Central European Journal of Economic Modelling and Econometrics

The Impact of Government Revenue on the Achievement of the Sustainable Development Goals and the Amplification Potential of Good Governance

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Submitted: 3.08.2021, Accepted: 27.11.2021

Abstract

The United Nations General Assembly established the Sustainable Development Goals in 2015 to achieve an equitable and sustainable future for all by 2030. This study aims to model the relationship between government revenue per capita, quality of governance and the targets of several of these goals, including the coverage of the critical determinants of 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, government revenue reflects a government's ability to spend across all sectors rather than just health or education. An unbalanced non-linear panel data model was employed, and annual data on 217 countries over the period 1960–2000 was used. The coverage of the Sustainable Development Goal variables was expressed as percentages and measures of the quality of governance 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 inappropriate. 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 increased progress towards the Sustainable Development Goals. 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 regarding progress towards the Sustainable Development Goals.

Keywords: government revenue, tax, debt, quality of governance, determinants of health, under-five mortality

JEL Classification: C01, C23, C50

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1 Introduction

The Sustainable Development Goals (SDGs) are 17 goals established by the United Nations General Assembly in 2015 to achieve a paradigm shift towards an equitable and sustainable future for all by 2030 (United Nations, 2021). In the same year in Addis Abba, heads of states affirmed their strong political commitment to addressing the challenges of financing these goals. They acknowledged that it is the primary responsibility of each country to mobilise and effectively use public resources to provide the SDGs for their citizens and pledged to support countries to modernise their revenue authorities. They acknowledged that an enabling international economic environment is required and committed to scaling up international tax cooperation to substantially reduce tax abuses by 2030 (United Nations, 2015). To sustainably finance the SDGs, the United Nations Secretary-General has said the needs are massive and urgent and domestic finance is critical for public goods and essential services. Governments need to engage in tax reforms, including subsidy removals, and private enterprises must incorporate the many opportunities for sustainable development into their business models. In addition, the international community should ensure that global economic policies align with the 2030 Agenda. The United Nations Secretary-General has stated that achieving the Goals will open up $12 trillion in market opportunities and 380 million new jobs, while investing in climate change would save $26 trillion, and has called on all countries to align global economic policies with the SDGs (United Nations Secretary-General, 2019).

Thus, to achieve the SDGs, massive and efficient investment in public services is required in many countries. This paper aims to model the relationship between government revenue and progress towards the SDGs. Given the importance of governance, we include it in the model and focus on those SDGs which are critical to health and survival; access to water, sanitation (SDG 6), education (SDG 4), healthcare (SDG 3) (Kuruvilla et al., 2014). We believe this model provides realistic estimates of the potential in terms of these SDGs for additional revenue and improved governance at an individual country level.

The structure of the paper is as follows; following this introductory section, Section 2 gives an overview of the literature, Section 3 outlines our methodological approach, Section 4 gives the estimation results and Section 5 draws some general conclusions and discusses the results.

2 Literature review

Research shows that increased government spending on public services improves access to the SDGs independent of governance. For example, Reeves et al. used a cross-national panel model with fixed effect and studied 89 lower-income countries. 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% (SDG 3) (Reeves et al., 2015). Gupta et al. studied a sample of 50 developing and emerging economies and show that a 5% increase in GDP spending on education increases secondary school enrolment by 1%, and a 1% GDP increase in public health spending reduces child mortality by 3/1000 live births (Gupta et al., 2002). Others empirically show that spending on the social sectors improves access to healthcare, education and social welfare, which are SDGs (Haile and Niño-Zarazúa, 2017). Hall et al. studied the relationship between government revenue and mortality. They explored this relationship as global influences such as international tax and debt will impact governments revenue but are unlikely to affect spending decisions. They found the government revenue-mortality elasticity to be highly non-linear and that increasing revenue had a much more significant impact on mortality in lower-income countries. They proposed two possible explanations for this. First, revenue in lower-income countries is so low that any additional income has a substantial impact. Second, impactful interventions to reduce mortality rates in lower-income countries are primarily public health measures such as ensuring access to clean water, sanitation and education and vaccinations (SDGs 3, 4 and 6) which are less costly than advanced hospital care (Hall et al., 2020).
Others who studied the impact of government revenue on health outcomes (SDG 3), and included governance in the model, found that while revenue has a significant effect independent of governance, an improvement in governance also has an impact that is independent of an increase in revenue (Moon and Dixon, 1985). Hall et al. confirm this and find that while government revenue is essential, the quality of governance is even more critical in determining health outcomes, including survival (Hall et al., 2021).

