.79	0.70	53.20	58.18	1.34%	3.95%
Gambia	7.63	7.28	0.91	0.66	53.24	57.34	0.49%	0.92%
Ghana	7.42	8.12	0.71	0.81	52.44	57.17	0.41%	1.69%
Guinea	7.81	7.32	0.88	0.62	46.01	51.28	0.15%	0.32%
Guinea-Bissau	7.06	7.04	0.82	0.97	43.85	49.54	0.06%	0.15%
Iran (Islamic Republic of)	7.69	8.88	0.82	0.76	57.76	66.48	1.29%	23.42%
Iraq	8.36	9.10	0.65	0.89	58.25	61.44	2.86%	9.13%
Jordan	7.86	8.87	0.81	0.56	62.81	67.85	3.97%	35.44%
Kenya	7.30	7.84	1.13	0.76	52.45	57.08	0.27%	1.35%
Lesotho	7.69	7.81	0.99	0.84	39.72	44.87	0.04%	0.12%
Liberia	6.45	6.79	0.67	0.65	52.02	55.44	0.18%	0.43%
Madagascar	6.64	7.07	0.85	0.80	49.96	55.61	0.13%	0.52%
Malawi	6.56	6.70	1.34	0.84	39.86	55.45	0.02%	0.36%
Mali	6.28	7.17	0.96	0.60	44.85	51.28	0.04%	0.29%
Mauritania	7.83	7.86	0.95	0.60	53.57	60.96	0.59%	3.21%
Morocco	8.06	8.31	0.73	0.73	58.60	63.06	2.25%	6.80%

