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Working paper

The impact of government revenue on child health and the amplification potential of good governance

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GRADE
Government Revenue and Development Estimation

Abstract

Children who do not have access to the critical determinants of health are more likely to die, and the under-five mortality rate is ten times higher in low-income countries than in high-income countries, mainly because of poor access to health determinants. This study aimed to model the relationship between government revenue per capita, quality of governance and the coverage of the determinants of child health; water, sanitation, healthcare and education. We used government revenue because the policies and practices of international and multinational organisations – including corporations and banks – are more likely to influence revenue rather than government spending in countries in which they are engaged. Also, it reflects a government's ability to spend across all sectors rather than just health or education spending.

We employed an unbalanced non-linear panel data and annual data on 217 countries between 1960-2000. All determinants of health examined were expressed as a percentage, and six dimensions of quality of governance were included in the model. A linear relationship between revenue and the determinants of health would not be appropriate; therefore, we employ a logistic function. A standard panel logistic function would impose the same shape 'S' curve on all countries, which is not appropriate. Therefore, we augment the parameters of the logistic function with measures of the quality of governance in each country, which allows each country to have a different 'S' shape as the quality of its governance varies.

Our study found that increased government revenue is associated with an increase in the coverage of the determinants of health. An improvement in the quality of governance could amplify this effect. This modelling and its accompanying visualisations can predict the potential of an increase in government revenue in an individual country in terms of the rise in the number of children who can access their determinants of health.

1. Introduction

The under-five mortality rate (U5M) indicates the number of deaths before five years / 1000 live births. There are many factors which contribute to health and children are more likely to survive when they have access to the critical determinants of health (DOH): water, sanitation, education and healthcare (Kuruvilla et al., 2014). Low coverage of the DOH and high levels of U5M remains a significant concern in most low-income countries (LICs) and lower-middle-income countries (LMICs). For example, in 2018, the average U5M in LICs was 67 / 1000 live births which are ten times higher than the average of 6 / 1000 in high-income countries (HICs), and far from the sustainable development goal (SDG) 3 target, of less than 25 / 1000 live births (The United Nations, 2018). Many living in LICs and LMICs do not access their DOH (which are also SDGs 3,4 and 6), see figure 1.

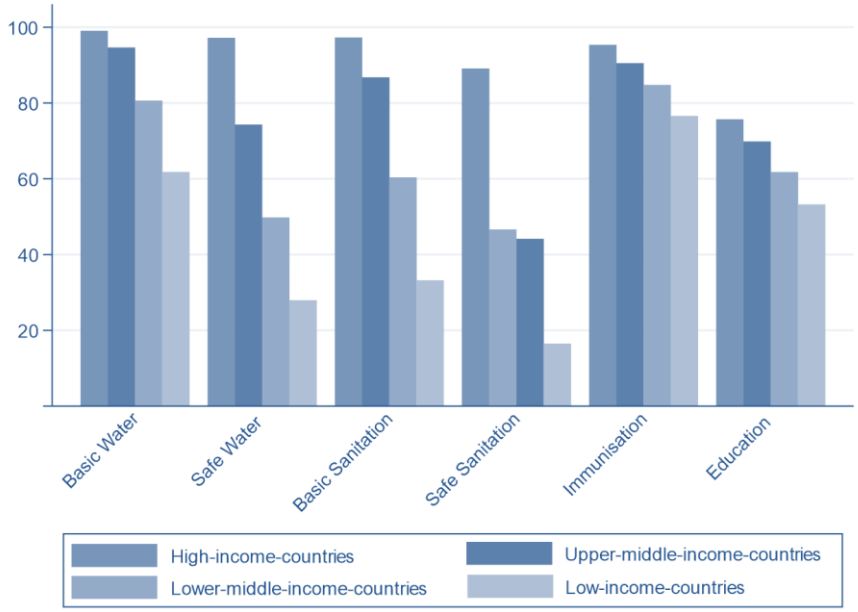

Figure 1: Average coverage of the determinants of health in countries at different levels of income in 2015 (see the appendix for definitions)

Many researchers have empirically shown that there is an inverse relationship between income at the national level, Gross Domestic Product per capita (GDPpc) and child mortality (Filmer & Pritchett, 1999; Bernadette O'Hare et al., 2013). However, income cannot change mortality unless used to purchase goods which contribute to survival, and the pathway between GDPpc and government spending acts via Government Revenue per capita (GRpc), government spending and the DOH (Reeves et al., 2015). In pursuit of an understanding of the dynamics, and consequently, the interventions which could reduce children's chances of dying, Hall et al. recently studied the relationship between GRpc and U5M (Hall, Illian, et al., 2020). They explored the GRpc-U5M relationship, rather than government spending-U5M relationship, because outside entities such as multinational corporations may impact the GRpc but are unlikely to affect allocation decisions by governments. Also, GRpc, rather than health spending, reflects the ability of governments to spend across all sectors, many of which will influence health. They found the GRpc-U5M elasticity (sensitivity of U5M to changes in GRpc) to be highly non-linear and that increasing GRpc has a much higher impact on U5M in LICs and LMICs than in upper-middle-income countries (UMICs) and HICs. They proposed two possible explanations for this. First, revenue in LICs and LMICs is low, so any additional income has a substantial impact. Second, impactful interventions to reduce mortality rates in LICs and LMICs are primarily public health measures such as ensuring access to the DOH, which are less costly than advanced hospital care.

Governance and child mortality

A further potential explanatory factor is the influence of the quality of governance (QoG). The importance of QoG is plausible, as efficient public services providing the DOH can help households to care for children and arguably, their provision requires government intervention, especially when levels of poverty are high (Boachie et al., 2020).

There are several different composite measures of QoG. The Worldwide Governance Indicators (WGI) compiled by the World Bank, cover six dimensions of governance (corruption, political stability, regulatory quality, the rule of law, government effectiveness and voice and accountability), for 212 countries. Compilation began in 1996 with information from a wide range of sources, to try and reflect perceptions of the QoG in a country (Kaufmann et al., 2010). We discuss the criticisms of the WGI under limitations. Another measure of QoG, which also uses a compilation of survey data, is called the Corruption Perceptions Index, carried out by Transparency International, but this compilation only gauges corruption (Rohwer, 2009).