Governance and the Sustainable Development Goals The importance of governance for efficient public services is plausible (Boachie et al., 2020), and many researchers report an association between governance and child mortality (Holmberg and Rothstein, 2011; Olafsdottir et al., 2011; Richards and Vining, 2016). Others have set out to test the hypothesis that good governance improves outcomes. Gupta et al. used panel data 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 and reverse causation. They split the countries into high and low corruption cohorts. They found that the GDP-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 (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 child mortality (Li et al., 2018). Lin et al. studied the impact of governance on child mortality in 149 countries between 1996-2010. They used factor analysis and found that as governance improves, mortality decreases, in an inversely linear way, when

controlling for economic growth and access to the SDGs critical for health (Lin et al., 2014).
Below, we discuss the pathways through which governance may mediate the impact of revenue on the SDGs, including the effect on economic growth, government revenue generation, allocation, and efficiency of use.

Governance and economic growth A meta-analysis which included 32 empirical studies of the effects of corruption on per-capita GDP growth showed an adverse effect when the studies were looking at long term growth and when data on low-income-countries only was used (Ugur, 2014). 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 and Kang, 2015).

Governance and revenue generation Using survey data gathered by Afro barometer in 33 African countries, Jahnke showed that tax compliance is inversely related to corruption perception. Empirical work supports this by showing that the tax/GDP ratio is inversely correlated with the perceived level of corruption in a country (Arif and Rawat, 2018; Besley and Persson, 2014; Cooray et al., 2017; Gupta, 2007; Jahnke, 2017). Cooray et al. empirically showed that governments that are responsive to their citizens are more stable, less likely to be toppled, and can focus public spending on productive sectors that generate higher revenues (Cooray et al., 2017). Empirical evidence shows that when levels of corruption are higher, tax incentives are higher (Zelekha and Sharabi, 2012). Additionally, several researchers have demonstrated that the benefits of incentives are questionable and do not attract investments (Klemm and Parys, 2009; Stausholm, 2017).

Governance and allocation Poor governance leads to overspending and diversion of public funds into sectors with opportunities for bribes over sectors that prioritises public interest, and reviews of the literature conclude that corruption biases allocation decisions away from education and health (Dreher and Herzfeld, 2005). A study of 64 countries, 1996–2001, empirically showed that corruption skews public spending away from social expenditure (Delavallade, 2006). A reduction in corruption leads to significantly increased allocations for education (Mauro, 1998; Nyamongo and 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, resulting in inefficiency (Cooray et al., 2017; The World Bank, 2010).
Debt service diverts spending from spending on the public sector 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 and Boyce, 2011).

Governance and the effectiveness of public spending Rajkumar and Swaroop studied the interaction between public spending and governance. They found that public spending improves health and educational outcomes in well-governed countries but had virtually no impact 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). Similarly, other researchers confirm the importance of governance for efficient public spending (Baldacci et al., 2008; Çevik and Okan Taşar, 2013; Dhrifi, 2020; Farag et al., 2013; Haile and Niño-Zarazúa, 2018; Hanf et al., 2013; Hu and Mendoza, 2013; Murshed and Ahmed, 2018; Nketiah-Amponsah, 2019).
Thus, the literature indicates that improved governance increases GDP and governments ability to generate, allocate and use revenue effectively. Here we model the relationship between government revenue and progress towards the SDGs and the interaction with governance at the individual country level. This model will permit prediction of the impact of increases in revenue or improvements in governance in terms of progress towards the SDGs, which are critical to health and survival, access to water, sanitation (SDG 6), education (SDG 4), healthcare (SDG 3).

