Global disparities in health-systems financing: a cross-national analysis of the impact of tariff reductions and state capacity on public health expenditure in 65 low- and middle-income countries, 1996-2015

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Highlights

- Understanding what influences government health spending can help identify how to reduce global disparities.
- Research to date has overlooked the potential influence of reducing international trade taxes, 'tariffs'.
- We find that tariff reductions have divergent associations with public health expenditure.
- Association varies according to states' capacities to compensate for lost tariff revenue and avoid budget constraints.
- Tariff reductions may be under-recognised contributors to global health spending disparities.

Abstract

Understanding what contributes to cross-national differences in public health spending among low- and middle-income countries (LMICs) can help identify how policy-makers can reduce global disparities. Yet, research on this topic has so far overlooked the potential influence of one of the most strongly recommended economic reforms during the post-war era: reducing international trade taxes, 'tariffs'. Tariffs are an important source of tax revenue for some LMICs. Tariff declines can impact on government finances, and these changes may constrain public health expenditure where states lack the capacity to tax non-trade activities. We examined the association between tariff changes and public health spending in 65 LMICs, 1996–2015. We identify substantial variation in this association according to one indicator of state capacity, a country's score on the World Governance Indicators government effectiveness (GE) index. For example, tariff declines corresponded to reduced public health expenditures in countries with low GE scores. Our results suggest that tariff changes and domestic taxation capacities have an under-recognised impact on public health expenditure and may contribute to global health spending disparities.

Keywords

International variations in health expenditure; government health expenditure; fiscal space; Sustainable Development Goals (SDGs); global health; health inequalities

1. Introduction

Increasing government spending on health in developing countries is a cornerstone of current efforts to achieve Universal Health Coverage (UHC) and address major diseases such as HIV/AIDS, tuberculosis, and malaria (UN, 2015; Obrizan and Wehby, 2018). Notably, a UN Task Team that informed the Sustainable Development Goals (SDGs) concluded that inclusive human development requires significant increases in health investment in order to "close the gaps in human capabilities that help perpetuate inequalities and poverty across generations" (UN System Task Team on the Post-2015 UN Development Agenda, 2012). Several public health expenditure targets have been identified, including a minimum annual spend of approximately 5% of Gross Domestic Product (GDP) and at least $72-86 per capita (in 2012 dollars) (Mcintyre, Meheus and Røttingen, 2017). There are signs of progress, but public health spending varies substantially between societies and is inadequate in many low- and middle-income countries (LMICs) (WHO, 2018). For example, public spending on health was, on average, approximately $60 per capita in lower-middle income countries and $10 per capita in low-income countries in 2016, compared with over $2,250 in high-income countries (ibid).

Cross-national research can generate important insights about how to expand public health expenditure in developing countries and reduce global disparities (Bauer and Ameringer, 2010; Fan and Savedoff, 2014). To this end, scholars have analysed whether and how diverse economic and political characteristics influence public health spending and contribute to cross-national differences among LMICs. For example, research has shown that weak economic growth can explain why some LMICs have low tax revenues and inadequate government spending on health-care and services (Dieleman, 2017). Economic development is therefore commonly discussed as a possible means for increasing health spending in LMICs (WHO, 2018). Others have analysed whether and how fiscal reforms, the structure of domestic taxes, and development aid all affect the quantity and proportion of public funds allocated to public health systems

(Stuckler, Basu and McKee, 2011; Dieleman and Hanlon, 2014; Reeves *et al.*, 2014; Basu, Carney and Kenworthy, 2017).

One potentially important contributor to cross-national differences in public health spending in LMICs that has received surprisingly little empirical scrutiny is tariff liberalization. International organizations and developed countries regularly encourage reductions in taxes on international trade, 'tariffs', in order to boost trade, incomes, and economic growth in LMICs (Edwards, 1997; Higgins and Prowse, 2010; Antràs and Miquel, 2011; UN, 2015; European Commission, 2016; UK Parliament, 2018; USTDA, 2018; World Trade Organization, 2018). Tariff liberalization is also a target of several SDGs (SDGs 17.10, 17.11 and 17.12). Yet, it is unclear whether tariff reductions serve as a barrier or catalyst towards public health expenditure growth in LMICs. As set out below, tariff reductions can have a significant impact on government finances (Smith *et al.*, 2015; McNeill *et al.*, 2017). This may affect the ability of states to spend on health-care and services.

One possibility is that tariff reductions lead to increased public health expenditure by generating a rise in revenue from labour, sales, and business taxes due to wage, consumption, and profit growth (Smith *et al.*, 2015; McNeill *et al.*, 2017). Research has consistently found that higher tax revenues enable increased public health expenditure by creating the 'fiscal space' that is necessary for prioritising and funding health-care and services (Jamison *et al.*, 2013; Reeves *et al.*, 2015; Reich *et al.*, 2016). For example, a 2015 analysis by Reeves and colleagues found that every additional US$100 per capita per year of tax revenues corresponded to a yearly increase in government health spending of $9·86 (95% CI 3·92–15·8), adjusted for GDP per capita. This suggests that tariff reductions lead to economic improvements that expand tax revenues and so, in turn, facilitate increased public health expenditure.