To test the hypothesis that QoG influences outcomes, researchers have employed both micro-level and national data to analyse the differences between countries (Tolmie, 2007). Cross-sectional studies have confirmed an association between QoG and child survival. A study using cross-sectional data for 46 African countries and multiple regression, found QoG to be strongly associated with U5M (Olafsdottir et al., 2011). A further cross-sectional study of 120 countries finds that QoG is associated with lower levels of U5M and that health spending, as a percentage of GDP, is more effective, if QoG is good and indeed can even compensate for low levels of spending (Holmberg & Rothstein, 2011). Richards and Vining study 69 LICs and LMICs using cross-sectional data between 2000-2003 and 2010-2013 and find that effective governance of high-level institutions is a significant determinant of U5M (Richards & Vining, 2016).

Others have set out to test the hypothesis that good QoG reduces U5M. Gupta et al. used panel data (data across countries over a number of years) for 128 countries, to study the impact of corruption on health and educational outcomes while controlling for other known determinants, using multiple regression and instrumental variables (IV) to control for endogeneity (where the explanatory variable is correlated with the error term) and reverse causation. They split the countries into high and low corruption cohorts. They found that the income-mortality elasticity in low corruption countries is twice that in the high corruption group and concluded that corruption adversely affects the provision of public services (S. Gupta et al., 2000). A study of 150 countries for the years 1995-2012, used panel data, ordinary least squares (OLS) and two-stage least squares (2SLS), found that as the perception of corruption increases so does neonatal, infant and U5M (Li et al., 2018). Lin et al. studied the impact of QoG on U5M in 149 countries between 1996-2010. They used factor analysis and found that as QoG increases, U5M decreases, in an inversely linear way, when controlling for economic growth and access to the DOH (Lin et al., 2014).

We see above that there is a causative relationship between QoG and U5M and between GRpc and U5M. This work aims to shed more light on the relationship between GRpc, QoG and access to the DOH, which are critical to reducing U5M (Bishai et al., 2016). We are interested in this step because this will allow realistic predictions of the impact of even small increases in GRpc, which may have minimal effect on mortality but a large effect on the access to the DOH for many. We hope this model will provide realistic estimations of the potential in terms of children's access to the DOH for increases in GRpc at the level of an individual country.

First, we reviewed the current literature on the relationship between GDPpc and U5M and the steps in between, including GRpc, government spending, QoG, and access to the DOH to understand the pathways by which GRpc and QoG may impact child mortality. Based on the

literature, we then suggest a conceptual framework and develop our modelling strategy. We then present our results, discuss these and draw conclusions.

2. Review of the literature and a conceptual framework

The relationship between GDPpc and child mortality has been systematically reviewed, and we briefly summarise it. For the literature review on QoG, each of the following search terms was used "quality of governance, public spending and mortality/education/health" and "government/tax revenue and child mortality/survival/health". It was limited to the English language and limited to the years 2000-2020. We used Google Scholar and Web of Science and included papers referenced by key studies.

Gross Domestic Product per capita and child mortality

There is a consensus in the literature that per capita income is a robust determinant of child mortality. FIlmer and Pritchett used cross-national data for >100 developing countries and multivariable regression to study the impact of public health spending on U5M. They found that one of the most important factors is the GDPpc of the country and empirically show that the GDPpc–U5M elasticity is -0.6 and if GDPpc in a country increases by 1%, the U5M decreases by 0.6% and thus a critical determinant of U5M. Many other studies have confirmed the elasticity between GDPpc and U5M: a meta-analysis of 24 empirical studies, found that the pooled elasticity between GDPpc and U5M was -0.45 (French, 2016a; B O'Hare et al., 2013).

Government Revenue and child mortality

Some have described state strength as being made up of two components, state size, defined as tax/GDP and state strength which is the efficiency and organisational ability of a country (Moon & Dixon, 1985). To identify the most important of these two components on U5M, Dawson carried out four cross-sectional time series analysis using fixed-effect regression for the following years, 1985, 1990, 1995 and 2000 on 62 LICs and LMICs and lagged the independent variables by five years. The independent variables included tax/GDP (log), GDP (log), the rule of law, democracy, trade/GDP, foreign direct investment/GDP and the GINI coefficient (a measure of inequality). They found that if the rule of law increases from the lowest to the highest level possible, there would be a decrease in U5M of 52/1000. They concluded that tax/GDP does not have a statistically significant effect on child mortality independent of the rule of law and a reduction in mortality will occur as a result of improvement in governance rather than an increase in revenue. Reeves et al. used cross-national longitudinal fixed effect regression on 89 LICs, LMICs and UMICs. They showed empirically that an increase in tax revenue of $100 is associated with a $10 increase in government health spending and an increase in skilled birth attendance by 7%. They did not find a statistical association with tax revenue and U5M. As mentioned in the introduction, Hall et al. found the relationship between GRpc and U5M to be significant and highly non-linear and to vary between countries, which may explain why studies which pooled results did not find a statistically significant relationship (Hall, Illian, et al., 2020).

When governments have more income, and the primary source is tax revenue, they spend more on public services, and when the ratio of non-resource taxes to GDP increases, expenditure on all sectors, except defence, goes up (Long & Miller, 2017; Reeves et al., 2015; Tamarappoo et al., 2016). Increased government spending improves access to the DOH, health outcomes, and decrease mortality (Bokhari et al., 2007; S. Gupta et al., 2002; Haile & Niño-Zarazúa, 2017).

Public spending and outcomes when the quality of governance is not entered into the model

Whether or not public spending has an impact on access to healthcare and education is an issue of considerable debate in the literature, with studies reporting opposing findings. Below we review those studies which did not control for QoG, first those that found that public spending had no impact and then those which found that public spending has a positive effect on outcomes.

In 1996, Musgrove reviewed the literature on health spending and found little evidence to support any relationship between public expenditure on health and health outcomes in LICs. They concluded that factors outside the health sector were more critical and only when countries have achieved most of the potential gains from increased coverage of the DOH (water, sanitation and education), can the gains from spending on healthcare be realised (Musgrove, 1996). FIlmer and Pritchett used panel data for >100 developing countries and find that the cross-national differences in health spending explain less than 0.15% of the differences in U5M between countries. Importantly, they found that it would require an increase in public health spending in the range of $50-100,000 to avert the death of one child (Filmer and Pritchett, 1999). This influential paper is often cited to support the argument that health spending has little or no impact, but the study finds that it does have an effect – but the costs are high. More recently, French empirically showed that the 41% reduction in child mortality between 1990-2010 in 129 developing countries to be entirely due to economic growth and unrelated to public health spending or overseas development aid (French, 2016b).