3 The methods

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

1. A better understanding of the relationship between government revenue and the SDGs is helpful because the policies and practices of governments, international and multinational organisations, including corporations and banks, are much more likely to influence government revenue than spending. For example, the facilitation of capital flight 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 (O'Hare et al., 2018).

2. Government revenue 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 or education, which is a fraction of total government spending, but we are interested in all sectors which impact the SDGs. In this work we are not asking what would be the cost of improving one of the SDG's, for example infant survival, this would simply be the cost

of a particular medical intervention and would be easy to calculate. However if this money was given to a government there is little prospect that it would be spent in this way, instead it would get lost in general expenditure. We are asking however; how much would government revenue need to be increased so that the desired SDG target would be improved by a government. This is a very different question.

3.1 Data

For the SDG variables, we used the 2020 World Development Indicators (WDI) for 217 countries. See the definitions in Appendix A (The World Bank, 2020). For government revenue per capita, we used revenue excluding grants as a percentage of GDP and multiplied this by the GDP per capita in constant 2010 US dollars (USD) from the WDI.

There are several different composite measures of quality of governance. We employ the Worldwide Governance Indicators compiled by the World Bank as these were the measures most frequently used by other researchers. Compilation began in 1996 with information from a wide range of sources to reflect perceptions of the governance in a country, and they cover six dimensions of governance, including; 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 for 212 countries (Kaufmann et al., 2010). The definitions are available in Appendix A.

3.2 The modelling strategy

We aimed to model the effect on our six SDG's of government revenues while controlling for each dimension of governance. The SDG variables 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 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. 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 the others, we did not add any controls to the models because we want to capture the total effect of government revenue and governance (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 government revenue, which is unacceptable. It is also probably true that at extremely low levels of income, an increase in government revenue would have a negligible effect. We need a model with a broadly defined "S" shape that

starts with minimal effects for very low levels of revenue 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. The most widely used function within this family is the logistic function, first used by Verhulst to describe population growth. Initially, the population is stable with no real change. Then, as development starts, the population begins to grow slowly and then 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

$$\mathrm{SDG}_i = M/(1 + e^{-\alpha(x-\beta)}), \tag{1}$$

where x is the independent variable, government revenue per capita in our case, and the dependent variable is each of the six SDG variables; M is the maximum of the curve and α and β 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 SDG 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 lower-income countries. 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 government revenue per capita 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

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

where w is a $k \times 1$ vector of exogenous variables, in our case, the indicators for governance and χ and δ are $1 \times k$ 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 governance from the World Governance Indicators, control of corruption, government effectiveness, political stability, regulatory quality, the rule of law and voice and accountability. Our general approach was to enter each of the six dimensions of governance into each equation as independent variables for our six SDG variables, the dependent variables, and then move from this general specification to a simpler one by eliminating each variable that proved insignificant. We were, therefore, able to determine which dimension of governance was most relevant to each of the SDGs.