Alternatively, tariff reductions may create budgetary pressures that lead to a decline in public health expenditure. This can happen because trade tax revenues are an important source of government finance for many LMICs. Cage and Gadenne examined the changing structure of tax revenues in 130 countries, 1792-2006 (Cagé and Gadenne, 2018). They found that trade taxes constituted more than 30% of total tax revenues among low-income countries from the 1970s onwards. However, tariff reductions can lead to a reduction in revenue from trade taxes (Baunsgaard and Keen, 2010). To maintain revenue, governments must levy and collect taxes on other activities. In recent years, developing countries have been unable to compensate for lost trade tax revenue following tariff reforms: between 1970 and 2006, over 40% of developing countries in Cage and Gadenne's sample experienced a net fall in total tax revenues that lasted more than ten years after liberalization. Tariff reductions may therefore lead to a reduction public health expenditure in LMICs because they create tax revenue shortfalls and so constrain fiscal space.

Whether or not this happens may depend critically on whether governments have the infrastructure and capacity that enables them to define, enforce, and administer taxes on domestic labour, sales, and businesses and so compensate for lost trade tax revenue. These 'state capacities' are the *sine qua non* of taxation: to levy and collect tax revenue from non-trade sources, states must have effective bureaucracies staffed by trustworthy agents that can reach their populations, collect and organize information, manage revenue, and ensure compliance with policy (Besley, 1995; Hanson and Sigman, 2013). The academic and policy literature concerning the economic benefits of tariff reforms typically assumes that governments have these capacities (Queralt 2017). But as Cage and Gadenne noted, an absence of these state capacities in many countries that remained poor in the late 20^{th} and early 21^{st} centuries may explain why they experienced tax revenue declines following trade reforms (Aizenman and Jinjarak, 2009; Acemoglu, García-Jimeno and Robinson, 2015). This may have been exacerbated by weak or non-existent growth in wages, sales, and profits: state capacities are essential for sustaining a range of commercial activities, and so they may also determine whether countries actually reap the economic benefits of trade liberalisation (Billmeier and Nannicini, 2013).

Previous analyses and systematic reviews have acknowledged that tariff changes may impact on public health expenditure in LMICs, for better or for worse (Bettcher, Yach and Guindon, 2000; Smith *et al.*, 2015; Barlow *et al.*, 2017; McNeill *et al.*, 2017). As discussed above, numerous studies have also identified how fiscal policy, loan conditions, and development aid impact on public health expenditure, highlighting the importance of political-economic characteristics in influencing spending and contributing to cross-national disparities (Liang and Mirelman, 2014; Khan *et al.*, 2017; Stubbs *et al.*, 2017; Datta, 2019). Yet no study, to our knowledge, has empirically investigated whether tariff reductions impact on public health expenditure in LMICs, or considered the possible role of state capacity in these relationships.

Here analyse the association between tariffs and public health expenditure in 65 low- and middle-income countries, 1996-2015. We examine whether these relationships differ according a country's state capacity and test the potentially mediating role of changing tax revenues. In addition, any increase (or decrease) in public health expenditure may be offset by 'crowding out' effects that entail a commensurate decrease (or increase) in private sector spending (Cutler, 2002). Public spending increases following tariff reductions may also be exacerbated or offset by household income gains that lead to a rise in private spending levels (Subramanian, Belli and Kawachi, 2002). As these coinciding changes would alter the context and substantive implications of our findings, we conduct additional analyses evaluating the relationship between tariffs and private health expenditure.

2. Materials and methods

Data and measures

Table S1 lists the data sources and measurement of the key variables included in the analysis. Our explanatory variable is the World Bank's measure of the weighted average of a country's import tariff on each product, in each country and year, from the World Development Indicators (WDIs) (World Bank, 2018). The tariff rate is expressed as a percentage of the import value, and weights correspond to product import shares. In robustness checks we evaluate whether our results are consistent when using alternative tariff measures, including the simple mean tariff rate and the mean Most Favoured Nation (MFN) rate levied on World Trade Organization (WTO) members. In all cases we multiply the tariff rate variables by -1 so that the resulting coefficients can be interpreted in relation to a tariff reduction (of 1%) rather than an increase. This makes the coefficients directly relatable to the common policy recommendation of reducing tariffs in LMICs (European Commission, 2016; UK Parliament, 2018; USTR, 2018; World Trade Organization, 2018).

Our main outcome variable of interest is government spending on health-care and services from domestic sources, also from the World Bank WDIs. Public health expenditure refers to three main forms of government spending allocated to health-care and services by e.g. a Ministry of Health and other ministries (e.g. Defence, Correctional Services, Police, Social Affairs). Public sources include transfers and grants, subsidies to voluntary health insurance beneficiaries, and compulsory prepayment and social health insurance subsidies and contributions. It excludes transfers distributed by government from foreign origin (e.g. aid). To evaluate possible changes to private health expenditure we again using World Bank data. This includes compulsory direct household spending (out-of-pocket expenditure, OOP), private voluntary insurance, and other non-state forms of funding (e.g. charities). Both private and public health expenditure measures are in US dollars per capita and are adjusted for inflation and differences in purchasing power.