On the other hand, other researchers, who did not control for QoG, found that public spending can produce positive outcomes. Gupta et al. studied a sample of 50 developing and emerging economies and empirically show that a 5% GDP increase in outlays on education increases secondary school enrolment by 1%, and a 1% GDP increase in public health spending reduces U5M by 3/1000 live births (S. Gupta et al., 2002). This finding is similar to Novignon et al., who empirically showed that a 1% GDP increase in total health spending reduces the infant mortality rate by 3/1000 live births (Novignon et al., 2012). A study of 47 African countries, 1999-2004, found that if per capita public health spending increases by $10, U5M would be reduced by 2/1000 live births and Bokhari studied 127 countries and showed that a $10 increase in per capita public health spending would reduce U5M, on average by 3/1000 live births (Anyanwu & Erhijakpor, 2009; Bokhari et al., 2007). In a study of 44 sub-Saharan African countries between 1995-2010, Boachie et al. empirically show that if public health spending is increased by 10%, infant mortality will decrease by 0.73% (Boachie et al., 2020).

Governance

There are several pathways through which QoG mediates the impact of income on children; these include the effects on economic growth, the impact on GRpc and revenue generation, allocation and efficiency of use.

i. QoG impacts U5M via the impact on economic growth, as countries with good governance attract domestic and foreign investment. A meta-analysis of 115 studies found that an improvement of one standard deviation in the perception of corruption is associated with a 0.59% increase in GDPpc (Ugur & Dasgupta, 2011). Studies done subsequently have also empirically demonstrated that efficient government spending and lower levels of corruption leads to higher economic growth (Chan et al., 2017; Factor & Kang, 2015).

ii. Losses from GR as a result of poor QoG include theft from the public purse, which directly reduces the GR available for public services, but even more importantly are the broader ramifications. For LICs which are heavily dependent on aid, donor responses to disclosures of corruption can include sudden changes in policies. For example, in Malawi in 2013, exposure of the theft of public funds resulted in the diversion of donor funding away from direct budget support of the government and into project aid which resulted in duplication and inefficiency (Adhikari et al., 2019). Debt is a drain on GR and is increased by corruption. An empirical study of 126 countries, between 1996-2012, showed that corruption increases public debt, while Ndikumana and Boyce studied 33 African countries and found that 60% of borrowed funds flowed out of the borrowing country in the form of capital flight almost immediately (Cooray et al., 2017; Ndikumana & Boyce, 2011).

iii. QoG may impact survival via GR generation, allocation, and effectiveness.

iiia. Revenue generation

Using survey data gathered by Afro barometer in 33 African countries, Jahnke showed that tax compliance is inversely related to the perception of corruption. Empirical work supports this by showing that the tax/GDP ratio is inversely correlated with the perceived level of corruption in a country (Arif & Rawat, 2018; Besley & Persson, 2014; Cooray et al., 2017; A. Sen Gupta, 2007; Jahnke, 2017). Cooray et al. empirically showed that governments which are responsive to their citizens are more stable, less likely to be toppled and therefore able to focus public spending on productive sectors that generate higher revenues (Cooray et al., 2017). Governments may offer tax incentives to attract foreign investment. Still, they come at a cost to GR and empirical evidence shows that when levels of corruption are higher, tax incentives are higher (Zelekha & Sharabi, 2012). This cost to GR is important because several researchers have demonstrated that the benefits of incentives are questionable and do not attract investments (Klemm & Parys, 2009; Stausholm, 2017).

iiib. Revenue allocation

Several reviews of the literature conclude that corruption biases allocation decisions away from education and health (Dreher & Herzfeld, 2005; Ugur & Dasgupta, 2011). Poor governance leads to overspending and diversion of public funds into sectors with opportunities for bribes over sectors which prioritises public interest. A study of 64 countries, 1996-2001, empirically showed that corruption skews public spending away from social expenditure (Delavallade, 2006), while a reduction in corruption leads to significantly increased allocations for education (Mauro, 1998;

Nyamongo & Schoeman, 2010). Large informal economies are associated with higher levels of corruption, and upstream corruption drives corrupt practices downstream at the frontline of public services which results in inefficiency (Cooray et al., 2017; The World Bank., 2010).

iiic. The influence of governance on the effectiveness of public spending

Rajkumar and Swaroop studied the interaction between public spending and QoG and find that 1% increase of GDP spent on public health reduced U5M by 0.32% in countries with good governance, 0.2% in countries with average QoG and has no effect in poorly governed countries (Rajkumar and Swaroop, 2008). Makuta and O'Hare studied countries in sub-Saharan Africa and found that a 1% increase of GDP spent on public health reduced U5M by 0.17-19% in well-governed countries and 0.09% in poorly governed countries (Makuta and O'Hare, 2015). Farag et al. studied 133 LICs and LMICs for the years 1995, 2000, 2005 and 2006 and found the government health spending-U5M elasticity to be -0.18 in countries in the highest performing QoG quintile and -0.07 for countries in the lowest quartile (Farag et al., 2013). Similarly, other researchers confirm the importance of QoG for efficient public spending (Baldacci et al., 2008; Çevik & Okan Taşar, 2013; Dhrifi, 2020; Haile & Niño-Zarazúa, 2017; Hanf et al., 2013; Hu & Mendoza, 2013; Murshed & Ahmed, 2018; Nketiah-Amponsah, 2019)

A conceptual framework for the pathway between gross domestic product per capita, government revenue per capita, quality of governance and the determinants of health

The literature indicates that improved QoG increases GDPpc, GRpc and a governments ability to allocate and use revenue effectively. Large amounts of public spending are required to reduce U5M when QoG is poor or not included in the model. Bishai et al. studied the reduction in U5M over 20 years in 146 LICs and LMICs and found that growth in GDP accounted for 20% of falls in U5M, and the remainder was due to increased provision of the DOH. They found, on average half of the mortality reductions were due to improvements in the health sector and a half due to increased coverage of the DOH in other sectors (Bishai et al., 2016). Based on the literature, we have developed a conceptual framework to map the pathway between GDPpc and U5M (channel I) and acting via GRpc, government spending on public services and household members' access to the DOH and U5M (channel II), see figure 2. The GRpc-U5M relationship has already been modelled at the individual country level and found to vary between countries, which may explain why studies which pooled results did not find a statistically significant relationship (Hall, Illian, et al., 2020). Here we are interested in the step between GRpc and the DOH, and the interaction with QoG at the individual country level. A model of this step will permit prediction of the impact of small increases in GRpc, which may have minimal effect on mortality but an enormous impact on the access to the DOH within a given country.