Our final modelling assumption is that we regard Equation (2) as a long-run relationship (formerly a non-linear cointegrating relationship Asteriou and Hall, 2021). This means that we expect this relationship; to hold over time but not instantaneously. So, for example, if a lower-income country experienced a sudden increase in government revenue, it would not be able to build 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

$$\text{SDG}_{it} = \text{SDG}_{it-1} + \phi_1 + \phi_2(\text{SDG}_{it-1} - \text{SDG}*_{it-1}) + \phi_3(\text{SDG}_{it-1} - \text{SDG}_{it-2}) + \varepsilon_{it} \quad (3)$$

where SDG_{it} is one of our six SDG variables for country i in period t and $\text{SDG}*_{it}$ 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 the 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 SDG variables 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 governance that modify the shape of the logistic curve for each country, that is the χ and δ in (2). Overall, five of the six models seem to work well and have high R^2 and the coefficients are well determined as judged by the "t" statistics. 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 governance indicators included), and a limited search of simpler models had to be undertaken. This was probably due to the relatively small sample and poor data quality. We will not attempt to interpret individual coefficients as this is not really possible in the usual way as these coefficients cannot be viewed as partial derivatives but instead they are coefficients which govern the shape of the logistic function for each country. To understand there working in the model we will instead perform simulations in the next section which are in fact effectively the partial derivatives of the model with respect to the governance and government revenue variables.

Table 1: The results for the logistic model for each Sustainable Development Goal variable

		Basic sanitation (SDG 6)	Safe sanitation (SDG 6)	Percentage schooling (SDG 4)	Basic water (SDG 6)	Safe water (SDG 6)	Immunisation (SDG 3)
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

Note: “t” statistics in parenthesis.

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 government revenue.

Table 2: The dynamic models for each Sustainable Development Goal variable

	Basic sanitation (SDG 6)	Safe sanitation (SDG 6)	Percentage schooling (SDG 4)	Basic water (SDG 6)	Safe water (SDG 6)	Immunisation (SDG 3)
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

Note: "t" statistics in parenthesis.

4.1 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 governance 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 governance and government revenue per capita, we conducted a simple set of experiments. We begin by setting all six dimensions of governance to -1.5 (we call this poor governance), which is representative of some of the countries

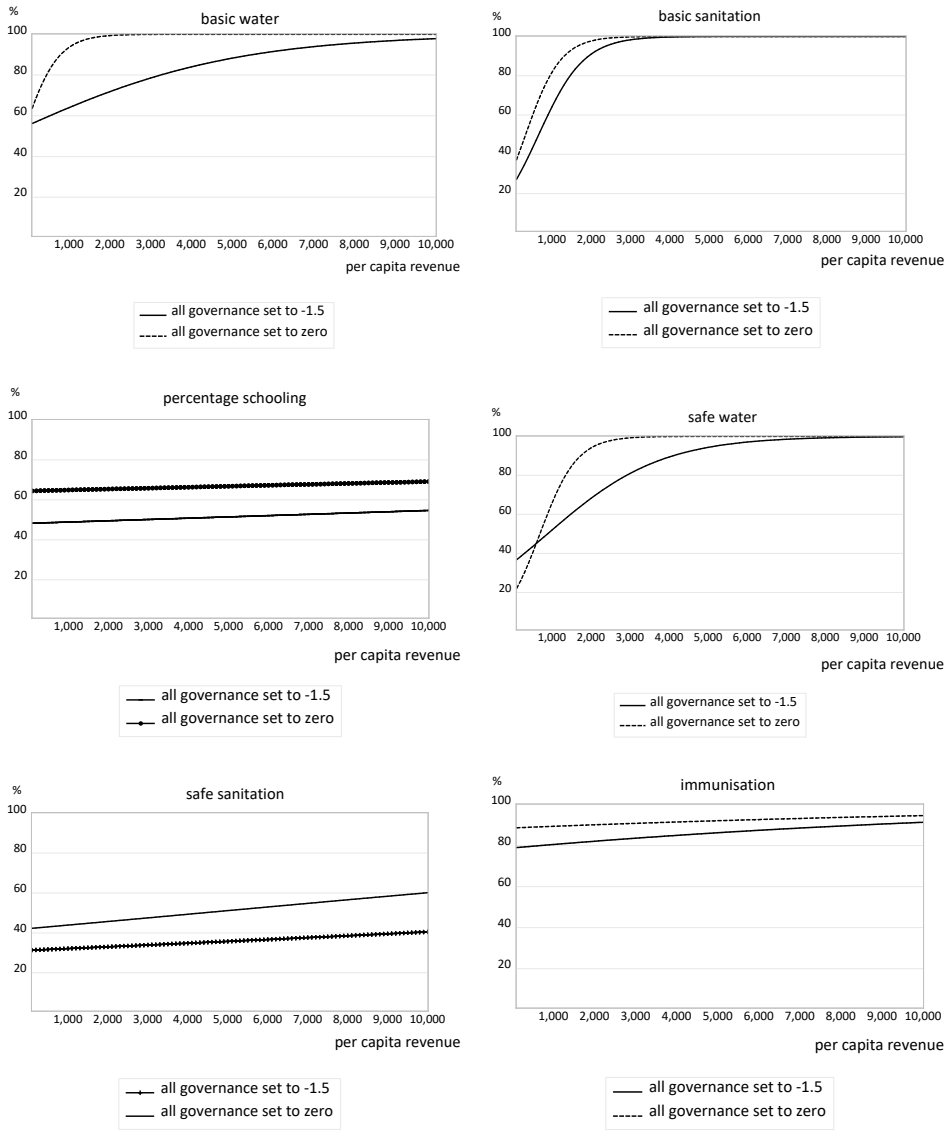
in our sample. For example, in low-income-countries in 2018, control of corruption ranged from -1.80 to +0.58 and government effectiveness, -2.19 to + 0.21. In the same year, the range for high-income countries was -0.57 to +2.21 and for government effectiveness, -0.02 to + 1.98.