In an additional set of models we examine government and private health expenditure as a share (%) of GDP. This measure is designed to capture differences in affordability relative to economic development within each country-context (Mcintyre, Meheus and Røttingen, 2017). A disadvantage of examining health expenditure as a share of GDP is that this measure is more difficult to interpret. This is because it can be influenced both by spending levels and by economic development, and tariff reforms may alter both of these indicators to different degrees and in different directions. Indeed, when we estimate our models using this relative measure our results are slightly less stable, which is likely attributable to the heterogeneous impact of tariff reforms on GDP (Chang, Kaltani and Loayza, 2009; Billmeier and Nannicini, 2013). We therefore focus on the per capita measure when presenting a majority of the regression results in the main text.

To evaluate whether the relationship between tariffs and health spending depends on elements of a country's state capacity that influence their ability to levy and collect domestic taxes, we use the government effectiveness (GE) component of the World Government Indicators (Kaufmann, Kraay and Mastruzzi, 2011). The index is calculated by aggregating and re-weighting information from 15 sources that contain expert assessments or surveys of firms. The selected information is designed to capture "perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies" (Kaufmann, Kraay and Mastruzzi, 2011, p. 3). This is relevant for our purposes as we aim to capture aspects of a state's bureaucracy and administration that influence the state's ability to effectively define, enforce, and administer non-trade taxes. These abilities are present where state bureaucracies are staffed by a well-trained civil service that are able to clearly formulate and credibly commit to a policy, effectively collect and administer reforms, distribute clearly formulated guidelines, and monitor compliance (Pomeranz and Vila-Belda, 2019). The GE index therefore proxies core components of state capacity that are central to our theoretical interests (Hanson and Sigman, 2013).

We considered a number of alternative indices and sub-components, including those contained in the Varieties of Democracy ('V-Dem') and Quality of Government indicators (Rothstein and Teorell, 2008; Lindberg *et al.*, 2014; Teorell *et al.*, 2016). However, these indicators measure features of a country's politics or governance that differ conceptually to state capacity, including the extent to which potentially unfettered political power is contestable and subject to checks and balances (V-Dem), or the extent to which civil servant recruitment and administration are free from political interference (Quality of Government). State capacities alternatively concern the technical and administrative ability of a government to construct and implement policies throughout a territory (Andersen, Møller and Skaaning, 2014). Although these political characteristics, processes, and related indicators may influence one another, they refer to different underlying phenomena (Carbone and Memoli, 2015; Xu, 2018).

The GE index has limitations, including measurement issues and possible biases. One possibility is that those coding the index – or the surveys used to construct it – hold the view that state capacity is integral to development. This raises the possibility that observers from, or selected by, organisations that hold such a view may code countries performing better economically with higher scores on the GE index or its constituent indicators, leading to 'observer bias' (Stubbs, King and Stuckler, 2014). Although coding bias may not be deliberate, it could still occur as a sub-conscious result of exposure to information about country economic performance. As a result, we would expect GE scores to have upward bias in countries with higher GDP per capita or GDP growth. Stubbs et al. showed that this form of bias can be partially counteracted by controlling for economic growth in the previous period. We therefore conducted a robustness test in which we control for GDP growth in the previous year. Appendix S1 provides additional detail and discussion of the GE index, alternative indicators, and associated measurement challenges.

Statistical analysis

To evaluate the relationships between tariff changes, state capacity, and government health expenditure we estimated a series of cross-national longitudinal multivariate ordinary least squares (OLS) models. Our models correct for a number of time-varying confounders of the association between tariffs and health expenditure as well as country-specific differences (i.e. country fixed-effects), as there may be several unmeasured characteristics which influence a country's tariff rate and public health expenditure. Our first set of models are as follows:

$$\text{Equation 1. } HXP_{it} = \beta_0 + \beta_1 T_{it} + \beta_2 X_{it} + \alpha_i + \Upsilon_t + \varepsilon_{it}$$

The outcome variable, HXP_{it}, is health spending (either public or private, per capita or % GDP) in country *i* in year *t*. T_{it} is the weighted average tariff rate. β_0 is the intercept and α_i in Equation 1 is a vector of country fixed-effects which account for time-invariant, unmeasurable characteristics which may influence a country's tariff rate and health expenditure. We also incorporate year fixed effects, Υ_t, to control for common external shocks affecting tariff policies and health spending across all countries.

X_{it} in Equation 1 is a vector of time-varying controls with coefficients in the vector β_2. We control for GDP per capita, converted into US dollars with adjustments for inflation and differences in purchasing-power, as economic development levels can influence a country's openness to trade and provide resources for government health spending (Sachs, 2001; Stuckler, Basu and McKee, 2011). We take the natural logarithm of this variable as the relationships between GDP per capita and our health spending measures are curvilinear, with a decreasing association between GDP per capita as countries get richer (Musgrove, Zeramdini and Carrin, 2002; Ke, Saksena and Holly, 2011). We also control for overseas development assistance

(ODA) as aid can be granted with the goal of increasing market access but it can also provide funds that the state can spend on health (Helble, Mann and Wilson, 2009; Dieleman, 2017). Alternatively, ODA can displace health spending from the government to the non-government sector (Dieleman and Hanlon, 2014). Again, we use a per capita estimate, and convert ODA into US dollars whilst adjusting for inflation and differences in purchasing-power.