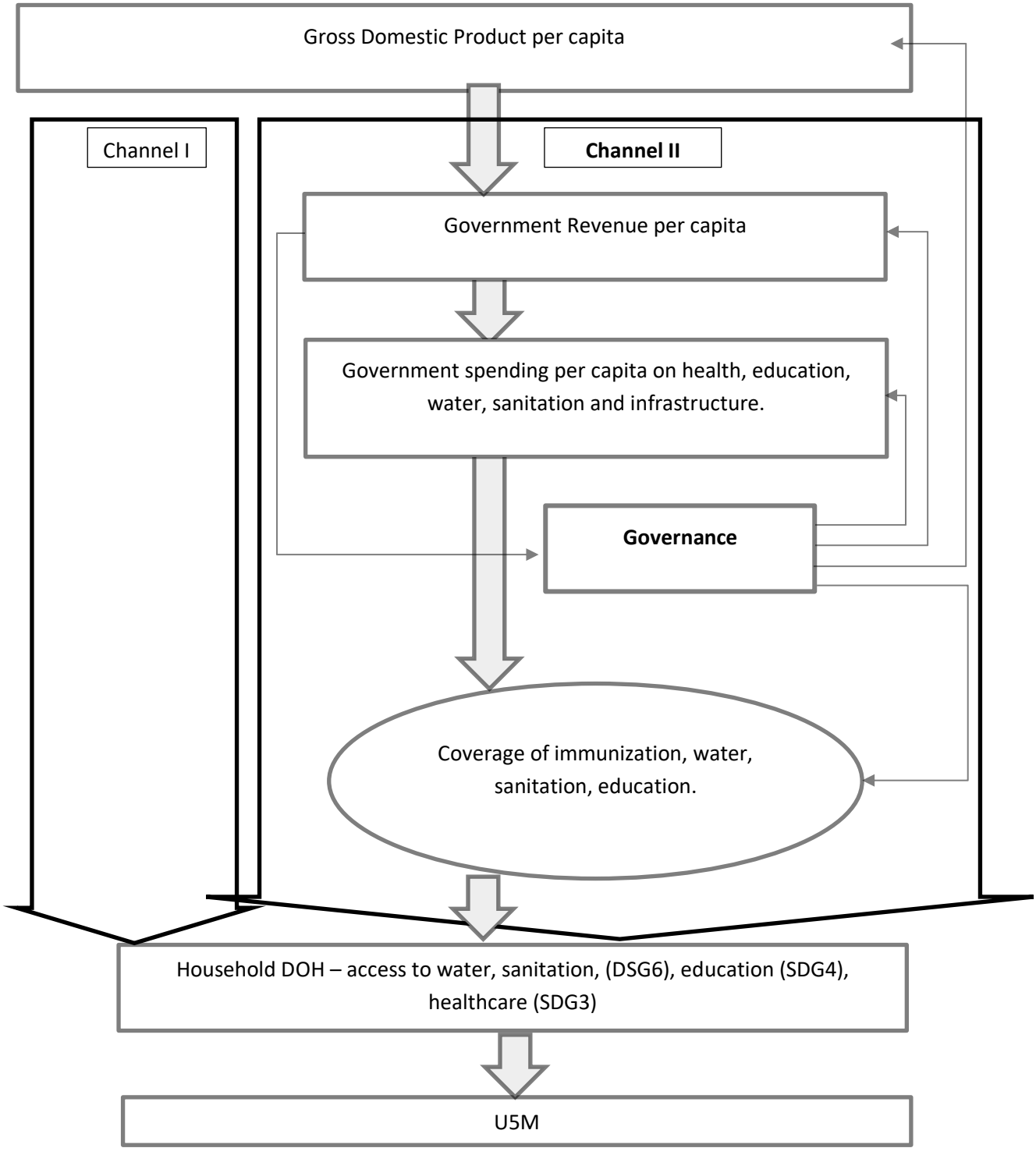

Figure 2 A conceptual framework for the pathway between Gross Domestic Product per capita, government revenue per capita, quality of governance, the Determinants of Health and under-five mortality.

3. The Methods

We use GRpc as an independent variable (rather than say, total health spending) for two reasons.

1. A better understanding of the relationship between GRpc and the DOHs is useful because the policies and practices of governments, international and multinational organisations, including corporations and banks, are much more likely to influence GR, than government spending. For example, the facilitation of capital flight which results in a large public debt or tax avoidance by multinational corporations. In contrast, international actors, except for the international monetary fund and donors in highly aid-dependent countries, are less likely to influence government spending (B. A.-M. O'Hare et al., 2018). An appreciation of the scale of the impact on children could contribute to policymaking, advocacy and economic and social governance decisions.
2. GRpc reflects the ability of governments to spend across all sectors. Many studies have concentrated on just one part of social spending, for example, spending on health, but we know that sectors outside the health sector account for half of the reduction in U5M in LICs and LMICs. Also, government spending on, for example, health, is a fraction (<10%) of total government spending in LICs. For example, spending on education raises maternal literacy, which is known to reduce child mortality while spending on infrastructure, say roads, ensures easy access to health facilities (Bishai et al., 2016; Gakidou et al., 2010).

Data

For the DOH, we used the 2020 World Development Indicators (WDI) for 217 countries, see the full definitions in the appendix (The World Bank., 2020). For GRpc, revenue excluding grants as a percentage of GDP was multiplied by the GDPpc in constant 2010 US dollars (USD) from the WDI. We employ the WGI, as these were the measures most frequently used by other researchers. The six dimensions of governance are Voice and Accountability; Political Stability and Absence of Violence/Terrorism; Government Effectiveness; Regulatory Quality; Rule of Law; and Control of Corruption; all measured on a scale of -2.5 to +2.5 (Kaufmann et al., 2010). They are described in full in the appendix.