We estimate the long-run relationship between governance and the six SDG variables. We then reset all the governance indicators to zero, the mid-point of the range, (which we call reasonable governance) and again calculate the relationship between per capita government revenue and SDG variable. We then graph each pair of relationships so that we can see both the effect of an improvement in governance and the effect of government revenue per capita. Figure 1 shows the graphs for this experiment for each of the six SDG variables. In all cases, the move from poor governance to reasonable governance has a dramatic and positive effect on the SDG variables. For basic water, at a government revenue per capita level of $1000, the coverage of basic water increases from 64% to 93% as governance improves, and coverage reaches 100% when government revenue per capita is over $2000, while coverage of safe water reaches nearly 100% when government revenue per capita reaches $3000 with reasonable governance. Consider basic sanitation, at a government revenue per capita level of $1000, the poor governance curve achieves only slightly over 40% coverage while with reasonable governance approximately 60% coverage is achieved. Safe sanitation also shows a similar dramatic level of improvement with the same government revenue of $1000, with poor governance coverage is about 32%, and this rises to nearly 45% as we move to reasonable governance. In both cases, coverage increases as government revenue rises. Equally in education, at a government revenue of $1000, the percentage SLE moves from under 50% of maximum to 65% as governance improves. The effect on immunisation: for a revenue level of $1000 and poor governance, immunisation rates are only around 81% while this improves to almost 89% as governance improves.

5 Discussion and conclusions

We find that as government revenue per capita increases, coverage of the SDG variables increases, and the government revenue-SDG effect varies by country. Increased access to the SDGs because of increased government revenue is substantially amplified if there is an improvement in governance. This contributes to the variation between countries regarding the efficacy of government spending. This finding emphasises the importance of good governance in the provision of essential public services. This finding aligns 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 and Robinson, 2012). Indeed, some who have described government revenue as state size and governance as state strength (the efficiency and ability to implement state functions) found that state strength is even more crucial than state size (Dawson, 2010). Others concur with

Figure 1: The effect of government revenue per capita on the coverage of the determinants of health with poor and reasonable quality of governance



this and note that good governance can even compensate for lower revenue levels (Holmberg and Rothstein, 2011). Here we see that increasing government revenue increases progress towards the SDGs and Hall et al. has shown that an increase in

government revenue also reduces mortality (Hall et al., 2020) and increases maternal and child survival (Hall et al., 2021), which are a good outcome measure of access to other SDGs critical for health. A further important aspect of an increase in government revenue was demonstrated by Baskaran and Bigsten who studied 31 sub-Saharan African countries between 1990-2005 and showed that increased government revenue reduced corruption. They 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 and Bigsten, 2013). The finding that increases in government revenue improves governance is exciting because it emphasises the critical importance of curtailing leaks from government revenue, especially those facilitated by international actors.