In addition, we incorporate a control for the occurrence of war as there is a greater propensity for violent conflicts in closed economies (Mansfield and Pevehouse, 2000; Hegre, Oneal and Russett, 2010). This can inflict costly damages on public health and infrastructures, leading to greater expenditure in order to re-build health infrastructure, treat injuries, and remedy additional public health challenges associated with conflict (Ghobarah, Huth and Russett, 2003). In robustness checks we incorporate additional possible predictors and covariates (see Appendix S3). ε_{it} is the error term. Robust standard errors were clustered by country.

In a second set of models we evaluate whether the association between tariff changes and health expenditure varies according to a country's score on the GE index. We re-estimate our models as above with an additional *Tariff x GE score* interaction term to test whether the associations between tariffs and health-spending vary according to our proxy for state capacity (see Appendix S1). Finally, we evaluate whether changes to public health spending may be attributable to changes in tax revenue (see Appendix S2), and test the sensitivity of our results to our modelling assumptions and specification decisions. All models were estimated using R version 3.1.

3. Results

Regression results

Appendix Table S1 shows the descriptive statistics for the main variables in our analysis. Figure 1 plots the association between a country's tariff rate and public health expenditure per capita and as a share of GDP. Figure 1 shows that there is a moderate, negative association between a country's mean tariff rate and public health expenditure per capita (r = -0·33, p = 0·007) and as a share of GDP (r = -0·38, p=0·002). Similar relationships are observed in most years (Figure S1 and S2). Associations between the mean tariff rate and private health expenditure per capita (r = -0·19, p = 0·12; Figure S3, Panel A) and as a share of GDP (r = 0·12, p = 0·35; Figure S3, Panel B) were both weak and were not statistically significant.

[Figure 1 about here]

Table 1 shows that every 1% reduction in a country's mean tariff rate was associated, on average, with a $2·15 (95% CI: 0·22 to 4·07) increase in per capita public health spending after adjusting for potential confounders of this relationship. This association was significantly different from zero at the 5% threshold but not the 1% threshold, and the confidence interval was wide, indicating potential effect heterogeneity. Table 1 also shows that the mean tariff rate was not significantly associated with a change in private health expenditure ($\beta_{private}$ = -0.25; 95% CI: -1·28 to 1·06).

[Table 1 about here]

Next, we assessed variation in the association between tariff changes and per capita public health spending according to our proxy for relevant aspects of a country's 'state capacity', the WGI government effectiveness (GE) index. GE scores varied substantially between countries. The countries with the lowest mean GE index scores (GE_{mean}) during the study period were Comoros (GE_{mean} = 2.32), Central African Republic (GE_{mean} = 4.28), and Zimbabwe (GE_{mean} = 5.70), whilst Botswana (GE_{mean} = 69.4), Mauritius (GE_{mean} = 77.0) and Malaysia (GE_{mean} = 82.2) had this highest mean scores.

Panel A in Figure 2 shows the Average Marginal Effect of a 1% tariff reduction ('AME_{tariff}') on per capita public health spending according to a country's GE index score. There is significant variation. Every 1% reduction in tariffs was associated, on average, with a $6·3 (95% CI: 3·99 to

8·64) increase in per capita public health expenditure in countries with GE scores above the 30th percentile. However, among countries with GE scores below the 10th percentile, every 1% reduction in tariffs was associated with a decline in public health expenditure of approximately $3·7 per capita (95% CI: -6·42 to -1·04). For countries with GE scores between the 10th and 30th percentile, tariff declines were not significantly associated with changing public health expenditure (AME_{tariff} = -0·49, 95% CI: -2·55 to 1·58). Panel B in Figure 2 also shows that there was no significant association between tariff changes, the GE score, and private health expenditure per capita. These results were consistent when examining both public and private health expenditure as a share of GDP (Figure S4).

[Figure 2 about here]

Additional analyses

We examined whether the differential associations between tariffs and health expenditure according to a country's GE score were partially explained by corresponding differences in government tax revenues (see Appendix S2) (Mustillo, Lizardo and McVeigh, 2018). Every $1 increase in per capita government tax revenue was associated with a $0.1 (95% CI: 0.08 to 0.13) increase in per capita government spending on health after adjusting for possible covariates. Furthermore, every 1% reduction in tariffs was associated with a reduction in per capita tax revenue among countries with a government effectiveness score below the 10th percentile (AME_{tariff} = $-10·7; 95% CI: -20·3 to -0·95), no change in tax revenue among countries with scores in the 10th-30th percentile (AME_{tariff} = $-3·23; 95% CI: -10·6 to 4·15), and a rise in tax revenue among countries with scores above the 30th percentile (AME_{tariff} = $12·1; 95% CI: 5·08 to 19·21). We also conducted a Sobel test to determine whether there is a statistically significant effect of the Tariff x GE score variable on government health spending as mediated through tax revenues. The result of this test rejects the null hypothesis of no mediation (z = -2.47, p =

0.007), suggesting that tax revenues at least partially mediate the relationships between tariffs, GE scores, and government health spending.