The modelling strategy

We aimed to model the relationship between GRpc and the six DOH individually while controlling for each dimension of QoG. The DOH are the coverage of basic water facilities (basic water), safe water facilities (safe water), basic sanitation (basic sanitation), safe sanitation (safe sanitation), schooling (schooling) and the immunisation rates (immunisation). Water, sanitation and immunisation are recorded as a percentage ranging from 0 to 100. The education data used is the school life expectancy (SLE), both primary and secondary for both sexes and is the number of years of education a child of school entrance age can expect to receive. The maximum SLE is just under 17 years, and we express the data as a percentage of 17, which gives us a variable between 0 and 100. Like others, we did not add any controls to the models because we want to capture the total effect of GRpc and QoG and most variables used in the

literature are influenced by GRpc and QoG so there would be problems of collinearity (Biggs et al., 2010).

A standard linear model or a log-log model with constant elasticities would be inappropriate. Such a model would suggest achieving rates above 100% for a sufficiently high GRpc which is unacceptable. It is also probably true that at extremely low levels of income, an increase in GRpc would have a negligible effect. What we need is a model with a broadly defined 'S' shape which starts with minimal effects for very low levels of GRpc and then has a period of rapid growth followed by a falling off as saturation is reached. Such a relationship is described by a broad family of functional forms called sigmoids. Within this family, the most widely used function is the logistic function first used by Verhulst to describe population growth. Initially, the population is stable with no real change. As development starts, the population begins to grow increasingly rapidly, but then growth slows as the saturation point is reached, and eventually, the population stabilises. This approach has found applications in many areas including ecology, medicine, chemistry, physics, linguistics, agriculture and economics. The basic form of the logistic function is.

$$DOH_i = M / (1 + e^{-\alpha(x-\beta)}) \tag{1}$$

Where x is the independent variable, GRpc in our case and the dependent variable is each of the six DOH; M is the maximum of the curve and $\alpha \; and \; \beta$ controls the steepness and shape of the curve.

The initial approach was to fit an unbalanced panel version of this logistic curve for our six DOH variables for all the countries in our data set. This model worked reasonably well, but on examining the fit for individual countries, we found that the model systematically produced overestimates for LICs and LMICs. This finding suggests that the pooling assumption – whereby the same curve can explain every country - does not hold in the data. At this point, we had several options to consider. A standard approach within a panel data context would be to add fixed effects to the model. But introducing fixed effects to the model would violate the bounds of the logistic function because, if a country were to have a positive fixed effect and then GRpc grew to the maximum of the curve, the total would exceed 100%. Another possibility would be to add further exogenous variables to the model in a linear way. But again, this could involve violating the bounds of the variables. We, therefore, decided to adapt the basic logistic model by adding a set of exogenous variables to the function itself in the following way

$$DOH_i = M / (1 + e^{-((\alpha + \chi w)(x - (\beta + \delta w)))}) \tag{2}$$

where w is a kx1 vector of exogenous variables, in our case, the indicators for QoG and $\chi \; and \; \delta$ are 1xk vectors of parameters. This allows the shape of the logistic curve to vary for each country depending on the w vector.

We chose to focus on the six dimensions of QoG from the WGI, control of corruption, government effectiveness, political stability, regulatory quality, the rule of law and voice and accountability; all are defined in the appendix. Our general approach was to enter each of the

six dimensions of QoG into each equation as independent variables for our six DOH indicators, the dependent variables, and then to move from this general specification to a simpler one by eliminating each variable which proved insignificant. We were, therefore, able to determine which dimension of QoG was most relevant to each of the DOH.

Our final modelling assumption is that we regard equation (2) as a long-run relationship (formerly a non-linear cointegrating relationship (Asteriou & Hall, 2021). This means that we expect this relationship to hold over time but not instantaneously. So, for example, if a LIC experienced a sudden increase in GRpc, it would not be able to deliver the infrastructure to deliver a high level of water or sanitation services instantly but would have to build these up over time. This implies a process of dynamic adjustment, and we model this using the following dynamic adjustment equation.

$$DOH_{it} = DOH_{it-1} + \phi_1 + \phi_2(DOH_{it-1} - DOH^*_{it-1}) + \phi_3(DOH_{it-1} - DOH_{it-2}) + \varepsilon_{it} \qquad (3)$$

where DOH_{it} is one of our six DOH for country *i* in period *t* and DOH^*_{it} is the fitted value from equation (2) for that indicator, ε_{it} is a standard error term $N(0,\sigma^2)$. This is a simple form of an equilibrium correction model (ECM) which says that the change in the dependent variable is a function of last period's change and the discrepancy between where it was last period and the long-run equilibrium it should be moving towards. For stability, we require that $-1<\phi_2<0$ which implies we are moving towards the long-run equilibrium, and this parameter partly controls the speed of adjustment towards the long-run equilibrium. The adjustment speed is also affected by ϕ_3 which helps to increase the speed of adjustment the larger it is, although it should not generally be more than 1.

4. The results

The results of the unbalanced panel data estimation of equation 2 for each of the six DOH are in table 1. Each column of the tables gives the parameters set out in equation 2. α *and* β are the two basic parameters of the logistic function. After each of these, we show the dimensions of QoG which modify the shape of the logistic curve for each individual country, that is the χ *and* δ in (2). Overall, five of the six models seem to work well and have high R^2 (the proportion of the variance for a dependent variable that's explained by an independent variable or variables). The one model which does not perform very well is immunisation where the R^2 is only 0.2. This was the one model where it was not possible to estimate the completely general model (that is with all QoG indicators included) and a limited search of simpler models had to be undertaken. This was probably due to the relatively small sample and poor quality of the data (see limitations). Perhaps interestingly, there is no clear pattern in the usefulness of the governance indicators. However, the regulatory quality was insignificant in the largest number of models (7) followed by the rule of law (6) and then voice and political stability (5). Corruption seems to do the most work as it is significant in all models, followed by government effectiveness. The fact that some of the governance indicators are significant in every case demonstrates that the shape of the logistic curve does vary between countries substantially.

Table 2 then gives the details of the dynamic model (equation 3) for each of the indicators. The parameter which governs the stability of the equation (ϕ_2) is in all cases negative and significant as required. The effect of the lagged change (ϕ_3) is mostly quite large and highly significant. The R^2 is very high, indicating a very good fit and the DW statistic clearly shows no sign of serial correlation in the errors. As we would expect, these results suggest that it takes several years to adjust these indicators to their equilibrium value after a change in GRpc.