The full set of country results are available through an online computer tool on the GRADE (Government Revenue and Development) web site (`https://med.st-andrews.ac.uk/grade/`). This visualisation of the model strikingly shows the importance of both government revenue and good governance. It allows users to estimate the effect of increases in government revenue per capita on the SDGs in an individual country while holding the governance constant. The user is also able to see the amplification effect of an improvement in governance. The model and visualisation may assist advocates and large taxpayers, including multinational corporations, to estimate the contribution they make towards the SDGs associated with the taxes they pay in a given country.

Few studies have analysed the impact of government revenue per capita on other SDG variables and even fewer have controlled for governance. Reeves et al. found a statistically significant relationship between an increase in tax revenue and skilled birth attendance but not with child mortality (SDG 3), but they did not control for governance. Dawson et al. controlled for governance and also studied the tax revenue child mortality (SDG 3) relationship and did not find a statistically significant relationship (Dawson, 2010; Reeves et al., 2015). Both studies used pooled data, and as we have seen here, the pooling assumption – whereby the same curve tries to explain every country – does not hold in the data. Hall et al. found a statistically significant relationship and found the government revenue-child mortality 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 (Hall et al., 2020) .

Other studies which control for governance are in concordance with our findings and find that increased revenue and spending leads to improved outcomes including child mortality (SDG 3) which can be amplified by better governance (Rajkumar and Swaroop, 2008). Studies which do not control for governance are mixed in their conclusions about the impact of increased public spending on outcomes, most have used child mortality (SDG3). However, it is worth noting that one of the papers often cited to support the argument that public expenditure has no impact, actually shows that it does reduce child mortality but it requires substantial spending to avert the

death of one child, even in lower-income countries. Indeed, they found that this was between $50,000–100,000 twenty years ago (Filmer and Pritchett, 1999). Two studies which used health spending and did not control for governance demonstrated that an increase of $10 per capita of health spending would only decrease child mortality by 2-3/1000 live births (Anyanwu and Erhijakpor, 2009; Bokhari et al., 2007). Although $10 per capita increase may seem relatively small, the average public health spending in low-income countries is $8 per capita, so even doubling the amount spent on health appears to result in a marginal improvement (O'Hare, 2019). Thus, large amounts of public spending are required to reduce mortality when governance is poor or not included in the model.

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 and Wilde, 2012; Filmer and 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 spending is ineffective.

When comparing this study with other studies, it is essential to note that researchers often use expenditures in one or two sectors. However, 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 government revenue in 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 government revenue per capita by $100 to have a similar impact if the percentage allocated to health is 10%.

Conclusions We have modelled the impact of government revenue and governance on SDG 3, 4, and 6 variables at the individual country level. We found that increased government revenue is associated with progress towards the SDGs and this progress could be amplified considerably when there is improved governance.

The online visualisations of the models for individual countries offer the ability to realistically predict the impact of increases in government revenue, 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 those who advocate for reduced corruption, reduced tax avoidance and debt service. This modelling makes explicit the link between government revenues and the quality of governance and the achievement of the SDG goals. When governments loose tax revenues due to any form of tax avoidance or evasion, either by individuals, multinational corporations or other agents the implications for the SDG goals investigated here are now clear (O'Hare et al., 2022).

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Appendix A

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 A1. 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 and Kraay, 2020).

Table A1: 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