Next, we evaluated the consistency of our results in alternative sample and model specifications. Figure 3 summarises the results and Appendix S3 provides a full description of each test. First, we estimated an additional model that seeks to address non-random tariff rate assignment by using a non-parametric Covariate Balancing Generalised Propensity Score (npCBGPS) weighting procedure (Figure 3, Model 1) (Fong, Hazlett and Imai, 2018). We also controlled for a range of government characteristics that may be correlated with the GE score: corruption, electoral accountability, and the strength of democracy (Figure 3; Models 2-5). We then adjusted for additional possible health expenditure predictors: demographic structure, urbanisation, and international political integration (Figure 3, Models 6-8). Trade openness can encourage aid and may mediate the associations in Table 1 and so bias the tariff coefficient (Richiardi, Bellocco and Zugna, 2013). In a subsequent test we therefore excluded official development assistance from the models (Figure 3, Model 9).

[Figure 3 about here]

We further evaluated whether our results were robust when using alternative tariff rate indicators (Figure 3, Models 10-11) and assessed whether our results were robust when lagging the explanatory variables by one year in order to correspond with the budget cycle (Figure 3, Model 12). We also conducted a robustness test in which we control for GDP growth in the previous year (Figure 3, Model 13) in order to adjust for possible 'observer bias' (Stubbs, King and Stuckler, 2014). Finally, we re-estimated our models excluding potentially influential cases, i.e. cases with a Cook's distance larger than 4/n (Figure 3, Model 14) (Snijders and Berkhof, 2008; Van der Meer, Te Grotenhuis and Pelzer, 2010).

Figure 3 shows the AME of a 1% tariff reduction on public health expenditure varied slightly in the tests described above, but the broad pattern of these results was consistent with the results from our original model. Associations examining government health expenditure as a share of GDP were slightly less robust (Figure S9). We also conducted additional tests to examine whether the association between tariff reductions and government health expenditure varied according to the size of the informal labour market, as this may restrict the ability of governments to tax labour (Auriol and Warlters, 2005; Lagomarsino *et al.*, 2012). We did not identify significant heterogeneity, although data limitations precluded robust assessment (Appendix S3).

In addition, we assessed whether the size of the association between reducing tariffs and public health spending varied according to the level at which the tariffs were set before the reduction, as reducing already low tariffs may not deliver large increases in growth (Dhingra *et al.*, 2016). Alternatively, the presence of low (or high) tariffs in a period before a tariff reduction may reflect the lack (or presence) of difficulties in levying domestic taxes, whilst already low tariffs may indicate an ability to tax domestic sources and hence correspond to larger increases in government health spending. Indeed, we find that the association between a 1% tariff reduction and public health spending was larger where tariffs were higher in the previous period (Appendix S3).

4. Discussion

In this paper we analysed whether tariff reductions could affect the ability of states to spend on health-care and services and so contribute to cross-national spending disparities among LMICs. Our analysis has shown that tariff reductions were, on average, weakly associated with increased public health expenditure in 65 LMICs, 1996–2015. However, this association varied substantially according to our proxy for aspects of a country's 'state capacity' that are important for sustaining tax revenues following tariff reforms: a country's score on the GE index. In countries with GE scores below the 10th percentile – indicating weak state capacities – we found that tariff declines were associated with reductions in public health expenditure. For countries with GE scores above the 30th percentile, we found that tariff declines were associated with increased public health expenditure, and for countries with GE scores between the 10th and 30th percentile there was no statistically identifiable relationship. These associations appear mediated by changes in tax revenues, as tariff reductions were associated with a rise or fall in tax revenues in countries with high or low GE scores respectively.

Previous studies examining the role of national economic and political factors in determining public health spending in LMICs have shown that diverse characteristics impact expenditure and contribute to cross-national disparities, including economic development, development aid, and fiscal policy (Ooms *et al.*, 2010; Fan and Savedoff, 2014; Reeves *et al.*, 2015). Our exploratory analysis complements and expand on prior research by demonstrating that tariff reductions – and their interaction with state capacities – may have a critical yet under-appreciated impact on public health spending in LMICs.

Before discussing the broader implications of our results, there are several important limitations and possible extensions to note. First, tariffs are not the only determinant of health spending as many other factors also play a role, such as government's political ideology or electoral incentives (Reich *et al.*, 2016). Future studies should therefore assess how a range of factors affect whether tariff reductions ultimately lead to a change in public health expenditure. Second, additional research is necessary to investigate precisely how tariff reductions and state capacities are linked to changes in public health expenditure. Our results suggest that countries which lack important state capacities are unable to sustain and grow their tax revenues following tariff reductions, leading to budgetary pressures that constrain public health spending. This is likely attributable to difficulties in raising revenue from non-trade sources in order to compensate for lost trade tax revenue, as the specific capacities we proxy for using the GE index are fundamental to levying and collecting non-trade taxes (Besley and Persson, 2009). Such challenges may be compounded by difficulties in leveraging the economic benefits of trade liberalisation in weak states (Billmeier and Nannicini, 2013). Future studies should investigate precisely which aspects of state capacity are important and whether difficulties in levying non-trade taxes or changing GDP per capita have a greater influence.