Table 1: The results for the logistic model for each health indicator

		Basic sanitation	Safe sanitation	Percentage schooling	Basic water	Safe water	Immunisation
α		0.002(21.4)	0.000007(8.0)	0.000002(8.0)	0.0028(21.5)	0.0021(20.5)	0.000008(7.1)
χ	Control of corruption	-0.001(7.1)	-0.000006(4.3)	-	-	0.002(8.7)	-0.000002(4.5)
	Government effectiveness	-0.0003(3.4)	-	-0.0000002(3.7)	0.0000008(2.6)	-	-
	Political stability	0.0009(6.1)	0.0001(6.0)	-	-	-	-
	Regulatory quality	0.0007(4.6)	-	-	0.008(8.1)	0.0016(7.4)	-
	Rule of law	0.0008(4.8)	-	-0.0000004(4.8)	0.001(13.1)	-0.002(9.1)	-
	Voice and accountability	-0.0005(5.3)	-0.000002(3.9)	0.000000(6.3)	-	-0.001(10.4)	-
β		233.9(8.1)	4264.1(8.0)	-28011.9(7.5)	-154.0(5.6)	593.1(23.7)	-25232.7(6.6)
δ	Control of corruption	235.1(4.9)	11489.1(8.3)	-5385.6(3.6)	-	-228.0(4.5)	-8328.6(6.6)
	Government effectiveness	75.4(19.5)	-	-5740.5(5.0)	108.3(6.0)	57.8(22.6)	-
	Political stability	-434.4(51.8)	-3922.0(3.7)	-	-	-270.4(6.1)	-
	Regulatory quality	-	-16245.0(7.3	8537.9(4.6)	247.8(7.1)	-	-
	Rule of law	-351.7(57.0)	-4314.2(3.8)	-17828.9(4.6)	-	143.8(2.2)	-
	Voice and accountability	254.2(8.1)	2870.7(3.7)	-	-	168.7(5.3)	-
R^2		0.64	0.67	0.54	0.64	0.78	0.2

Table 2: The dynamic models

('t' statistics in parenthesis)

	Basic sanitation	Safe sanitation	Percentage schooling	Basic water	Safe Water	Immunisation
ϕ_1	0.002(0.4)	0.16(11.5)	0.31(7.4)	0.005(1.4)	0.011(1.1)	0.21(2.2)
ϕ_2	-0.0006(2.8)	-0.004(3.2)	-0.04(7.3)	-0.001(4.1)	-0.006(6.9)	-0.08(9.0)
ϕ_3	0.96(201.9)	0.73(33.1)	0.09(3.5)	0.96(196)	0.91(89.4)	-0.16(7.5)
R^2	0.9999	0.9999	0.977	0.9999	0.9999	0.859
DW	1.9	1.82	2.16	1.7	1.98	1.84

('t' statistics in parenthesis)

The shape of the curves and the importance of the quality of governance

The estimates presented above seem reasonably satisfactory, but it is hard to get a clear understanding of precisely how important the QoG variables are from the estimated parameters. This is partly because there are no simple elasticities in this model, and the effect can be very different at different points along the 'S' shaped curve. We know that the governance effects are statistically significant, but this is not the same as being numerically important. It is also partly because we have many countries and every country will be different. Space constraints make it impossible to show the behaviour of each country individually. To help understand the relative importance of the QoG and GRpc, we conducted a simple set of experiments. We begin by setting all six dimensions of QoG to -1.5, (we call this poor QoG) which is representative of some of the countries in our sample. For example, in LICs in 2018, control of corruption ranged from -1.80 to +0.58 and government effectiveness, -2.19 to + 0.21. In the same year, the range for HICs was -0.57 to +2.21 and for government effectiveness, -0.02 to + 1.98.

We then estimate the long-run relationship between GRpc and the six DOH. We then reset all the governance indicators to zero, the mid-point of the range, (which we call reasonable QoG) and again calculate the relationship between per capita GR and each health indicator. We then graph each pair of relationships so that we can see both the effect of an improvement in QoG and the effect of GRpc. Figure 3 shows the graphs for this experiment for each of the six DOHs. In all cases, the move from poor governance to reasonable QoG has a dramatic and positive effect on the DOH. For basic water, at a GRpc level of $1000, the coverage of basic water increases from 64% to 93% as governance improves, and coverage reaches 100% when GRpc is over $2000, while coverage of safe water reaches nearly 100% when GRpc reaches $3000 with reasonable governance. Consider basic sanitation, at a GRpc level of $1000, the poor QoG curve achieves only slightly over 40% coverage while with reasonable QoG approximately 60% coverage is achieved. Safe sanitation also shows a similar dramatic level of improvement with the same GRpc of $1000, with poor QoG governance coverage is about 32%, and this rises to nearly 45% as we move to reasonable QoG. In both cases, coverage increases as GR rises. Equally in education, at a GRpc of $1000, the percentage SLE moves from under 50% of maximum to 65% as governance improves. The effect on immunisation is similarly impressive: for a revenue level of $1000 and poor QoG, immunisation rates are only around 81% while this improves to almost 89% as QoG improves.