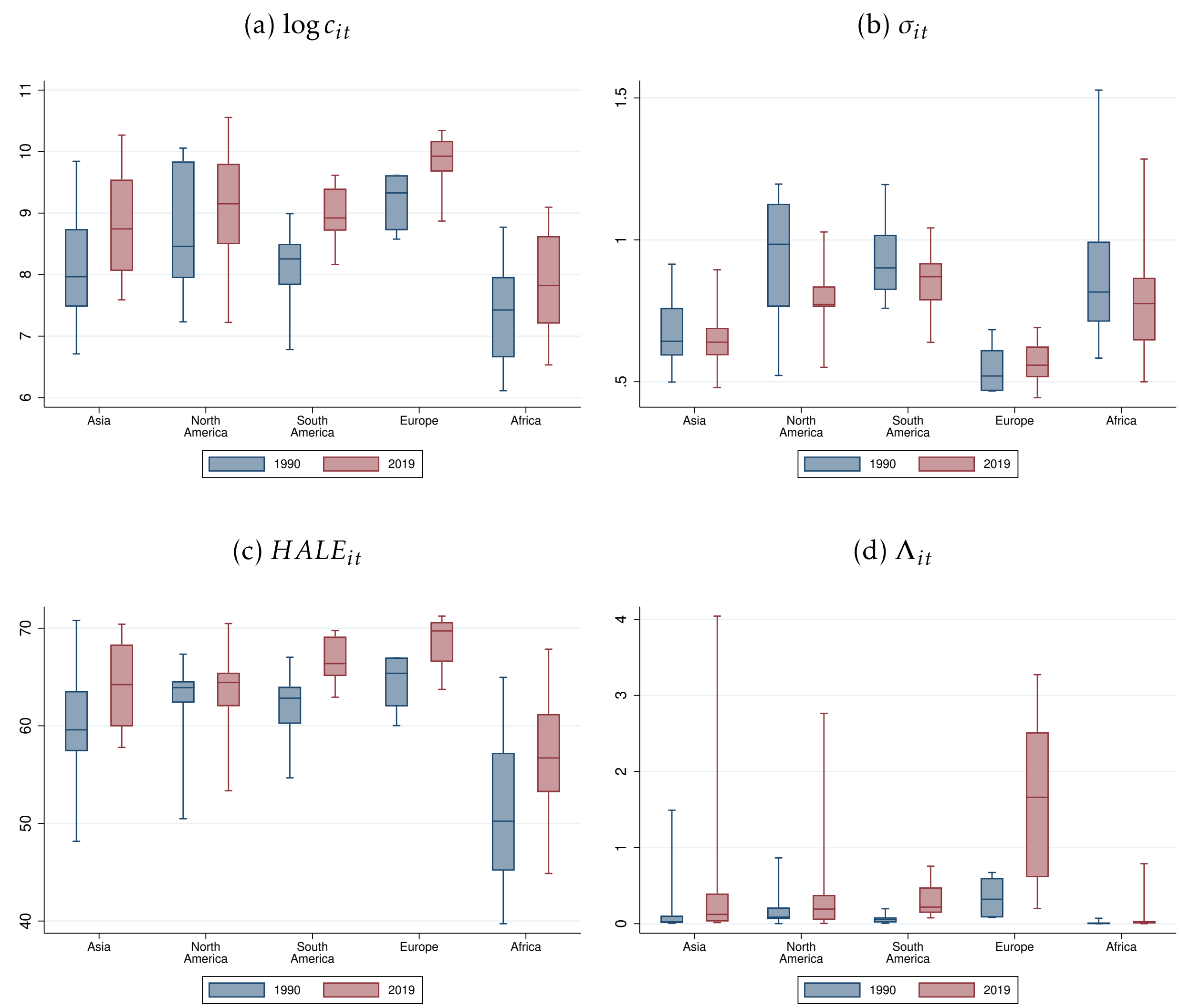
to be continued on the next page

Table C1: (continued from the previous page)

	$\log c_{i0}$	$\log c_{i1}$	σ_{i0}	σ_{i1}	$HALE_{i0}$	$HALE_{i1}$	Λ_{i0}	Λ_{i1}
Mozambique	6.32	6.82	0.74	0.88	45.48	48.69	0.05%	0.12%
Namibia	8.37	9.02	1.28	1.17	45.93	55.45	0.16%	1.92%
Niger	6.66	6.64	0.66	0.63	42.43	53.25	0.04%	0.26%
Nigeria	5.78	8.15	0.84	0.64	47.65	56.04	0.05%	1.55%
Palestine	8.09	8.54	0.62	0.69	60.32	64.31	3.46%	11.22%
Qatar	9.99	10.21	0.53	0.44	63.11	65.03	39.28%	78.86%
Rwanda	6.64	7.27	0.92	0.82	44.56	59.16	0.05%	1.14%
Sao Tome and Principe	7.38	7.92	0.59	1.10	57.61	61.89	1.10%	2.72%
Senegal	7.53	7.62	1.05	0.75	51.68	57.87	0.30%	1.30%
Sierra Leone	6.73	7.38	0.75	0.66	46.10	53.56	0.08%	0.50%
South Africa	8.58	8.98	1.17	1.28	55.63	54.65	1.36%	1.40%
Sudan	7.73	7.99	0.71	0.63	58.51	59.97	1.66%	2.92%
Syrian Arab Republic	7.75	8.13	0.69	0.63	64.96	65.41	5.84%	9.74%
Togo	6.85	7.21	0.79	0.80	50.50	54.75	0.18%	0.49%
Tunisia	8.30	8.97	0.75	0.60	63.30	67.11	7.02%	32.86%
Turkey	8.75	9.55	0.77	0.78	61.44	67.81	7.24%	61.06%
Uganda	6.41	7.20	0.77	0.80	41.51	56.67	0.03%	0.70%
United Arab Emirates	10.52	9.91	0.71	0.59	61.91	63.89	44.46%	41.79%
United Republic of Tanzania	6.65	7.27	1.53	0.75	47.51	58.26	0.05%	1.02%
Yemen	6.72	7.88	0.64	0.68	54.37	59.34	0.34%	2.27%
Zambia	6.92	7.47	1.20	1.12	44.36	53.00	0.05%	0.35%
Zimbabwe	8.12	7.80	1.47	0.83	47.80	52.55	0.16%	0.52%

Notes: Table summarizes log per capita consumption $\log c_{it}$, consumption inequality σ_{it}, health-adjusted life expectancy $HALE_{it}$, and wellbeing Λ_{it} for 157 countries in 1990 ($t = 0$) and 2019 ($t = 1$). I obtain per capita consumption and GDP from the Penn World Table 10.0, and obtain consumption inequality from the World Income Inequality Database. More details of the data are described in the main text.

Figure C1: Consumption, health, and wellbeing in 1990 and 2019, by continent



Notes: Figure plots the distribution of log per capita consumption, inequality, health-adjusted life expectancy, and wellbeing in 1990 and 2019 by continent. The box edges indicate the inter-quartile range (25th to 75th percentile) in each continent and the middle line indicates the median.

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