Third, there are several limitations to our data. One limitation pertains to the difficulties in accurately capturing aspects of state capacity that are central to effective tax administration. Although these characteristics are difficult to measure, our chosen proxy is generally regarded as one of the most widely applicable and carefully constructed governance indicators (Arndt, 2006). In addition, the relationship between public health spending and access to health-care and services varies widely within nearly all countries on the basis of socio-economic characteristics, including income, racial/ethnic group, immigrant status, and education (Marmot *et al.*, 2008; Kruk, 2012). Furthermore, our measure of per capita health expenditure does not capture differences in health-care quality or changing health outcomes. Future research should investigate within-country disparities and investigate a range of changing health indicators.

An additional important limitation concerns our ability to confidently detect a causal effect. Our models adjust for time-invariant heterogeneity and time-varying covariates, and our estimates provide evidence of a possible causal connection. This is bolstered by other studies showing the plausibility of the underlying pathways (Aizenman and Jinjarak, 2009; Cagé and Gadenne, 2018). Our findings were also consistent in an extensive set of robustness checks. Furthermore, we use among the best available statistical methods given that randomized interventions are infeasible for assessing country-level effects of trade reforms and valid instruments of tariff rates are notoriously difficult to identify (Baier and Bergstrand, 2009; Billmeier and Nannicini, 2013). However, future quasi-experimental studies should further investigate our findings and address potential time-varying confounding.

5. Conclusions

Notwithstanding these limitations, our results suggest that tariff reductions can facilitate increased public health spending in LMICs where state capacities are at least moderately strong, whereas tariff reductions correspond to a decline in public health expenditure in LMICs without these capacities. Tariff changes and state capacities may therefore contribute to cross-national differences in public health expenditure in LMICs. These factors may even explain why some LMICs have been unable to increase health spending in recent years whilst others have achieved substantial progress (WHO, 2018).

Thus, our findings have critical implications for research and policy concerning public health-expenditure in LMICs. First, there are substantial disparities in the amount that governments spend on health-care and services, and increased public health expenditure is necessary in many LMICs in order to expand public health systems, prevent multiple diseases, reduce premature mortality, and alleviate global health inequalities and inequities (WHO, 2018). The erosion of public health expenditure following tariff reductions in weak states may undermine the ability of governments to address these challenges, whilst tariff reductions may serve as a catalyst towards health expenditure expansion in states with at least moderately strong state capacities.

Our study therefore suggests that health policy-makers and scholars interested in how LMICs can expand public health expenditure and health-systems should pay attention to how these efforts may by influenced by the interaction between tariff changes and state capacities. These relationships have hitherto received little attention among researchers and policy-makers.

However, ensuring adequate state capacities are in place may help to ensure tariff changes serve to advance progress towards increasing public health spending – rather than undermine it.

Second, many developed countries and international organizations such as the United Nations, World Bank, and International Monetary Fund (IMF) regularly encourage countries to lower trade tariffs in order to reduce poverty, boost incomes, and stimulate economic growth (Edwards, 1997; Higgins and Prowse, 2010; Antràs and Miquel, 2011; UN, 2015; European Commission, 2016; UK Parliament, 2018; USTDA, 2018; World Trade Organization, 2018). These policies can indeed yield important health benefits, especially where they translate into widespread economic gains, increase access to medicines, and strengthen health regulations (Hanefeld *et al.*, 2017; Barlow, 2018). Yet, the policy prescription to liberalize tariffs – and the academic literature which informs it – typically overlooks potential health harms whilst assuming that governments have the capacity to raise revenue from sources other than trade taxes, and always reap the economic advantages of trade reforms (Queralt, 2017). Our study suggests that a failure to recognise potential health harms and where these assumptions do not hold may undermine health-system expansion in ways that could be avoided. Future research and policy advice concerning tariff changes should pay greater attention to these potential disadvantages and whether the aforementioned assumptions are tenable in specific country-contexts, and should focus on developing state capacities where they are insufficient.

Third, there is increasing recognition that efforts to liberalise trade can serve as a lever for achieving certain global health goals, for some individuals, and in some contexts, but there are also important caveats, trade-offs, and unintended harms (Hanefeld *et al.*, 2017; Barlow, 2018; Barlow *et al.*, 2018). Here, we identified a contingent relationship between tariff liberalization and public health expenditure, which is an important determinant of myriad global health goals (Evans and Etienne, 2010; UN, 2015; Mahler, 2016; Obrizan and Wehby, 2018). By showing that the association between tariff reductions and public health expenditure is contingent on aspects of a country's state capacity, our study suggests that developing state capacities may be essential to whether countries benefit from a positive interaction between tariff policies and other health determinants and outcomes.