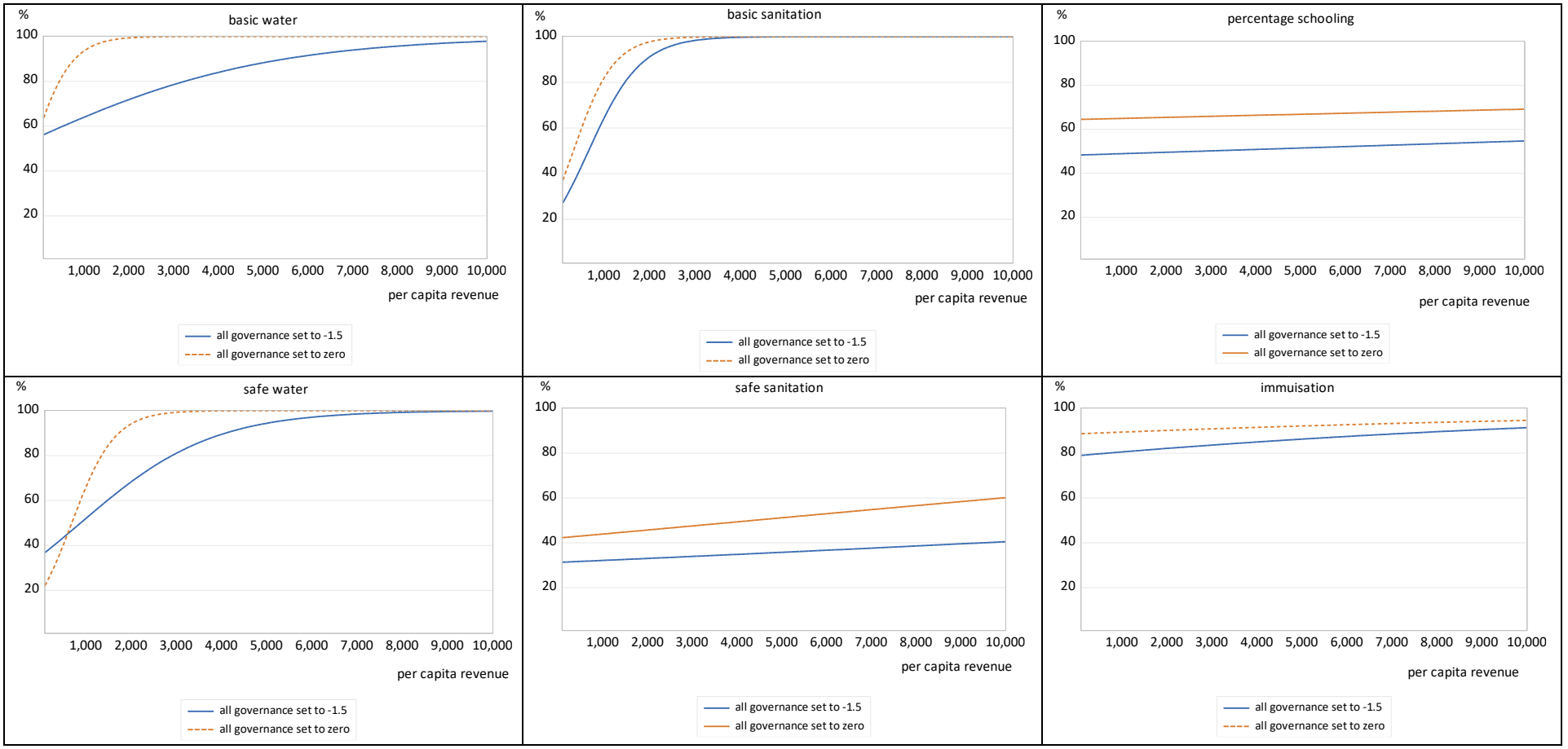

Figure 3 The effect of government revenue per capita on the coverage of the determinants of health with poor and reasonable quality of governance

5. Discussion and conclusion

We find that as GRpc increases, coverage of the DOH increases, and the GRpc-DOH elasticity varies by country. Any increase in access to DOH as a result of an increase in GRpc is substantially amplified if there is an improvement in the QoG. This finding emphasises the importance of good governance in the provision of essential public services. The online visualisation of the model strikingly shows this. It allows users to estimate the effect of increases in GRpc on the DOH in an individual country while holding the QoG constant. The user is also able to see the amplification effect of an improvement in QoG. The model and visualisation may assist advocacy for reduced debt service and tax avoidance, and assist large taxpayers, including multinational corporations, to estimate the effects of the tax they pay. The actual and fitted models show how precise the fitted estimates are (Hall, O'Hare, et al., 2020).

Few studies have analysed the impact of GRpc on U5M and the DOH. Dawson and Reeves et al. study the tax revenue/GDP-U5M relationship. Dawson controls for QoG while Reeves et al. did not. Neither found a statistically significant relationship between revenue and U5M (Dawson, 2010; Reeves et al., 2015). Both studies used pooled data, and as we have seen above, the pooling assumption – whereby the same curve tries to explain every country - does not hold in the data. Hall et al. did find a statistically significant relationship and found the GRpc-U5M relationship to be highly non-linear and to vary between countries, which may explain why studies which pooled results did not find a statistically significant relationship. Other studies which control for QoG (see iiic. in the literature review) are in concordance with our findings and find that increased revenue and spending leads to improved outcomes which can be amplified by better QoG.

When comparing this study with other studies, it is essential to note that researchers often use expenditures in one or two sectors. Still, the health and education sectors constitute a fraction of government spending, and this will fail to capture the broader impact as we outlined in our rationale for using GRpc (see the methods section). It is, however, possible to indirectly compare our findings with those of others if results are available for individual countries. For example, if an increase of $10 per capita health spending has a given outcome in a given country, we could expect an increase of GRpc by $100 to have a similar impact if the percentage allocated to health is 10%.

Studies which do not control for QoG are ambivalent about the impact of increased public spending on outcomes. However, it is worth noting that one of the papers often cited to support the argument that public expenditure has no impact on child health, actually shows that it does reduce U5M but it requires substantial spending to avert the death of one child, even in LICs. Indeed, they found that this was between $50,000-100,000 twenty years ago (Filmer & Pritchett, 1999). Two studies which used health spending and did not control for QoG demonstrated that an increase of $10 per capita of health spending would only decrease U5M by 2-3/1000 (Anyanwu & Erhijakpor, 2009; Bokhari et al., 2007). Although a $10 per capita increase may seem relatively small, the average public health spending in LICs is $8 per capita, so even doubling the amount spent on health appears to result in a marginal improvement (O'Hare, 2019). Such findings may contribute to the narrative that public spending is inefficient. This narrative is fuelled by comparing public expenditure, with the cost of a single medical intervention, multiplied by estimates of the number of children affected by a disease which this

intervention could prevent (Daniel & Wilde, 2012; Filmer & Pritchett, 1999). However, these estimates may not include all costs, such as the training and salary of staff, the civil service, road infrastructure, electricity and internet. Such misleading comparisons could explain the divergence between the actual and apparent potential of public spending and result in the conclusion that government expenditure is ineffective.

Here we see that increasing GRpc increases children's access to their DOH and Hall et al. has shown that an increase in GRpc reduces U5M (Hall, Illian, et al., 2020). A further important aspect of an increase in GRpc was demonstrated by Baskaran and Bigsten who studied 31 sub-Saharan African countries between 1990-2005 and showed that increased GRpc reduced corruption. They used the tax/GDP ratio, and empirically show that a 1% increase in the tax/GDP ratio reduces corruption by 0.08 points (measured on a scale of 0-6) (Baskaran & Bigsten, 2013). The finding that increases in GR improves QoG is exciting because it emphasises the critical importance of curtailing leaks from GR.