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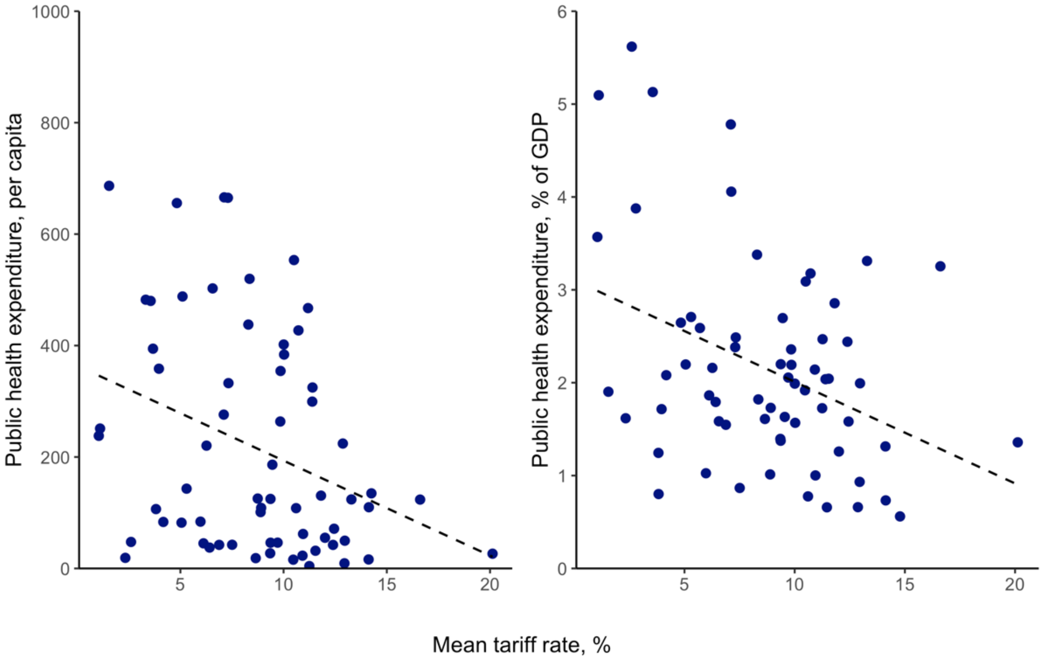
7. Figures

Figure 1. Association between country mean tariff rate and public health expenditure per capita and as percentage of GDP, 1996-2016



Notes: Figure shows averages for each country in the full study period. See Figure S1 for association in each year.

Figure 2. Average marginal effect of 1% tariff reduction on per capita health expenditure

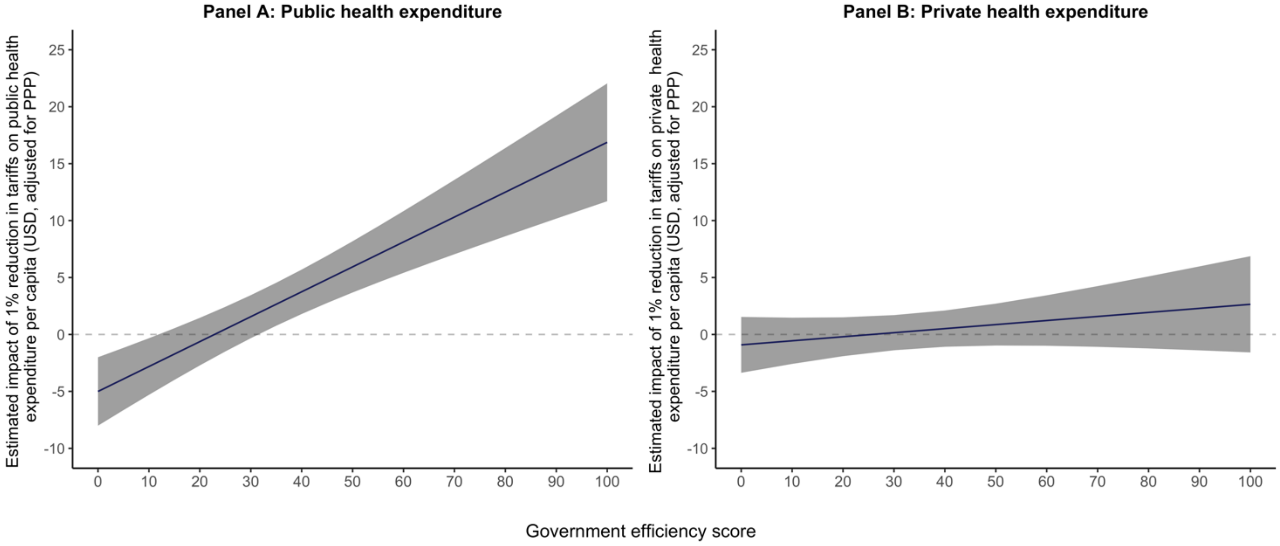
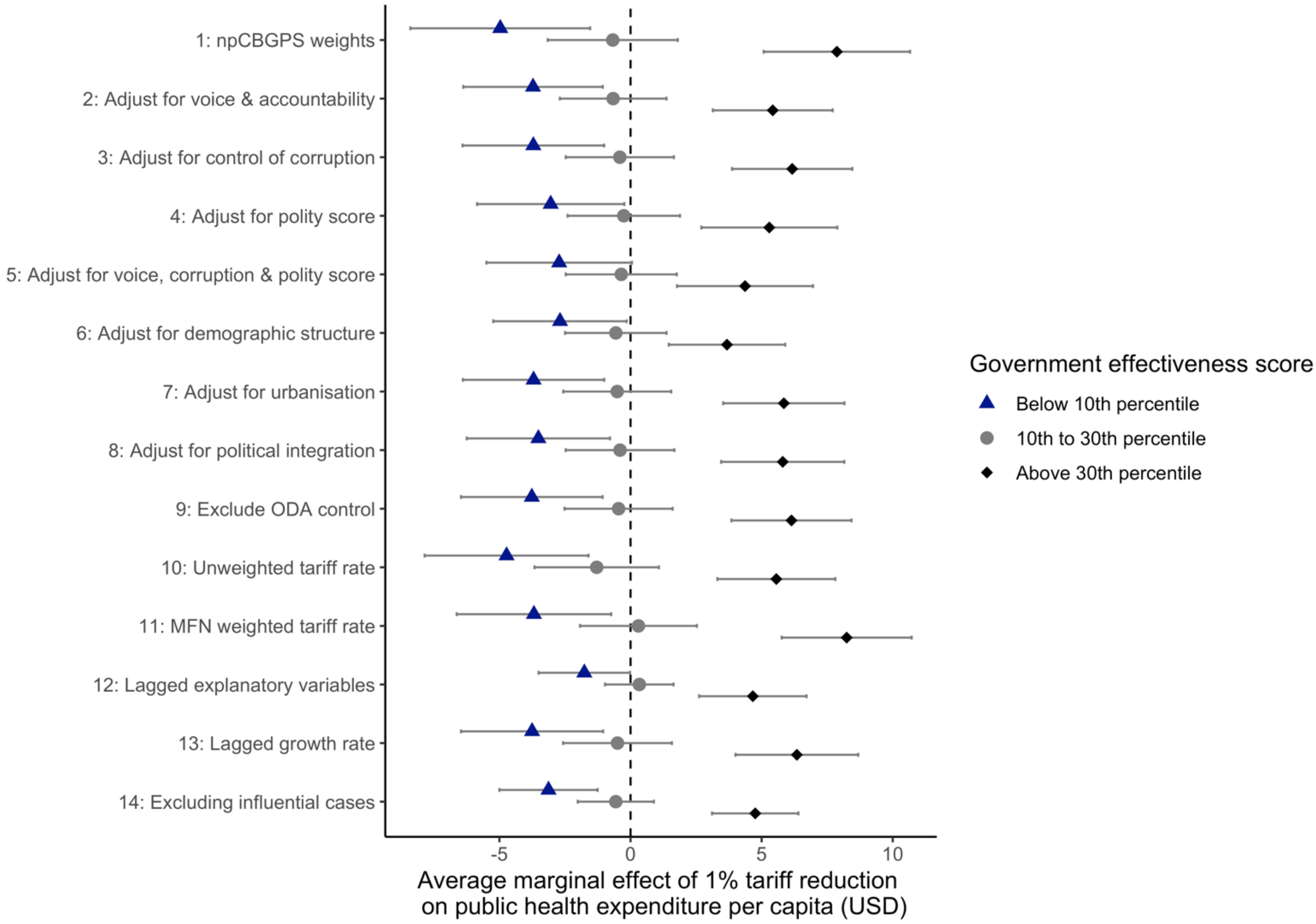


Figure 3. Alternative specifications



Notes: Table S3 lists the data sources and measurement of variables included in robustness checks. Appendix S3 describes each test in detail. Model 1 is a weighted fixed-effects regression model which includes the same controls as the main model and also re-weights country observations using non-parametric Covariate Balancing Generalised Propensity Score weight. Mean absolute Pearson correlation of tariff covariates and predictions reduces from 0·20 to 0·0002 when using npCBGPS weights; see Figure S6 for visualisation of covariate balance in npCBGPS specifications. Models 2-9 include/exclude the listed variables as controls in the model. Model 10 uses the unweighted mean tariff as predictor rate rather than the import-weighted average tariff rate and Model 11 uses the MFN, trade-weighted tariff rate. Model 12 lags all explanatory variables by one year to account for budget cycles. Model 13 adjusts for the growth rate in the previous year to reduce 'observer bias'. Model 14 excludes influential cases with Cook's D larger than 4/n.

8. Tables

Table 1. Tariff reductions and per capita spending on health-care and services in low-income and middle-income countries, 1996–2015

	Government health expenditure		**Private health expenditure**	
1% reduction in tariffs	2·49** (0·51 to 4·46)	2·15** (0·22 to 4·07)	0·28 (-1·00 to 1·57)	0.25 (-1·28 to 1·06)
$100 increase in GDP per capita		1·28*** (0·59 to 1·97)		0·59** (0·12 to 1·06)
$10 increase in ODA per capita		-0·02 (-0·12 to 0·08)		-0·07* (-0·16 to 0·01)
At war[a]		-5.00 (-32·65 to 22·65)		-34·64** (-88·00 to 18.71)
Country-years	632	632	632	632
R^2	0·92	0·93	0·91	0·92

Notes: GDP: Gross Domestic Product. ODA: Official Development Assistance. a: Dichotomous variable coded as 1 in a country if there was an armed conflict resulting in 1,000 or more deaths in that year, 0 otherwise. Models control for country and year fixed effects. P-values: * denotes significance at 10% level; ** denotes significance at 5% level; *** denotes significance at 1% level. See Table S1 for list of data sources and variable measurement and Table S4 for list of countries included in the analysis and number of years of data for each country.