This work shows in a striking manner that increased revenue provide governments with the fiscal space to spend on public services, and over time and if used effectively, can have a massive impact. QoG amplifies the effect and contributes to the variation between countries with regards to the efficacy of government spending. This finding is in line with what others have said about the quality of a country's public institutions being the most critical explanation for variation in economic performance and social wellbeing (Acemoglu & Robinson, 2012). Indeed, some who have described GR as state size and QoG as state strength, (the efficiency and ability to implement functions of the state) found that state strength is even more crucial than state size (Dawson, 2010). Others concur with this and note that good QoG can even compensate for lower levels of GRpc (Holmberg & Rothstein, 2011). However, our findings show that both GRpc and QoG are critical, and as an increase in GRpc improves QoG, it is essential that global actors try to increase the GRpc in the countries where they are engaged (Baskaran & Bigsten, 2013).

Limitations

The gauge of corruption most frequently employed in the literature was the WGI, and to facilitate comparison with other studies we also used these. However, there are criticisms of the WGI on the grounds of both content and methodology. Langbein and Knack criticise the fact that the six measures are all related concepts and that the components have considerable overlap. In their opinion, the averaging of the six indexes into a single index would be more logical (Langbein & Knack, 2010). Our model found that there are differences between the QoGs and control of corruption, and government effectiveness did most of the work. Others, using pooled estimates, also found differences between the different dimensions and that government effectiveness, the rule of law and accountability mediated the effects of public health spending on U5M, while control of corruption, the rule of law and accountability mediates the impact on life expectancy (Makuta and O'Hare, 2015).

Others argue that the WGI does not measure what it purports to measure (Thomas, 2010). However, the authors of the WGI have responded to critics to remind them that a better theoretical concept of governance has yet to be proposed, and something is better than nothing in the meantime (Kaufmann et al., 2015). When comparing the WGI measure of corruption with the CPI methodology, both are aggregate indicators, but the WGI uses sources such as the

Afrobarometer, (which interviews several thousand people in each country on each survey round), while in contrast the CPI gauges corruption from expert opinions (Rohwer, 2009).

A further limitation is the data available, especially for immunisation. In many countries, inaccurate data on the size of the cohort of one-year-old children makes immunisation coverage challenging to estimate. Also, the data presented in the World Development Indicators extrapolates from available information, including administrative data from service providers, household surveys on children's immunisation histories and the opinion of local experts (The World Bank., 2020). This may explain the divergence between the fitted and actual estimates for immunisation, while there is a more precise fit for the other DOH (Hall, O'Hare, et al., 2020).

Conclusion

We have modelled the impact of GRpc on the DOH, and role of QoG at the level of the individual country level. We found that increased GR is associated with an increase in the coverage of the DOH. The size of this influence could be amplified to a considerable degree by an improvement in the QoG.

The online visualisations of the models for individual countries offer the ability to realistically predict the impact of increases in GR, for example as a result of a reduction in debt service or an increase in the tax paid by large taxpayers such as multinational corporations. We expect this modelling to be of value to child health and human rights advocates who advocate for reduced corruption, reduced tax avoidance and debt service. This modelling may help multinational corporations to quantify their contribution to countries and support their social, economic and governance reporting, and to make informed decisions when considering their contribution to a country's development goals.

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Appendix

Definitions (The World Bank., 2020)

Basic drinking water services – the percentage of the population drinking water from an improved source, provided collection time is not more than 30 minutes for a round trip. Improved water sources include piped water, boreholes or tube wells, protected dug wells, protected springs, and packaged or delivered water.
Safely managed drinking water services – the percentage of the population using drinking water from an improved source that is accessible on premises, available when needed and free from faecal and priority chemical contamination.
Basic sanitation services - the percentage of the population using at least, that is, improved sanitation facilities that are not shared with other households. This indicator encompasses both people using basic sanitation services as well as those using safely managed sanitation services. Improved sanitation facilities include flush/pour flush to piped sewer systems, septic tanks or pit latrines; ventilated improved pit latrines, compositing toilets or pit latrines with slabs.
Safely managed sanitation services – the percentage of the population using improved sanitation facilities that are not shared with other households and where excreta are safely disposed of in situ or transported and treated offsite. Improved sanitation facilities include flush/pour flush to piped sewer systems, septic tanks or pit latrines: ventilated improved pit latrines, compositing toilets or pit latrines with slabs.
Child immunisation - the percentage of children ages 12-23 months who received diphtheria, pertussis (or whooping cough), and tetanus (DPT) vaccinations before 12 months or at any time before the survey. A child is considered adequately immunised against (DPT) after receiving three doses of vaccine.
School life expectancy (primary and secondary), both sexes (years) -the number of years a person of school entrance age can expect to spend within the specified level of education. For a child of a certain age, the school life expectancy is calculated as the sum of the age-specific enrolment rates for the levels of education specified. The part of the enrolment that is not distributed by age is divided by the school-age population for the level of education they are enrolled in and multiplied by the duration of that level of education. The result is then added to the sum of the age-specific enrolment rates. A relatively high SLE indicates a greater probability for children to spend more years in education and higher overall retention within the education system. It must be noted that the expected number of years does not necessarily coincide with the expected number of grades of education completed, because of repetition. Since school life expectancy is an average based on participation in different levels of education, the expected number of years of schooling may be pulled down by the magnitude of children who never go to school. Those children who are in school may benefit from many more years of education than the average. Here education is shown as the percentage of the maximum SLE, both primary and secondary, both sexes, globally, which is 17 years.

The Worldwide Governance Indicators

The WGI reports aggregate and individual governance indicators for over 200 countries and territories over the period 1996–2019, for six dimensions of governance, see table 3. These are composite indicators, based on more than thirty data sources. Firstly, individual questions from the underlying sources are assigned to one of the aggregate indicators. The compilers then rescale the data to make it comparable across sources using the unobserved components

model. The resulting composite measures are in units of a standard normal distribution with mean zero, running from -2.5 to +2.5 and higher values corresponding to better governance (Kaufmann et al., 2010; Kaufmann & Aart Kraay, 2020).

Table 3: Definitions of dimensions of Quality of Governance

Dimension of Governance	What it captures
Control of corruption	Perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests
Government effectiveness	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
Political stability	Perceptions of the likelihood that the government will be destabilised or overthrown by unconstitutional or violent means, including politically-motivated violence and terrorism
Regulatory quality	Perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development
Rule of law	Perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence
Voice and accountability	Perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media